

SECTION 230100 – COMMON WORK RESULTS FOR HVAC

PART 1 – GENERAL:

- 1.1 The 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.
- 1.2 All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals to any part if for work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with all documents of Contract Documents. In case of conflict between these Common Work Results and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination prior to the Bid.
- 1.3 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.
- 1.4 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.
- 1.5 It is not the intent of this Section of the Specifications to make any Contractor, other than the General Contractor, responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the General Contractor 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.
- 1.6 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 Plans and Specifications when preparing Bids, prices and quotations.
- 1.7 This Section of the Specifications or the arrangement of the contract documents shall not be construed as an attempt to arbitrarily assign responsibility for work, material, equipment or services to a particular trade Contractor or Sub-Contractor. Unless stated otherwise, the

subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

- 1.8 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.
- 1.9 In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least forty-eight (48) hours prior to the interruption of any services. The Owners 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.
- 1.10 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 Contractor'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 to the Owner, except where otherwise provided for in the contract for the work.
- 1.11 Each Contractor shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.
- 1.12 Definitions and Abbreviations:
- Contractor - Any Contractor whether bidding, proposing or working independently or under contract with General Contractor, or Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the General Contractor.
  - Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
  - Architect - The Architect of Record for the project.
  - 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, General and Special Conditions, Addenda, Alternates, Unit Prices, Shop Drawings, Field Orders, Change Orders, Construction Contract with Owner, and other documents enumerated in the Owner/Contractor Agreement.
  - 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.
  - The Project - All of the work required under this Contract.
  - Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
  - Provide - Furnish and install complete, tested and ready for operation.
  - Install - Receive and place in satisfactory operation.

- Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto or incorporated in the contract documents by reference.
- Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
- ADA - Americans with Disabilities Act.
- ANSI - American National Standards Institute.
- ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.
- ASME - American Society of Mechanical Engineers.
- IBC - International Building Code.
- NEC - National Electrical Code.
- NEMA - National Electrical Manufacturers Association.
- NFPA - National Fire Protection Association.
- OSHA - Office of Safety and Health Administration.
- SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
- UL - Underwriters Laboratories.

#### PART 2 – INTENT AND INTERPRETATION:

- 2.1 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 in the contract sum.
- 2.2 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.
- 2.3 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.
- 2.4 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 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.

#### PART 3 – INDEMNIFICATION:

- 3.1 Refer to Project General Conditions and Supplementary Conditions.
- 3.2 The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability

resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

PART 4 – PLANS AND SPECIFICATIONS:

- 4.1 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.
- 4.2 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.
- 4.3 The Plans and Specifications shall be considered to be complementary 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.
- 4.4 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.
- 4.5 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.
- 4.6 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.
- 4.7 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.
- 4.8 Each Bidder/Proposer shall review all Plans in the Contract Documents to insure 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 insure 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.

- 4.9 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.
- 4.10 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.
- 4.11 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.
- 4.12 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.

#### PART 5 – EXAMINATION OF SITE AND CONDITIONS:

- 5.1 Each Bidder/Proposer shall inform their self 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.
- 5.2 Each Bidder/Proposer shall also fully acquaint their self 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.

PART 6 – EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

- 6.1 When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, 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.
- 6.2 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; unless specifically indicated; 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 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.
- 6.3 Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Owner utilizing Procurement Substitution Requests or Substitution for Cause as indicated in Division 01 specifications.
- 6.4 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 insure 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.
- 6.5 Ten (10) days prior to the submission of a proposal, each Bidder/Proposer shall give written notice to the Engineer 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. In the absence of such written notice, Bidder/Proposers signify that they have included the cost of all required items in the proposal and that the Bidder/Proposer will be responsible for the safe and satisfactory operation of the entire system.

PART 7 – CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

- 7.1 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.
- 7.2 Ignorance of Codes, Rules, Regulations, Laws, etc. shall not render the Contractor irresponsible for compliance. The Contractor shall also be versed in all Codes, Rules and Regulations pertinent to their part of the work prior to submission of a proposal. Refer to M-001 for applicable codes.
- 7.3 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.
- 7.4 All materials furnished and all work installed shall comply with the 2007 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.
- 7.5 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.
- 7.6 All plumbing work is to be constructed and installed in accordance with applicable codes, Plans and Specifications which have been approved in their entirety and/or reflect any changes requested by the State Department of Health. Plumbing work shall not commence until such Plans are in the possession of the Plumbing Contractor.
- 7.7 All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the 2021 International Mechanical Code (IMC) and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association.
- 7.8 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.
- 7.9 Where minimum code requirements are exceeded in the Design, the Design shall govern.

- 7.10 The Contractor shall insure that their work is accomplished in accord with the OSHA Standards and that they conduct their work and the work of their personnel in accord with same.
- 7.11 All work relating to the handicapped shall be in accord with regulations currently enforced by the Department of Housing, Buildings and Construction, Commonwealth of International and the American Disabilities Act.
- 7.12 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.
- 7.13 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. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the Plans and Specifications require better materials, equipment, and construction than these minimum standards, in which case the Plans and Specifications shall be the minimum standards.

#### PART 8 – QUALIFICATIONS OF CONTRACTOR/WORKERS:

- 8.1 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.
- 8.2 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.
- 8.3 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 a workers shall be made through the normal channels of Architect, Contractor, etc.
- 8.4 All plumbing work shall be accomplished by licensed contractors with Journeymen or Master Plumbers as defined under State Plumbing Law Regulations and Code.
- 8.5 The installation of all Heating, Ventilating and Air-Conditioning Systems (HVAC) by any Contractor shall be performed by a Licensed Contractor with Journeymen or Master Tradesmen

as defined under State Regulations and Code. This includes any Contractor installing HVAC systems, piping and ductwork.

- 8.6 All sheet metal, insulation and pipe fitting work shall be installed by workers normally engaged in this type work.
- 8.7 All automatic control systems shall be installed by workers normally engaged or employed in this type work.
- 8.8 All special systems (Automatic Sprinkler Equipment, etc.) shall be installed only by workers normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.
- 8.9 All electrical work shall be accomplished by licensed contractors with Journeymen or Master Electrician as defined under State Regulations and Code. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

#### PART 9 – SUPERVISION OF WORK:

- 9.1 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.

#### PART 10 – CONDUCT OF WORKERS:

- 10.1 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 relief of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or debilitating drugs on the job site is strictly forbidden.

#### PART 11 – COOPERATION AND COORDINATION WITH OTHER TRADES:

- 11.1 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.
- 11.2 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  $\frac{1}{4}'' = 1'-0''$ , 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.

- 11.3 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.

PART 12 – GUARANTEES AND WARRANTIES:

- 12.1 The Contractor shall guarantee all equipment, apparatus, materials, performance, 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 for a minimum of two years in addition to the time frames outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Engineer's Statement of Substantial Completion. 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.
- 12.2 All compressors shall have five year warranty (5 year parts and labor).
- 12.3 Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

PART 13 – COST BREAKDOWNS (SCHEDULE OF VALUES):

- 13.1 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.
- 13.2 The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding (minimum of ½ % of associated mechanical contract value installation scope) for startup, testing, documentation, acceptance, owner training, etc.:
- Mechanical Shop Drawings
  - Motor Load Coordination with other subcontractors
  - Mechanical Record Drawings & Acceptance
  - Mechanical O&M Manuals & Acceptance
  - Mechanical Owner Training & Acceptance
  - Mechanical Startup, Testing, Management Plan, Documentation, Acceptance, Owner Training, etc.
  - Mechanical Identification Materials & Labor
  - Insulation (Piping) Materials & Labor

- Insulation (Ductwork) Materials & Labor
- HVAC Piping Materials & Labor
- HVAC Piping Testing, Cleaning, Documentation, Acceptance, etc.
- HVAC Piping Purging, Flushing, Cleaning
- Geothermal Materials & Labor
- Geothermal Grouting Materials & Labor
- Geothermal Flushing, Purging, Testing, Documentation, Site Survey Submittal, Acceptance, etc
- Sheetmetal Equipment
- GRDs Materials & Labor
- Sheetmetal Materials & Labor
- Sheetmetal Shop Fabrication
- Filters and Racks Materials & Labor
- Spare Filters
- Heat Pump / Fan Coil Equipment & Labor
- Heat Pump / Fan Coil Startup, Testing, Documentation, Training, Acceptance, etc.
- Water to Water Heat Pump Equipment & Labor
- Water to Water Heat Pump Startup, Testing, Documentation, Training, Acceptance, etc.
- Air Handling Unit Equipment & Labor
- Air Handling Unit Startup, Testing, Documentation, Training, Acceptance, etc.
- Chemical Treatment Materials & Labor
- Chemical Treatment Startup, Testing, Documentation, Training, Acceptance, etc
- Controls Shop Drawings
- Controls Materials & Labor
- Controls Graphics
- Controls Startup, Testing, Documentation, etc.
- Controls Training and Acceptance
- Test and Balance Materials & Labor
- Test and Balance Initial Report, Final Report and Acceptance

PART 14 – CHANGES IN MECHANICAL WORK:

14.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

PART 15 – CLAIMS FOR EXTRA COST:

15.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

PART 16 – MATERIALS AND WORKMANSHIP:

16.1 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 this work shall be the responsibility of the Contractor. All equipment shall be

installed so that all parts are readily accessible for inspection, maintenance, replacement of 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.

- 16.2 Materials and equipment, where applicable, shall bear Underwriters' Laboratories label where such a standard has been established.
- 16.3 Use extreme care in the selection of equipment and its installation to insure that noise and vibration are kept at a minimum. The Engineer's determination shall be final and corrections to such discrepancies shall be made at the cost of the Contractor.
- 16.4 Each length of pipe, fitting, trap, fixture and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.
- 16.5 All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a data plate indicating required horsepower, voltage, phase and ampacity. Pumps shall have a data plate indicating horsepower, static pressure head and flow rate.

#### PART 17 – HAZARDOUS MATERIALS:

- 17.1 The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.
- 17.2 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, insure 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.
- 17.3 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.
- 17.4 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.
- 17.5 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.

- 17.6 No asbestos or mercury containing materials shall be installed in this project.
- 17.7 It is the policy of the Owner that no asbestos - containing materials are to be purchased by the Owner, supplied by any person supplying to the Owner or installed in or on Owner property by any person performing work for the Owner. 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.

#### PART 18 – COORDINATION DRAWINGS:

- 18.1 Detailed 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". The Construction Manager shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
- 18.2 Coordination Drawings shall be provided on this project by each Trade (Mechanical, Fire Protection, Electrical). Drawings shall be 30x42 sheet size and shall be at 1/4" scale and shall match the drawing setup as included in the Architectural Drawings. The Architect and Engineer may supply electronic drawings files of the Contract Documents upon the Contractor's request and release.
- 18.3 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, heat pump system piping and other major components in the ceiling cavity. The Coordination Drawings shall be prepared by the Mechanical Contractor with cooperation of all the contractors. 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. These drawings shall indicate all ductwork as double lined with bottom elevations noted.
- 18.4 The sheet metal fabrication shop drawings shall be completed in a timely manner so as not to conflict with construction schedule and phasing plan. At the Contractor's discretion, these drawings shall be completed in phases to correspond with the project construction work sequencing. The Mechanical Contractor shall furnish an electronic copy of these ductwork shop drawings to all other Trades, specifically the Fire Protection and Electrical and other Contractors as requested by the Construction Manager and General Contractor for the purpose of including other trades work on the Coordination Drawings.

- 18.5 Pre-Coordination Meetings with all necessary trades should be performed. 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. Within 30 days of the meeting, 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 may be required so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at the Construction and Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.
- 18.6 It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
- All supply/return/exhaust ductwork.
  - All above slab sanitary and roof drainage piping.
  - HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
  - Electrical conduits which are 1.5" in size and greater.
  - Cable tray and bridal ring paths.
  - Multiple smaller piping/conduits hung on a common trapeze hanger.
  - All wall, roof, floor penetrations.
- 18.7 After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meeting 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 (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper 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 Contractor, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.
- 18.8 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 insure 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 Contractor, Owner, Architect and Engineer for their Records.

- 18.9 The mechanical contractor is responsible to the general contractor for the shop drawing layout of the following rooms and details:
- Concrete pads and foundations
  - Equipment room layouts with actual equipment
  - Roof layouts
  - Trench locations and sizes
  - Dimensioned floor drain locations
  - Congested areas above ceilings adjacent to mechanical and electrical room
  - Dimensioned ductwork shop drawings

PART 19 – TEMPORARY SERVICES:

- 19.1 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.
- 19.2 All temporary services shall be removed by Contractor prior to acceptance of work.

PART 20 – SURVEY, MEASUREMENTS AND GRADE:

- 20.1 The Contractor shall lay out their work and be responsible for all necessary lines, levels, 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.
- 20.2 The Contractor shall base all measurements, both horizontal and vertical from established bench marks. 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.
- 20.3 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.

PART 21 – PROTECTION OF EQUIPMENT:

- 21.1 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.

PART 22 – REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

- 22.1 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.

PART 23 – EQUIPMENT SUPPORT:

- 23.1 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.

PART 24 – DUCT AND PIPE MOUNTING HEIGHTS:

- 24.1 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 above ceiling.

PART 25 – BROKEN LINES AND PROTECTION AGAINST FREEZING:

- 25.1 No conduits, piping, troughs, 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. If in doubt, contact the Engineer. Do not install piping across or near openings to the outside whether they are carrying static or moving fluids or not. Insulation on piping does not necessarily insure that freezing will not occur.

PART 26 – WEATHERPROOFING:

- 26.1 Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as 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.
- 26.2 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.

PART 27 – FINAL CONNECTIONS TO EQUIPMENT:

27.1 The Contractor shall finally connect to mechanical services (water, sanitary, gas, air, etc.), any terminal equipment, appliances, kitchen equipment, etc., provided under this and other divisions of the work. Various equipment connections indicated are based upon “basis of design” equipment selections. Should alternate equipment be purchased by the General Contractor, then this Contractor shall make the necessary provisions in the Bid for any and all differences. Change Orders shall not be considered for any differences due to alternate equipment purchase. Such connections shall be made in strict accord with current codes, safety regulations and the equipment manufacturer’s recommendations. If in doubt, contact the Engineer prior to installation.

PART 28 – ACCESSIBILITY:

28.1 The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and hung 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.

28.2 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, etc.

28.3 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.

PART 29 – SCAFFOLDING, RIGGING AND HOISTING:

29.1 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.

PART 30 – CONCRETE WORK:

30.1 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. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication AC1-318. Heavy equipment shall not be set on pads for

at least seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.

- 30.2 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" round bars on 6" centers both ways. Bars shall be approximately 3" 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.
- 30.3 In general, concrete pads for equipment shall 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.

#### PART 31 – RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

- 31.1 The Contractor shall at their expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, landscaping, existing or new building surfaces and appurtenances, and any other items damaged or removed by their operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Owner and/or Engineer.

#### PART 32 – MAINTENANCE OF EXISTING UTILITIES AND LINES:

- 32.1 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.
- 32.2 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. Contractor shall bear costs of repairing damaged utilities.
- 32.3 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.
- 32.4 Cutting into existing utilities and services shall be done 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.

- 32.5 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.
- 32.6 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 excavates only in accord with utility company, agency or other applicable laws, standards or regulations.
- 32.7 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.
- 32.8 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.

PART 33 – CLEANING:

- 33.1 The Contractor shall, at all times, keep the area of their work presentable to the public and clean of rubbish and debris caused by their operations; and at the completion of the work, 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.
- 33.2 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.
- 33.3 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 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.

PART 34 – TEMPORARY USE OF EQUIPMENT:

- 34.1 The permanent heating and plumbing equipment, when installed, may be used for temporary services, with the consent of the Owner and 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.

- 34.2 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.
- 34.3 A pre-start-up conference shall be held with the Architect, Owner, Construction Manager and the Mechanical Contractor. Equipment shall not be started until after this meeting.
- 34.4 For Fan Coil Units during all phases of construction:
- 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 substantial completion. 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.
  - On the outside of all return 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.
  - At substantial completion 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.
- 34.5 For Outside Air Units during all phases of construction:
- The outside air unit shall be made operational, tested, etc. as specified during construction by the Contractor. Four complete sets of filters are required for the unit; Install one set of filters during construction; the remaining install one set of filters at substantial completion. Leave the remaining filters in boxes in appropriate mechanical room as a spare set for the Owner. Dispose of all construction filters.
  - 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.
  - At substantial completion 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.

#### PART 35 – NOISE, VIBRATION OR OSCILLATION:

- 35.1 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, or exceeds the noise criteria limits as scheduled, 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.

- 35.2 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. Unitary equipment, such as small room heating units, small 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.
- 35.3 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.

#### PART 36 – EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

- 36.1 The Contractor shall include in the bid to provide equipment and controls startup and verification for ALL Mechanical Systems specified for this project.
- 36.2 A pre-start-up conference shall be held with the Architect, Engineer, Owner, General Contractor, 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
- 36.3 Specific line-items shall be included on the schedule of values by each Trade for "equipment and controls startup". This line-item value 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.
- 36.4 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.

- 36.5 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer’s Checklists. Factory startup is required for all HVAC equipment. 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:
- Air-to-Water Heat Pump Chiller (Use the attached forms – no exceptions)
  - Outside Air Units (Use the attached forms – no exceptions)
  - Terminal Units
  - Variable Frequency Drives
  - Water Flow Meters/BTUH Meters
  - System Pumps
- 36.6 Except for the 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.
- 36.7 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. Furnish to the Testing Agent and Engineer. Sample checklists shall be submitted to the Engineer, Owner, and Testing Agent for approval.

#### PART 37 - INSPECTION, APPROVALS AND TESTS

- 37.1 Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installation 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.
- 37.2 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.
- 37.3 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 work. Failure of the Inspecting Agency to inspect the work in the stage following and submit the related reports may result in the Contractor's having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

- 37.4 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 roughing-in without fail. Report of each such Agency Inspection visit shall be submitted to the Architect, Engineer and the Contractor within three days of the inspection.
- 37.5 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.
- 37.6 Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspectors 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.

PART 38 - ABOVE-CEILING AND FINAL PUNCH LISTS:

- 38.1 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.
- 38.2 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.
- 38.3 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.
- 38.4 If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of \$100.00 per hour for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

PART 39 - OPERATING INSTRUCTIONS:

- 39.1 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. 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.

- 39.2 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, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions.
- 39.3 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.

#### PART 40 - RECORD DRAWINGS:

- 40.1 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 insure 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.
- 40.2 All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State. This shall include underground geothermal piping mains, vaults and vertical bore locations. 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.
- 40.3 The survey information shall be included in the closeout documentation.

**OUTSIDE AIR UNIT  
SYSTEM START-UP**

**Project:** \_\_\_\_\_ **Date/Time:** \_\_\_\_\_

**Tag:** \_\_\_\_\_ **Contractor:** \_\_\_\_\_

**System:** \_\_\_\_\_ **Technician:** \_\_\_\_\_

<b>Outside Air Unit</b>	<i>Data</i>	<i>P/F</i>	<i>Comments</i>
<b>Unit Off</b>			
Supply Fan & Exhaust Fan Off			
Energy Recovery Wheel Off			
Outside Air and Exhaust Air Damper Closed			
Face & Bypass Damper Face			
<b>Unit On</b>			
Equipment Schedule Verified with Owner			
Water to Water Heat Pump & Circulating Pumps On			
Hydronics Circulating Pumps On			
Supply Fan & Exhaust Fan On			
Energy Recovery Wheel On			
Outside Air and Exhaust Air Damper Open			
Face & Bypass Damper Modulating			
<b>Cooling Mode</b>			
OA Temperature within Cooling Mode Range			
Face and Bypass Position			
Unit Discharge Air Temperature per Sequence			
Coil Leaving Air Temperature			
<b>Heating Mode</b>			
OA Temperature within Heating Mode Range			
Face and Bypass Position			
Unit Discharge Air Temperature per Sequence			
Coil Leaving Air Temperature			
<b>Economizer Mode</b>			
OA Temperature within Economizer Mode Range			
Face and Bypass Position			
Unit Discharge Air Temperature per Sequence			
Face & Bypass Damper Full Bypass			
<b>Outside Air Unit Safeties (Smoke &amp; Freezestat)</b>			
Supply Fan Off			
Exhaust Fan Off			
Outside Air Damper Closed			
Exhaust Air Damper Closed			
Face and Bypass Damper Open			

<b>Outside Air Unit</b>	<b><i>Data</i></b>	<b><i>P/F</i></b>	<b><i>Comments</i></b>
Alarm and Unit Reset			
Alarm Activated			

**AIR TO WATER HEAT PUMP CHILLER UNIT  
SYSTEM START-UP REPORT**

**Project:** \_\_\_\_\_ **Date/Time:** \_\_\_\_\_

**Tag:** \_\_\_\_\_ **Contractor:** \_\_\_\_\_

**System:** \_\_\_\_\_ **Technician:** \_\_\_\_\_

<b>Air to Water Heat Pump Unit</b>	<i>Data</i>	<i>P/F</i>	<i>Comments</i>
Equipment Schedule Verified with Owner			
Voltage and Power Supply Correct per Name Plate			
Check Unit Voltage and Amps			
Phasing is Correct Per Compressor Rotation			
Maximum Overcurrent Protection Correct			
Low Voltage Wiring Correct			
Verify Water Flow and Direction Through Unit			
<b>Cooling Mode</b>			
Fans On			
Chilled Water Pump On			
Compressor(s) On			
Load Entering and Leaving Fluid Temperature			
Load Temperature Differential			
Load Water Inlet and Outlet Pressure Inlet			
<b>Heating Mode</b>			
Fans On			
Hot Water Pump On			
Compressor(s) On			
Load Entering and Leaving Fluid Temperature			
Load Temperature Differential			
Load Water Inlet and Outlet Pressure Inlet			
<b>Unoccupied Mode</b>			
Scheduled Command System Off of Unoccupied			
Chilled/Hot Water Pump Off			
Compressor(s) Off			
<b>Air to Water Heat Pump Unit</b>	<i>Data</i>	<i>P/F</i>	<i>Comments</i>

**AIR-TO-WATER HEAT PUMP UNIT  
SYSTEM VERIFICATION CHECKLIST**

**Project:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Tag:** \_\_\_\_\_ **Time:** \_\_\_\_\_

**Area Served:** \_\_\_\_\_ **Technician:** \_\_\_\_\_

**Contractor:** \_\_\_\_\_

<i>Air-to-Water Heat Pump Unit</i>	√	<i>Comments</i>
<b>Preliminary Checklist</b>		
Verify Correct Model Installed #		
Voltage and Power Supply Correct per Name Plate		
Phasing is Correct Per Compressor Rotation(2)		Fuse Size
Max Overcurrent Protection Correct		
Verify Electrical Disconnect Location & Accessibility with Lamecoid Nameplate		
Test Disconnect Switch		
Low Voltage Wiring Correct- Controls		
Verify Water Flow Through Unit		
Check, Clean and Note Strainer Condition		
Verify Unit installed on Concrete Pad		
Insulation installed and piping labeled		
Unit Labeled		
Verify Piping Installation per Schematic		
-Pressure Relief Valve		
-Thermometers		
-Pipe size –Supply/Return to Unit		
-Flexible Hose Kits		
-Pete’s Plug		
-Pressure Gauges		
-Control Valves Installed & Operational		
-All Valves/Strainers/Check Valves		
<b>Start Up</b>		
Attach Start Up Report from Manufacturer Representative		

END OF SECTION

SECTION 230300 - SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS

- 1.1 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 The Contractor shall prepare and submit to the Engineer, through the General 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 1 requirements for shop drawing submittal requirements.
- 1.3 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it 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.
- 1.4 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.
- 1.5 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the General 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.
- 1.6 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.
- 1.7 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.
- 1.8 The Engineers 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 and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

- 1.9 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.
- 1.10 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.
- 1.11 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors. Color samples shall be furnished with the shop drawing submission for such equipment.
- 1.12 All submittals for mechanical equipment shall include all information specified. 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.
- 1.13 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.
- 1.14 Any submittals received in an unorganized manner without options listed and with incomplete data will be returned for resubmittal.

PART 2 - SHOP DRAWINGS:

- 2.1 Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:
  - (2.2.1) Air Filtration & Components
  - (2.2.1) Chemical Treatment
  - Ductwork Accessories/Volume Dampers
  - (2.2.1) Exhaust Fans
  - (2.2.1 & 2.2.4) Firestopping
  - (2.2.1) Fan Coil Units
  - (2.2.1) Piping, Specialties
  - Insulation
  - (2.2.1) Outside Air Handling Units & Energy Recovery Wheels
  - (2.2.1) Pumps and Hydronic Specialties
  - Register, Grilles, Diffusers and Louvers
  - System Verification Check Lists
  - (2.2.1 & 2.2.2) Temperature Controls
  - Valves
  - (2.2.1) Variable Frequency Drives

- (2.2.1) Air-to-Water Heat Pump Units
- (2.2.1) Electric Water Heaters
- Painting of Piping, Colors and Diagram

2.2 Special Notes:

2.2.1 Upon substantial completion of the project, the Contractor shall deliver to the Engineers (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item marked (2.2.1) above. These documents shall include at least:

- 2.2.1.1 Detailed operating instructions
- 2.2.1.2 Detailed maintenance instructions including preventive maintenance schedules.
- 2.2.1.3 Addresses and phone numbers indicating where parts may be purchased.
- 2.2.1.4 Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
- 2.2.1.5 Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.

2.2.2 Shop drawings for the Control Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system. Refer to Specification Section – CONTROLS for additional requirements.

2.2.3 Shop drawings for the Building Fire Protection System shall be prepared and stamped by a Certified Contractor and shall meet the criteria of the Department of Housing, Buildings and Construction and submitted to the Engineer. After the Engineer's review, they shall be submitted by the Contractor to the proper state authorities along with the required State review fee. Refer to Specification Section – FIRE PROTECTION for additional requirements.

2.2.4 The Contractor shall submit project specific UL listed firestopping installation drawings to the Authority having jurisdiction.

PART 3 - BALANCE REPORTS:

3.1 Upon substantial completion of the project, the Contractor shall submit to the Engineers three (3) bound copies of the Certified Air and Hydronic Balance Report.

END OF SECTION.

## SECTION 230513 – COMMON MOTOR ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

### PART 1 – GENERAL:

- 1.1 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 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section – HVAC EQUIPMENT for additional requirements. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.
- 1.3 Review the Specification Section – TEMPERATURE CONTROLS AND SEQUENCE OF OPERATIONS FOR HVAC to determine controls, including variable frequency drives, to be furnished.
- 1.4 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 - MOTORS:

- 2.1 The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.
- 2.2 Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
- 2.3 Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
- 2.4 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.
- 2.5 Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.

- 2.6 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.
- 2.7 Unless otherwise noted or required by application, motors shall conform 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.
- 2.8 Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (fans, pumps, etc.) manufacturer's standards to suit specific application.
- 2.9 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.
- 2.10 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.
- 2.11 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.
- 2.12 Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.
- 2.13 Provide energy efficient motors with a minimum efficiency in accordance with 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 hp - 82.5%   | 5 hp – 87.5%   | 20 hp – 91%   |
| 1.5 hp – 84.0% | 7.5 hp – 89.5% | 25 hp – 92.4% |
| 2 hp – 84%     | 10 hp – 89.5%  | 30 hp – 92.4% |
| 3 hp – 87.5%   | 15 hp – 91%    | 40 hp – 93%   |
- 2.14 On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

### PART 3 - MOTOR STARTERS:

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

- 3.2 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.
- 3.3 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.
- 3.4 Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See other sections of these specifications and mechanical schedules for further requirements.
- 3.5 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.
- 3.6 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.
- 3.7 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.
- 3.8 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.
- 3.9 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.
- 3.10 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.
- 3.11 All starters shall be thru-wiring type.
- 3.12 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.

PART 4 - ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT:

- 4.1 All mechanical equipment shall be provided for single point electrical connection unless noted otherwise.
- 4.2 The equipment manufacturer shall provide internally mounted fuses with his 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.
- 4.3 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.
- 4.4 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.
- 4.5 Refrigeration condensing units with internal compressors shall be furnished with integral starter.
- 4.6 All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.
- 4.7 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.
- 4.8 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.
- 4.9 Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

PART 5 - REQUIREMENTS FOR MECHANICAL EQUIPMENT 3/4 H.P. OR LESS:

- 5.1 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.

- 5.2 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 DDC controls, thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.
- 5.3 Provide transformer within unit as required to provide low voltage A.C. for thermostat control.
- 5.4 Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder.
- 5.5 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.

END OF SECTION.

## SECTION 230517 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

### PART 1 – GENERAL:

- 1.1 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 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.
- 1.3 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 go through; however, when this is not done, 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 buildings by the workers of the responsible Contractor must be corrected or rectified at their own expense.
- 1.4 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete or masonry. Set all concrete inserts and sleeves for their work. Failing to do this, Contractor shall cut openings for the work and patch same as required at their own expense.
- 1.5 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.
- 1.6 All work improperly performed or not performed as required by the Mechanical Trades in this section, shall be corrected by the General Contractor at the responsible Contractor's expense.

### PART 2 – SLEEVES:

- 2.1 Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing. Utilize "Link-Seal" at these locations.
- 2.2 In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation.

- 2.3 Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize "Link-Seal" at these locations.
- 2.4 Vertical sleeves in roofs shall be flashed and counterflashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves pass through roof construction, sleeves shall extend minimum of 12" above the roof.
- 2.5 Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

#### PART 3 – CUTTING:

- 3.1 All rectangular or special shaped openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, wood or metal 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 grilles, diffusers, louvers, etc.
- 3.2 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, wall boxes, exhaust fans, etc.). Lintels shall be sized as follows:
  - 3.2.1 New Openings under 48" in width: Provide one 3½"x3½"x3/8" LLV steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
  - 3.2.2 New Openings over 48" in width: Consult with structural engineer.
- 3.3 No cutting is to be done at points or in a manner that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.
- 3.4 Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edge of trenches and large openings shall be scribe cut with a masonry saw.

#### PART 4 - PATCHING AND REPAIRING:

- 4.1 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 or trades for work cut or damaged. 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 and Owner.
- 4.2 Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.
- 4.3 Where ducts penetrate fire rated assemblies, fire dampers shall be provided with an appropriate access door whether indicated or not on the Drawings.

- 4.4 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.
- 4.5 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.

#### PART 5 - FIRESTOPPING:

- 5.1 The Contractor shall submit project specific UL listed firestopping installation drawings to the local building inspectors for their approval as required. Acceptable manufacturers include Hilti, 3M, Metacaulk or approved equal. Coordinate firestopping systems with other trades. Refer to life safety plans for additional information.
- 5.2 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. Piping materials and ductwork gauges shall be as required for the UL listed assembly.
- 5.3 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 satisfactory to maintain the rating integrity of the wall, floor or ceilings affected.
- 5.4 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.
- 5.5 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 local building inspector.
- 5.6 The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractors the proper installation techniques for all the firestopping materials. Contact the Engineer prior to conducting this training session.
- 5.7 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.

- 5.8 The following indicates the 3M penetration detail for uninsulated pipe penetration of various wall and floor construction types:
- 5.8.1 One or two hour fire rated concrete floor - 3M #5300-MPC8.
  - 5.8.2 One or two hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
  - 5.8.3 One hour fire rated gypsum wallboard - 3M #5300-MPC7.
  - 5.8.4 Two hour fire rated gypsum wallboard - 3M #5300-MPC7.
- 5.9 The following indicates the 3M penetration detail for insulated pipe penetrations of various wall and floor construction types:
- 5.9.1 One or two hour fire rated concrete floor - 3M #5300-IMP2.
  - 5.9.2 One or two hour concrete block wall - 3M #5300-IMP2.
  - 5.9.3 One hour fire rated gypsum wallboard - 3M #5300-IMP4.
  - 5.9.4 Two hour fire rated gypsum wallboard - 3M #IMP7.
- 5.10 HVAC ducts penetrating a one or two hour fire rated wall or floor shall be firestopped per 3M #5300-HVD1.
- 5.11 Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit UL listed details for specific applications if this method of firestopping is chosen.

END OF SECTION.

## SECTION 230519 – METERS AND GAGES FOR HVAC PIPING

### PART 1 – GENERAL:

- 1.1 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 The Contractor shall include all thermometers, pressure gauges and/or compound gauges at the locations indicated. All thermometers, pressure gauges and/or compound gauges shall be provided with "PET Cocks" to allow the gauge to be removed and replaced without shutting down system.

### PART 2 – THERMOMETERS AND PRESSURE GAUGES:

- 2.1 Gauges and thermometers shall be Marsh, Marshalltown, Terrice, or Weksler.
- 2.2 All thermometers and pressure gauges shall be readable from a standing position on the floor. Mount thermometers in approved wells. Do not make direct contact of base with fluid in pipe. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.
- 2.3 Digital thermometers shall be WIKA Type T1.D01, 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.
- 2.4 Water thermometers shall be Bimetal type with 3" dial, stainless steel case, stainless steel stem and socket with length as required by piping system. Accuracy to be plus or minus 1%. Lens to be plastic. Water thermometers shall have a 25°F to 125°F range.
- 2.5 Pressure gauges shall be Bourdon Type, circular, 2-1/2" 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 2%. Water pressure gauges shall have 0 to 100 PSI range.
- 2.6 Provide direct mount Bimetal dial thermometers in HVAC ductwork. Thermometer shall be 4" diameter, with acrylic plastic lens and stainless steel case. Air temperature range shall be 25°F to 125°F.

### PART 3 – PRESSURE/TEMPERATURE PORT (PETE'S PLUG – P/T PLUG):

- 3.1 Provide 1/4" NPT fitting to receive either a temperature or pressure probe, 1/8" OD. Fitting shall be solid brass with two valve cores. Valve core material to be neoprene for temperatures up to 200°F and Nordel for temperatures between 200°F and 275°F. Pete's Plugs to have 3"

length when installed on insulated pipes and 1-1/2" length for uninsulated pipes. Pete's Plug to be fitted with a color coded cap strap with gasket and shall be rated at 1000 PSIG at 140°F.

- 3.2 The installing contractor shall supply the owner (4) pressure gauges with 1/8" OD probe and (4), five-inch stem pocket testing thermometers rated for 25-125°F water and 4, 0-200°F water thermometers.

END OF SECTION.

## SECTION 230523 – GENERAL DUTY VALVES FOR HVAC PIPING

### PART 1 – GENERAL:

#### 1.1 RELATED SECTIONS:

1.1.1 Division 01 Section “Enhanced Transition To Operations (eTOP)” for administrative and procedural requirements associated with generating record information to be included in COBie2 worksheet.

1.2 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.

1.3 Each Contractor shall provide all valves required to control, maintain and direct flow of all fluid systems indicated or specified. This shall include but may not be limited to all valves of all types including balancing valves, air vents, drain valves, check valves, special valves for special systems, etc., for all Mechanical Systems.

1.4 ACCEPTABLE MANUFACTURERS: Lunkenheimer, Powell, Nibco, Crane, Jenkins, T & S Brass, Walworth, Milwaukee, DeZurik, Consolidated Valve Industries, Inc., Bell & Gossett, Apollo.

1.5 The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.

1.6 Each type of valve shall be of one manufacturer, i.e., ball valves, one manufacturer, butterfly valves, one manufacturer, check valves, one manufacturer, etc.

1.7 All valves shall comply with current Federal, State and Local Codes. All valves shall be new and of first quality. All valves shall be designed and rated for the service to which they are applied. Zinc, plastic, fiber or non-metallic valves shall not be acceptable.

1.8 Contractor shall provide colored tape on ceiling tile where valves are located above ceiling. Provide access panels where valves are located above hard ceiling.

### PART 2 – HVAC HYDRONIC PIPING APPLICATIONS:

2.1 Gate Valve (2" and under): Use ball valves as specified.

2.2 Check Valves (2" and less): Check valve shall have bronze body, disc and hinge. Check valve shall be Y-pattern type horizontal swing, renewable disc and rated for 200 psi working pressure. Check valve shall be Nibco T-413 for threaded ends or Nibco S-413 for solder ends.

2.3 Check Valves (2½" and larger): Check valve shall have cast iron body and cast iron bolted bonnet the disc and seat ring shall be bronze. Check valve shall be horizontal swing with renewable seat and disc. Valve shall be rated for 200 psi working pressure. Check valve shall be

- Nibco F-918 for flanged ends and Nibco T-918 for threaded ends. Threaded ends valve allowed for sizes 3" and less only.
- 2.4 Two Piece Ball Valves (2" and under): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve shall be two piece construction. Valve shall be "full port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-585 for threaded ends and Nibco S-585 for solder ends. Provide extended handles for all ball valves installed in insulated piping systems.
- 2.5 Ball Valves (2½"-3"): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve shall be "full port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco S-FP-600 for threaded ends and Nibco T-FP-600 for solder ends. Provide extended handles for all ball valves installed in insulated piping systems.
- 2.6 Butterfly Valve (4" and larger): Butterfly valve shall have cast iron body with bronze disc. Valve to have extended neck to allow for insulation and be "lug" type configuration. Interior liner shall be made of EPDM. Lever handle shall be lock type with 10 position settings. Valve to be rated for 200 psi working and have positive shut-off equal to Hammond 6000 Series.
- 2.7 Strainers (2" and under): Watts 77S Series "Y" type strainer with cast iron body and threaded ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with cleanout plug and be rated for 200 psi working pressure.
- 2.8 Strainers (2½" and larger): Watts 77F Series "Y" type strainer with semi-steel body and flanged ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with bolted cleanout and be rated for 200 psi working pressure.
- 2.9 Balancing Valve (4" and less): Balancing valve shall have bronze or brass body. Valves to have differential pressure readout ports across valve seat area with integral check valves. Valve shall be equipped with memory stop. Valves to have threaded ends for sizes 3" and less, flanged ends for larger sizes. Valve to be provided with performed molded insulation casing. Design working pressure and temperature to be 200 psi at 250 degrees F balancing valve shall be similar to Bell & Gossett Model CB. Provide with balancing valves, one (1) water gpm readout kit to be turned over to Owner which shall include a differential pressure meter with full scale overrange protection, hoses, readout probes, filters, carry and calculator.
- 2.10 Flexible Connection: Pumpsaver SMP or equal braided stainless steel pump connector(s). Construction to be of annular corrugated stainless steel close-pitch hose with stainless steel overbraid. The corrugated metal hose, braid(s), and a stainless steel ring-ferrule/band (material gauge not less than .048") must be integrally seal-welded using a 100% circumferential, full-penetration TIG weld. End fittings shall be flat-face plate steel flanges with 150# ANSI drilling and outside diameter. Fittings must be attached using a 100% circumferential TIG weld. Braided stainless steel pump connector(s) must be suitable for operating temperatures up to 850 degrees F. The rated working pressure of the braided metal hose must have a minimum 4:1

safety factor. Each braided stainless steel pump connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure. Flanged pump connectors shall be prepared for shipment using cut-to-length spacers, securely positioned between the flanges to prevent axial compression damage and maintain the manufactured length. Spacers must be removed prior to system start up.

- 2.11 Automatic Air Vent: Armstrong Model 79 automatic air vent for vertical mounting with brass body and polypropylene float. Vent to be rated for 150 psi working pressure and 240 degrees F working temperature. Pipe discharge to nearest floor drain.
- 2.12 Manual Air Vent: Armstrong Model 505A manual air vent with brass body. Install with 12" length of 1/4" soft copper discharge piping.

### PART 3 – EXECUTION:

#### 3.1 EXAMINATION

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

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

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

- Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- Examine threads on valve and mating pipe for form and cleanliness.
- Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- Do not attempt to repair defective valves; replace with new valves.

#### 3.1.4 VALVE INSTALLATION

- Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- Locate valves for easy access and provide separate support where necessary.
- Install valves in horizontal piping with stem at or above center of pipe.
- Install valves in position to allow full stem movement.
- Install chain wheels on operators for all butterfly valves 6" and larger and more 8 foot above floor. Extend chains to 5 foot above finished floor.
- Install check valves for proper direction of flow and as follows:
  - Swing Check Valves: In horizontal position with hinge pin level.
  - Valves: In horizontal or vertical position, between flanges.
  - Lift Check Valves: With stem upright and plumb.
- Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

### 3.1.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- If valve applications are not indicated, use the following:
  - Shutoff Service: Ball or butterfly valves.
  - Butterfly Valve Dead-End Service: Single-flange (lug) type.
  - Throttling: Globe or ball valves.
  - Pump-Discharge Check Valves: Bronze swing check valves with bronze disc.

END OF SECTION.

## SECTION 230529 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

### PART 1 – GENERAL:

- 1.1 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 This section includes, but is not limited to, furnishing and installing dampers, supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work.
- 1.3 Power driven anchors and expansion anchors shall be permitted only when permission is granted in writing by the Architect and Engineer.

### PART 2 – MATERIALS AND EQUIPMENT:

- 2.1 Hangers, Clamps, Attachments Schedule:
  - ACCEPTABLE MANUFACTURERS: Grinnell, Fee & Mason.
  - All hangers, clamps and attachments shall be manufactured products.
  - Pipe Rings (2" pipe and smaller) – adjustable swivel split ring or split pipe ring.
  - Pipe Clevis (2.5" pipe and larger) – adjustable wrought clevis type.
  - Pipe Clevis (All pipe sizes) – steel clevis for insulated pipe.
  - Riser Clamps (All pipe sizes) – extension pipe or riser clamp.
  - Beam Clamps (All pipe sizes) – malleable beam clamp with extension piece.
  - Brackets (All pipe sizes) – medium weight steel brackets.
  - Concrete Inserts (All pipe sizes) – wrought or wedge type inserts.
  - Concrete Fasteners (All pipe sizes) – self-drilling concrete inserts.
  - Rod Attachments (All pipe sizes) – extension piece, rod coupling, forged steel turnbuckle
  - U-bolts (All pipe sizes) – standard u-bolt.
  - Welded Pipe Saddles (All pipe sizes) – pipe covering protection saddle sized for thickness of insulation.
  - Pipe Roll (All pipe sizes) – adjustable swivel pipe roll.
  - Protection Saddle (All pipe sizes) – 180 degree coverage, sheet metal pipe protection saddle.
  - Hanger Rods (All pipe sizes) – Steel, diameter of hanger threading.
  - Concrete Channel Inserts (All pipe sizes) – continuous heavy duty slot inserts unistrut.
  - Adjustable Spot Inserts (All pipe sizes) – continuous heavy duty spot insert unistrut.
  - Miscellaneous steel such as steel angles, rods, bars, channels, etc used in framing for supports, fabricated brackets, anchors, etc. shall confirm to ASTM-A-7.

### PART 3 – INSTALLATION:

- 3.1 Unless otherwise specified, all supporting, hanging and anchoring of piping, ductwork, equipment, etc., shall be performed by each trade as is necessary for completion of the work and shall be as directed in the following paragraphs.

- 3.2 Supporting and hanging shall be done so that excessive load will not be placed on any one hanger or structural member and as required to allow for proper pitch and expansion of piping.
- 3.2.1 Hangers with less than 100# may eccentrically load the bar joist with "C clamps". Hangers greater than 300# and must concentrically load (i.e.- no "C clamps") the top or bottom chord. This 300# must include impact load factors. If the 300# load limit can't be attained then the hangers must hit at a joist panel point location and load the joist concentrically. The concentrically loaded term means the rod must come up the gap between the chords.
- 3.2.2 All major hangers (loads greater than 100 lbs) at structural floors must attach to the steel members and not into the slab. Minor hangers (loads less than 100#) may go into the slab.
- 3.2.3 All hangers attached to wood members must go into the upper half of the member and not into the bottom soffit or the lower half of the sides.
- 3.3 Hangers and supports shall be placed as near as possible to joints, turns and branches.
- 3.4 For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power driven devices may be used when approved in writing by the Architect/Engineer.
- 3.5 Utilize beam clamps for fastening to steel joists and beams and expansion anchors in masonry construction.
- 3.6 When piping is routed in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger. Do not support piping or ductwork from bridging angles.
- 3.7 Trapeze hangers are not allowed, unless specifically approved by the Engineer.
- 3.8 Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross steel joists.
- 3.9 Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.
- 3.10 Where piping, etc., is routed vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum and an approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run.
- 3.11 Where piping is routed along walls, knee braced angle frames, etc. pipe brackets with saddles, clamps, and rollers mounted on structural brackets fastened to walls or columns shall be used.
- 3.12 Support all ceiling hung equipment with approved vibration isolators.

- 3.13 Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.
- 3.14 Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping.
- 3.15 All insulated piping shall be supported with clevis type and pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.
- 3.16 Under no conditions will perforated band iron or steel wire driven hangers be permitted.
- 3.17 Support steel and copper piping at a minimum of eight (8) foot intervals for piping 3" and smaller and ten (10) foot intervals for larger piping. Provide additional support at end of the branches and change of direction.
- 3.18 Support plastic pipe at intervals at a minimum of six (6) foot intervals for piping 4" and smaller; support a minimum of eight (8) foot intervals for larger piping. Smaller plastic piping systems, 2" and smaller, supports shall not to exceed four (4) feet. Support all piping at the end of the branches and at the change of direction and shall be installed as to permit freedom of movement. Vertical piping shall be supported at their bases and all upward movement shall not be restricted. Hangers shall be at least one (1) inch wide and shall not compress, distort, cut or abrade the piping to allow free movement at all times. In addition, all piping installation shall conform to manufacturer's installation instructions.
- 3.19 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants.
- 3.20 Ensure that all bolts and nuts are tightened.

END OF SECTION.

SECTION 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL:

- 1.1 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.

PART 2 – TAGS AND CHARTS:

- 2.1 Provide and install on appropriate valves on the mechanical system a valve tag made of bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed with an identifier. IdentifierS shall be determined by the Contractor. Identifiers include bypass valves, normally open/normally closed valves, zone isolation, etc.
- 2.2 Provide in the operation manual valve tag information indicating valve identifier, the valves service, normal position and its location.
- 2.3 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. water, domestic hot water, main HVAC valves, etc.).
- 2.4 Label all control panels and disconnect switches with service and equipment served.

PART 3 – PIPING IDENTIFICATION:

- 3.1 All piping installed shall be identified according to the chart hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping installed under this contract. Markers and arrows shall be painted on the piping 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 shall be identified on twelve (12) foot centers. All piping 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.
- 3.2 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"
Over 10"	24"	3 ½"

- 3.3 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.
Chilled Water Supply	C.W.S.
Chilled Water Return	C.W.R.
Hot Water Supply	H.W.S.
Hot Water Return	H.W.R.
Domestic Cold Water (Fill)	D.C.W.

PART 4 – PAINTING OF PIPING:

- 4.1 All insulated and uninsulated piping in the mechanical rooms, shall be completely painted by this contractor.
- 4.2 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
Hot Water Supply	Medium Green w/Black Letters	H.W.S.
Hot Water Return	Light Green w/Black Letters	H.W.R.

- 4.3 Mechanical equipment shall be factory painted white or light gray.
- 4.4 Where a pipe is not specifically identified in this table, painting and marking shall be in accordance with the most recent ANSI Standards.

PART 5 – EQUIPMENT IDENTIFICATION:

- 5.1 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.
- 5.2 All mechanical equipment shall have the electrical panel number and circuit number identified on the lamacoid plate. Coordinate with the Electrical Contractor.

PART 6 – DUCTWORK IDENTIFICATION:

- 6.1 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.

6.2 Ductwork shall be labeled a minimum of 12 foot centers.

6.3	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

PART 7 – ACCESS THROUGH LAY-IN CEILINGS:

7.1 Mark at each location of the lay-in ceiling panel, on T-bar, which is nearest access to equipment, valves, dampers, etc., with flexible vinyl tape with pressure sensitive adhesive backing and printed markings (P-touch labels) with name of scheduled device (i.e. - VAV, valve, damper, etc...). Coordinate labeling (device name, type, etc) with owner.

END OF SECTION.

SECTION 230700 – HVAC INSULATION, EQUIPMENT, DUCTWORK, AND PIPING

PART 1 – GENERAL:

1.1 RELATED SECTIONS:

- 1.1.1 Division 01 Section “Enhanced Transition To Operations (eTOP)” for administrative and procedural requirements associated with generating record information to be included in COBie2 worksheet.
- 1.2 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.
- 1.3 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.
- 1.4 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.
- 1.5 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.
- 1.6 Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.
- 1.7 Insulation shall comply with UL GREENGUARD which provides independent third party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.
- 1.8 All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.
- 1.9 The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.
- 1.10 LEED Submittals: Comply with Section 018113.
- EQ Credit 2: Low-Emitting Materials
    - Paints and Coatings applied within building interior: Certificate stating compliance with California Department of Public Health (CDPH) Standard Method including TVOC range

and product data stating VOC content in grams per Liter (g/L). Include volume of material per product.

PART 2 – MANUFACTURERS:

- 2.1 ACCEPTABLE MANUFACTURERS: Manville, Keene Corp., Knauf, Owens-Corning, Armstrong, World Industries.
- 2.2 Interior wet-applied mastics, paints, and coatings: Comply with emissions requirements of CDPH Standard Test Method and VOC content limits in Section 018113.

PART 3 – MATERIALS STANDARDS:

- 3.1 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.
- 3.2 All products and their packaging shall bear a label indicating above requirements are not exceeded.
- 3.3 Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.
- 3.4 Products shall not contain formaldehyde, asbestos, lead, mercury, or mercury compounds if possible. Products shall be Certified UL GREENGUARD Gold or Indoor Advantage Gold.
- 3.5 Insulation materials applied to carbon steel shall be Mass Load Corrosion Rate (MLCR) tested per ASTM 1617.
- 3.6 Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- 3.7 Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Earthwool 1000 Degree Pipe Insulation with ECOSE Technology or Earthwool Redi-Klad 1000 Degree Pipe Insulation with ECOSE Technology. Type I, 850 Deg F (454 Deg C) or Type IV 1000 Deg F (528 Deg C)
- 3.8 Materials: Glass Mineral Wool bonded with a thermosetting resin. EPD Certified by UL Environment, UL/ULC Classified for Earthwool Pipe; FHC 25/50 per ASTM E 84 for Redi-Klad. Living Building Challenge - Declare Red List Free for Redi-Klad Pipe; or unjacketed Earthwool Pipe only. Comply with ASTM 585, ASTM C 411, ASTM C795, and ASTM C 547, Type I, and Type IV, with factory-applied ASJ+-SSL+ or ASJ-SSL.
- 3.9 Glass Mineral Wool Blanket Insulation: Glass Mineral Wool bonded with a thermosetting resin. Comply with ASTM C 553, Types I, II, and III, ASTM C 1136 Type II, and ASTM C 1290, Type I. UL/ULC Classified FSK, FHC 25/50 per ASTM E 84 for PSK only. UL GREENGUARD Gold Certified and UL Environment Validated to be formaldehyde free. Product shall contain no polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Basis-of-Design

Product: Subject to compliance with requirements, provide Knauf Insulation; Atmosphere Duct Wrap with ECOSE Technology.

- 3.10 Glass Mineral Wool Board Insulation: Glass Mineral Wool bonded with a thermosetting resin. UL/ULC Classified per UL 723 for unfaced, ASJ, ASJ+ and FSK; FHC 25/50 per ASTM E 84 for PSK only. Comply with ASTM C 612, Type IA or Type IB. UL GREENGUARD Gold and Verified by UL Environment to be formaldehyde free. Living Building Challenge – Declare Red List Free. For duct and plenum applications, provide insulation with factory-applied ASJ, with factory-applied ASJ+ jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Earthwool Insulation Board with ECOSE Technology.
- 3.11 Glass Mineral Wool Pipe and Tank Insulation: Glass Mineral Wool bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb./cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in. /h x sq. ft. x deg F (0.042 W/m x C) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Earthwool Pipe and Tank Insulation with ECOSE Technology or Kwik-Flex Pipe and Tank Insulation.

#### PART 4 – GENERAL APPLICATION REQUIREMENTS:

- 4.1 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, ductwork or equipment until tested, inspected and released for insulation.
- 4.2 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.
- 4.3 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe and 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.
- 4.4 "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 and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as "exposed".
- 4.5 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced as directed by the Engineer.

- 4.6 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples thru the jacket.
- 4.7 All insulation shall be installed with joints butted firmly together.
- 4.8 The Contractor shall insure that all insulation (piping, ductwork, equipment, etc.) is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (air, water, 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 there from shall be repaired solely at the expense of the Contractor.
- 4.9 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

PART 5 – PIPING SYSTEMS:

- 5.1 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.
- 5.2 Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over is, etc. to insure no condensation drip or collection.
- 5.3 Valves, flanges and unions shall only be insulated when installed on piping whose surface temperature will be at or below the dew point temperature of the ambient air.
- 5.4 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.
- 5.5 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 ° 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"
Over 10"	14	24"

- 5.6 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.
- 5.7 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.

5.8 PIPE INSULATION MATERIAL: Insulation shall be Owens-Corning model 25ASJ/SSL or approved equivalent fiberglass pipe insulation with an all-service jacket. The insulation shall be a heavy density, pipe insulation with a K factor not exceeding 0.27 Btu per inch/h.ft<sup>2</sup> °F at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of 0.02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturer's recommendations. The following pipes shall be insulated with the thickness of insulation as noted.

5.8.1 Hot & Chilled Hydronic Water:

- 5.8.1.1 Piping 1-1/2" and less: 1-1/2" thick insulation
- 5.8.1.2 Piping 2" and greater: 2" thick insulation
- 5.8.1.3 All exterior piping: 3" thick insulation and jacketing

5.8.2 Domestic Water Fill Lines: 1" thick.

5.8.3 Condensate Drain Lines - 1/2" thick.

#### PART 6 – DUCTWORK SYSTEMS:

6.1 Duct sizes indicated are the net free area inside clear dimensions.

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

6.3 EXTERNAL INSULATION FOR SUPPLY AND OUTSIDE AIR DUCTWORK: Owens/Corning, All Service Fiberglass Duct Wrap, "Faced Duct Wrap - Type 75" or approved equivalent, 2.2" thick fiberglass duct wrap, 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.

- Exhaust air ductwork upstream of OA unit (under negative pressure) does not require insulation. All other duct including louver plenums requires installation per the above.

6.4 EXTERNAL INSULATION FOR SUPPLY AND OUTSIDE AIR DUCTWORK (CONCEALED/UN-CONDITIONED SPACE): Owens/Corning, All Service Fiberglass Duct Wrap, "Faced Duct Wrap - Type 75" or approved equivalent, 3" thick fiberglass duct wrap, 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 8.3. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch.

PART 7 – MECHANICAL EQUIPMENT:

- 7.1 AIR SEPARATOR, EXPANSION, AND STORAGE TANKS: Owens-Corning "Thermal Insulating Wool - Type II" or approved equivalent. Insulation shall be constructed of non-combustible, flexible wool. Insulation shall be 2" thick.  $K = 0.24 \text{ Btu in/hr.ft}^2 \text{ }^\circ\text{F @ } 100^\circ\text{F}$ . Insulation shall be attached in strict accordance with the manufacturer's recommendations. All insulation shall be jacketed with 6 oz. canvas with fire retardant lagging.
- 7.1.1 For tanks, pumps, and equipment, Armacell engineered foam may be used. Total insulation thickness of 2".  $K=0.27 \text{ Btu in/hr ft}^2 \text{ }^\circ\text{F @ } 75 \text{ }^\circ\text{F}$ . Install per manufacturer's instructions utilizing black adhesive (low voc) with a minimum of 2" insulating tape.
- 7.1.2 Insulate pump volutes as part of the piping system as referenced in Part 5.

END OF SECTION.

## SECTION 230800 – HVAC COMMISSIONING

### PART 1 – GENERAL:

#### 1.1 RELATED SECTIONS:

- 1.1.1 Division 1 – General
- 1.1.2 Division 22 - Plumbing
- 1.1.3 Division 23 - Mechanical
- 1.1.4 Division 26 – Electrical

#### 1.2 REFERENCES

- 1.2.1 Drawings and general provisions of contract, including general and supplementary conditions, general mechanical provisions and Division-1 Specification sections, apply to work of this section.
- 1.2.2 ASHRAE Guideline 1-1996
- 1.2.3 ASHRAE Guideline 0-2005
- 1.2.4 ACG Commissioning Guideline – 2005

#### 1.2 DESCRIPTION OF WORK

- 1.2.1 The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the mechanical systems have been installed in the prescribed manner and operate within the performance guidelines set in the Basis of Design Documents (BOD). The CA shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The CA will be a member of the construction team, administrating and coordinating commissioning activities with the design team, General Contractor, subcontractors, manufacturers and equipment suppliers.
- 1.2.2 The independent commissioning agent (CA) contracted directly with the owner for this project. This specification has been included for reference only to define contractors' responsibilities. Each contractor should review this procedure and include adequate time in their proposal.

### PART 2 - PRODUCTS

- 2.1 Not used.

## PART 3 - EXECUTION

### 3.1 ROLES OF THE COMMISSIONING AGENCY

- 3.1.1 The primary point of responsibility is to inform the General Contractor, the owner and design team on the status, integration, and performance of HVAC systems within the facility.
- 3.1.2 The CA shall function as a catalyst and initiator to disseminate information and assist the design and construction teams in implementing completion of the construction process. This shall include system verification, functional performance testing, and conformance with the intended design of each system. Services include documenting construction observations, verification and functional performance testing, and documenting proper distribution of performance and operating information to the owner's O&M staff.
- 3.1.3 Assist the responsible parties to maintain a high-quality level of installation by meeting or exceeding prevailing standards and specifications.
- 3.1.4 The CA shall observe and coordinate testing as required to assure system performance meets the design intent.
- 3.1.5 The CA shall document the results of the performance testing directly and/or assure that the appropriate technicians document testing. The CA shall approve standard forms to be used by all parties for consistency of approach and type of information to be recorded.
- 3.1.6 The CA shall provide technical expertise to oversee and verify the correction of deficiencies found during the commissioning process.
- 3.1.7 The CA is to remain an independent party with specific knowledge of the project. The CA shall investigate the scope and extent of the problem and facilitate communication to determine responsibilities by delineating specifications. The CA shall monitor resolution for conformance with design intent and prevailing industry standards.
- 3.1.8 The CA shall document the date of acceptance as determined by the General Contractor, owner and design team. System Verification Checklists and Functional Performance Test results may be used in determining the start of the warranty period for HVAC systems and subsystems.
- 3.1.9 The CA will review operating and maintenance materials for HVAC systems.
- 3.1.10 The CA will review phasing plans as provided by the CM relating to temporary use of HVAC equipment, O&M considerations, warranty issues, impact of construction sequencing on occupied areas, and interruption of services from the existing equipment.

### 3.2 SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS

- Water to Water Heat Pumps
- Dedicated Outdoor Air Units

- Fan Coil Units
- Exhaust Fans
- DDC Control System
- VAV Terminal Units
- Hydronic Water Pumps

### 3.3 HVAC COMMISSIONING PLAN

3.3.1 Commissioning Team: The Commissioning Team (CT) shall consist of key parties involved in design, construction and testing of this facility. It is necessary for each agency to appoint team members that will have long-term commitments to this project. Switching team members during the project will reduce the ability of the CT to provide continuity and acceptable results to the building owner. Team members must maintain an ongoing supervisory position on this project. One team member shall be provided by each of the parties listed below:

- Program Manager (PM)
- Facilities Management Division (FMD)
- Commissioning Agent (CA)
- Design Team (DT)
- General Contractor (GC)
- Mechanical Contractor (MC)
- Controls Contractor (CC)
- Test and Balance Contractor (TABC)
- Electrical Contractor (EC)

#### 3.3.2 Basis of Design Document

- The Basis of Design Document (BOD) represents a composite of design drawings, project specifications, submittals, change orders and industry standards that describe the systems of this facility. References to design intent will be taken from these contract documents. The BOD is an evolving manuscript maintained by the design professional to track and incorporate design alterations that occur throughout the construction process. Any industry standards used for this project will be specifically noted when referenced.
- The CA will review the BOD documents for adequate commissioning provisions, functional performance, optimization of performance, accessibility, TAB provisions, and O&M considerations.

#### 3.3.3 Commissioning Meetings

- Commissioning meetings will be held in conjunction with progress meetings as necessary. The CA will be on site for the CX meetings. Commissioning meetings will be used to address any problems that alter the design intent or affect the commissioning process. These meetings provide an open forum for exchange of ideas between contractors, vendors, designers, users and owners.

#### 3.3.4 Resolution Tracking Forms (RTF)

- The use of Resolution Tracking Forms is a method employed by the CA to monitor and record problems, their causes, and solutions. The use of these lists promotes communication between the installing contractors, design team, commissioning agent, and owner, in order to expedite their resolution in a timely manner.

- The CA will regularly submit RTF's to the CT in order to document and resolve deficiencies as quickly as possible. The frequency of RTF submission will be adjusted as project conditions dictate.

### 3.3.5 System Verification Checklists (SVC) / Manufacturers' Checklists

- The MC will provide SVC's based on manufacturers start-up procedures. These tests should be provided for all systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS*. Draft copies will be submitted to the CT for review and comment prior to placement on the job site. A master copy of the SVC's will be bound in a three-ring binder and placed on the job site for use by the installing contractors. No system will be started until the appropriate SVC's have been completed.
- The CA will review the SVC for each piece of equipment prior to start-up. Equipment will be released for start-up only after these checklists have been completed by the installing contractor and reviewed by the CA.
- The equipment manufacturers' checklists must also be reviewed by the CA prior to start-up. These lists must be completed by the installing contractor and reviewed by the CA before start-up can commence.

### 3.3.6 Start-Up

- Start-up of major HVAC systems will be witnessed the CA. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate SVC's have been completed. No system will be started until the Manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The CA will visit the site to review completeness of installation in conjunction with progress meetings prior to starting HVAC equipment.
- CT members involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the BoD.

### 3.3.7 Controls Monitoring

- Close monitoring of the Control Contractor's progress will promote efficient coordination of the TAB work. The CC will be expected to submit point-to-point checklists verifying that his work has been completed and all systems are ready for TAB work and Functional Performance Testing. Programming and graphics will be surveyed by the CA for completeness and conformance with the BoD and the owner's scheduling requirements.

### 3.3.8 TAB Monitoring

- The preliminary TAB report set-up will be reviewed prior to HVAC equipment start-up, in order to assure that the final TAB report format and content is acceptable.
- TAB work will be monitored so that any problems that prevent or hinder proper air and water balance can be addressed and corrected with minimal delays. By addressing these problems as quickly as possible, we can assure that functional performance testing and owner training will take place on schedule.

- A pencil copy of the TAB report will be reviewed prior to submission of the final TAB report. A written review will be submitted to the TAB contractor and to the DT for their comments. A TAB report approved by the DT will be required before Functional Performance Testing can be carried out. The CA will visit the site during the TAB process in order to assist TABC and CC in the effective completion of their scope of work.

### 3.3.9 Functional Performance Tests (FPT)

3.3.9.1 The CA will write FPT's based on the respective sequence of operations. These tests will be created for systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS* above.

3.3.9.2 Each major system will be tested. A random sample of each subsystem will be tested. This will be coordinated and witnessed by the CA and the owner's maintenance staff. Witnessing the FPT's will serve as a compliment to the O&M Training. No FPT's will be performed until the system and related subsystems have been started, the TAB report has been submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.

3.3.9.3 The Functional Performance Tests shall include HVAC and related equipment.

- The outside air unit will be tested in designed operating modes. Proper operation will be verified at minimum OA, maximum OA, automatic control, and other modes, if necessary, to achieve BOD conformance.
- Variable Air Volume terminals without reheats will be tested at minimum and maximum temperature set points, and under automatic control. Intermediate settings will be tested as necessary.
- Hydronic 4-pipe chilled/hot water system will be tested in designed operating modes. Proper operation will be verified at minimum loads, maximum loads, waterside economizing mode, Manual control, automatic control, and other modes.
- Water to water heat pump units will be tested under relevant operating conditions.
- The fan coil units will be tested under relevant operating conditions.
- EF's will be tested for conformance to BoD.
- Hydronic pumps will be tested under relevant operating conditions.
- DDC control systems will be tested as necessary.
- HVAC systems will be tested to assure that the building as an integrated system operates properly.
- Trend verification of systems and subsystems shall be completed prior to start of functional performance testing. CA will provide trend format to CC and discuss trend requirements in CX meetings throughout the construction phase of project.

3.3.9.4 Deferred Testing

- If tests cannot be completed because of a deficiency outside the scope of the responsible contractor, the deficiencies shall be documented and reported to the Owner. Deficiencies shall be resolved and corrected by the appropriate parties and test rescheduled.
- Off-season mode testing will be implemented as necessary to assure conformance with the BoD. Installing contractors will be expected to participate as required by the project specifications.

#### 3.3.9.5 Rescheduled Functional Performance Test

- During Functional Performance Testing period, it is assumed that the contractors will be complete with all checklists when the commissioning agents travel to site. If the work is not ready for commissioning when the commissioning personnel are on site, their time will be billed to the contractor as an additional fee.
- If the contractor has deficiencies that cannot be corrected at the time of the test, that part of the sequence will be retested at a later date. If the deficiency does not pass during the retest, the contractor will be billed for the commissioning personnel's return trip.

#### 3.3.9.6 Building Turn-Over / Owner Orientation / User Training

- The CA will oversee contractors prepare, coordinate and review O&M manuals, working closely with each contractor to achieve specificity and completeness.
- The CA will review as-built drawings, working closely with each contractor to achieve specificity and completeness.
- Owner training will be coordinated with the assistance of the CA. The training will be provided by the installing contractor, or manufacturer's representative, and witnessed by the CA. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The CA will visit the site during the Turn-Over and Training period to assure that any on-going HVAC related problems are being addressed and corrected in a timely and efficient manner.
- The CA will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

### 3.4 RESPONSIBILITIES OF TEAM MEMBERS

#### 3.4.1 General Contractor (GC)

- Include commissioning requirements in the mechanical, electrical, and controls contracts, as well as other subcontracts, to assure full cooperation of all parties in the HVAC commissioning process.
- Assure acceptable representation, with the means and authority to prepare and coordinate execution of the mechanical commissioning program as described in the contract documents.
- Assure that the CA shall receive a copy of all construction documents, addenda, change orders and appropriate approved submittals and shop drawings for review and use in development of the commissioning plan.
- Coordinate inclusion of commissioning activities in the construction schedule.
- Facilitate resolution of deficiencies identified by observation or performance testing.
- Involve CA in selection of the air balancing contractor.
- Assist the CA in monitoring the duct leakage testing.

#### 3.4.2 Mechanical Contractor (MC)

- Each contractor in this division shall include in their quote the cost of participating in the commissioning process.

- Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.
- Assure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, water treatment, temperature controls, and TAB in commissioning activities.
- Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.
- Attend commissioning meetings scheduled by the CA.
- Assist the CA in system verification and performance testing.
- Prepare preliminary schedule for HVAC system inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, system verification, performance testing, and system completion for use by the CA. Update schedule as appropriate throughout the construction period.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Notify the CA a minimum of two weeks in advance of scheduled system start-up.
- Update drawings to as-built condition and review with the CA throughout the construction process.
- Schedule vendor and subcontractor provided training sessions as required by project specifications.
- Provide written notification that the following work has been completed in accordance with the project documents and that the equipment, systems and sub-systems are operating in accordance with design intent.
  - HVAC equipment including fans, air handling units, dehumidification units, ductwork, dampers, terminal devices, etc.
  - Fire detection and smoke detection devices furnished under other divisions as they affect the operation of the HVAC systems.
  - That BAS is functioning in accordance with design intent.
- Participate in the Functional Performance Tests.
- Participate in the off-season mode testing.
- Participate in O&M Training as required by project specifications.
- Provide a complete set of as-built drawings and O & M manuals for review. The CA shall review the as-built drawings and O&M manuals concurrently with the design team.

#### 3.4.3 Test and Balance Contractor (TABC)

- Include cost for commissioning requirements (participation) in the contract price.
- Attend commissioning meetings scheduled by the CA.
- Submit the TAB procedures and preliminary TAB report to the CA for review at least two weeks prior to beginning TAB work.
- Notify the CA a minimum of two weeks in advance of scheduled TAB work.
- Provide partial, preliminary TAB Reports by phase, by building section, by system, or as required by the CA.
- Assist the CA in system verification and performance testing.

- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CA for verification or diagnostic purposes.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Provide sound and vibration where required to assist in diagnosis of areas exhibiting unacceptable levels of noise or vibration.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications.

#### 3.4.4 Temperature Control Contractor (TCC)

- Include cost for commissioning requirements in the contract price.
- Review control sequence and component selection for conformance with design intent.
  - Attend a submittal review meeting with the CA and Engineer to ensure clear understanding of scope of work and expectations.
  - Verify that specified safeties and interlocks have been selected.
  - Verify proper selection of control valves and actuators based on design parameters.
  - Verify proper selection of control dampers and actuators based on design parameters.
  - Verify that sensor selection conforms to design intent.
- Attend commissioning meetings scheduled by the CA.
- Provide the following submittals to the CA:
  - Hardware and software submittals.
  - Control panel construction shop drawings.
  - Narrative description of control sequences for each HVAC system and subsystem.
  - Schematics showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access.
  - A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
  - A complete listing of all software routines employed in operating the control system. Also provide a program narrative that describes the logic flow of the software and the functions of each routine and sub-routine. The narrative should also explain individual math or logic operations that are not clear from reading the software listing.
  - Hardware operation and maintenance manuals.
  - Application software and project applications code manuals.
  - Panel and equipment insert documents.
  - Assist CA with remote monitoring capabilities. Supply any software and/or hardware needed.
- Verify that specified interfaces provided by others are compatible with BAS hardware and software.
- Coordinate installation and programming of BAS with construction and commissioning schedules.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
- Provide control system technician to assist during equipment startup.

- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Participate in the Functional Performance Tests as required by the project specifications.
- Provide a control system technician to assist during verification and performance testing.
- Provide system modifications to achieve system operation as defined by the design intent.
- Provide support and coordination for TAB contractor. Provide all devices, such as portable operator terminals and all software for the TAB to use in completing TAB procedures.
- Provide written notification that the TCC scope of work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent, and that BAS is functioning in accordance with design intent.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications. Include training on hardware operations and programming

END OF SECTION.

SECTION 230995 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 – GENERAL:

- 1.1 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 The Engineer, or authorized representative, shall be notified by the Contractor two weeks in advance of any tests called for in these Specifications or required by others.
- 1.3 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.

PART 2 – PIPING TESTS:

- 2.1 Piping shall be tested 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.
- 2.2 Water piping systems shall be subjected to a hydrostatic test of one hundred fifty pounds. The system shall be proven tight after a twenty-four (24) hour test.
- 2.3 Thermometers and gauges shall be checked for accuracy. If instruments prove defective, they shall be replaced.
- 2.4 Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

PART 3 - HEATING, VENTILATING AND AIR CONDITIONING TESTING:

- 3.1 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. The Test and Balance contractor shall report all deficiencies to the Engineer.
- 3.2 Mechanical Contractor shall provide all start-up documents to Test and Balance Contractor prior to any test and balance services.
- 3.3 The Mechanical 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 of not less than one hundred pounds and shall be proven tight after a twenty-four (24) hour test.
- 3.4 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.
- 3.5 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.
- 3.6 All fan belts shall be adjusted for proper operation of fans.
- 3.7 Testing shall occur after completion of installing the ceiling systems.
- 3.8 All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.
- 3.9 Refer to Specification Section HVAC PIPING and Specification Section DIRECT DIGITAL for additional requirements.
- 3.10 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 hand written. Any systems that are not found to operate within the design tolerances by the Test and Balance Contractor shall be 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.
- 3.11 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.
- 3.12 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.
- 3.13 The following systems shall be tested and balanced:
- The supply, return, outside and exhaust air duct systems associated with all OA units and fan coil units. Provide static pressure profiles thru each system. Static pressure profiles shall include all sections from the return duct inlet and supply duct outlet of the fan coil unit and air handling units. Show accurate representation of return, relief, outdoor and economizer damper locations. On units equipped with exhaust air fans; show location and profile of the exhaust fan.
  - Outside and exhaust air in each room to within 5% of design air flow rate.
  - Relative/resultant relief air for each grille.
  - Terminal unit total air flow and discharge and inlet pressures.

- Determine and record air source heat pump exchanger pressure loss and compare to submittal data to verify flow exceeds minimum.
  - Hydronic and domestic pumps total water flow.
  - Balance heat pump chiller loops, circulating pumps and associated coil air flows.
  - Verify calibrations of the duct static pressure and water pressure sensors for all systems.
  - Balance each fan coil unit and adjust ECM motor to design airflow. Record inlet and outlet static pressure, including filters. Measure outside air flow at each heat pump and space.
  - Balance all supply and return air grilles to within 5% of design air flow rate.
  - Balance all exhaust air and ventilation fans and record inlet static pressure.
- 3.14 The flushing and purging of the system shall be witnessed and approved. Refer to Specification Section HVAC WATER TREATMENT, CLEANING FILLING, AND PURGING for additional requirements.
- 3.15 Balance the water flow rate of each domestic hot water recirculating pump. Set the flow rate for each balancing valve in the recirculating hot water system. If flow rates are not indicated, contact the engineer for each balance valve GPM.
- 3.16 Determine and record water flow rate of each geothermal circulating pump. Estimate flows based on pump curves and pressure loss.
- 3.17 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.
- 3.18 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.
- 3.19 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.
- 3.20 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.
- 3.21 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.
- 3.22 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.

SECTION 232200 – HVAC PIPING

PART 1 – GENERAL:

- 1.1 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 Each Contractor's attention is also directed to Specification Section HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT.
- 1.3 Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified.
- 1.4 Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.
- 1.5 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.
- 1.6 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.
- 1.7 All piping shall be installed straight and true, parallel or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.
- 1.8 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants. Reference 230529 for additional piping support requirements.
- 1.9 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation. Refer to Specification Section HVAC INSULATION, EQUIPMENT, DUCTWORK AND PIPING.

- 1.10 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.
- 1.11 In metal buildings or buildings with light gauge trusses, support piping with standard pipe hangers with C-clamp connection to main structural members (not perlines), use angle steel cross pieces between main structural members where required to provide rigid support.
- 1.12 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.
- 1.13 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.
- 1.14 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to insure that no foreign matter is lodged therein.
- 1.15 All hot and cold water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.
- 1.16 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.
- 1.17 Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.
- 1.18 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.
- 1.19 Dielectric unions shall be provided at all connections of dissimilar materials.
- 1.20 Nipples shall be of the same material, composition and weight classification as pipe with which installed.

- 1.21 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.
- 1.22 Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings shall not be permitted.
- 1.23 High points of closed loop chilled / hot water (4-pipe system) and geothermal systems shall have manual air vents as required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.
- 1.24 Installation of pipe shall be in such a manner as to provide complete drainage of the system toward the source. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with ¾" hose thread end and vacuum breaker. Label each drain valve.
- 1.25 Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted.
- 1.26 Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.
- 1.27 When running any type of pipe below a footing, perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with concrete. The zone of influence is the area within a 45 degree angle projecting down from the top edge of footing on all sides of the footing.
- 1.28 When running any type of pipe below a footing, parallel to the footing, the area underneath the zone of influence shall be backfilled with 4" of crushed stone or sand bedding under the pipe. Each pipe section shall be anchored into unexcavated earth on both ends with deadman anchor system. The remainder of the trench in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the top edge of the footing on all sides of the footing.
- 1.29 Piping for all drainage systems shall be installed to permit flow, trapping, and venting in accord with current codes and best practice.
- 1.30 The domestic hot and cold-water piping system shall be sterilized in strict accord with requirements of the Department of Health Codes, Rules and Regulations for the State in which the work is being accomplished.
- 1.31 When connecting to the hydronic water system (chilled / hot, geothermal, etc.), the Contractor shall include cost to drain the piping system and refill with water/closed loop chemicals. 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. Refer to Specification Section HVAC WATER TREATMENT, CLEANING, FILLING, AND PURGING.

## PART 2 – UNIONS, FLANGES AND WELDED TEES:

- 2.1 Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.
- 2.2 Dielectric insulating unions or couplings shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.
- 2.3 Tee connections for welded pipe shall be assembled with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller.
- 2.4 Weld-o-let, thread-o-let and T-drill branch connections are acceptable.

## PART 3 – SPECIFICATIONS STANDARDS:

- 3.1 All piping and material shall be new, made in the United States and shall conform to the following minimum applicable standards:
  - Steel pipe; ASTM A-53.
  - Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.
  - Welding fittings; ASA B16.9.
  - Cast brass and wrought copper fittings; ASA B16.18.
  - Cast brass drainage fittings; ASA B16.23.

## PART 4 – PITCH OF PIPING:

- 4.1 All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:
- 4.2 Condensate Drain Lines From Cooling Equipment: Not less than ¼" per foot in direction of flow.
- 4.3 All Other Lines: Provide ample pitch to a low point to allow 100 percent drainage of the system.

## PART 5 – HVAC PIPING APPLICATIONS

- 5.1 HVAC Hydronic Piping:
  - 5.1.1 System Types:
    - Chilled/Hot Water (4-pipe)
    - Condensate Piping

- 5.2 Chilled/Hot Water (4-pipe Hydronic Loop) Piping:
  - 5.2.1 2" and Smaller: Type "L" hard copper tubing with wrought copper fittings and 95/5 solder. "ProPress" or equivalent pipe/fitting system is acceptable for piping 3" and smaller. All vertical risers concealed in a shaft shall be soldered joints.
  - 5.2.2 2½" and Larger: Schedule 40 black steel pipe with 125# welded or flanged joints. Weldolets may be used for branch line connections to pipe mains. Type "L" hard copper piping with wrought copper fittings and 95/5 solder may be installed.
- 5.3 Air Vent Discharge Lines: Type "L" soft copper; wrought copper fittings, 95/5 solder. Pipe to a suitable drainage location.
- 5.4 Condensate Drain Lines: Type "M" copper tubing with sweat fittings and 95/5 solder.
- 5.5 Refrigerant Piping: Type "ACR" copper tubing with forged or wrought copper fittings and silver soldered joints. Solder must have a minimum of 15% silver content.
- 5.6 At the Contractor's option the following shall be permitted:
  - 5.6.1 2½" and Larger: Schedule 40 Victaulic 107/W07 or approved mechanical grooved pipe couplings and fittings with a minimum 125# rating. Install gaskets as recommended by the manufacturer. Piping system shall be rated for minimum of 250 degrees F water temperature. Mechanical grooved piping may not be used if system water temperature exceeds 250°F. All grooved components must be of one manufacturer. All vertical risers concealed in a shaft shall be welded.

END OF SECTION.

SECTION 232500 – HVAC WATER TREATMENT, CLEANING FILLING, AND PURGING

PART 1 – GENERAL:

- 1.1 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 Review the Specification Section – REQUIRED SHOP DRAWINGS, ETC. List and provide all documentations called for therein.
- 1.3 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected.
- 1.4 Provide a water treatment program for the closed loop piping systems. It is the Contractor's responsibility to contact the engineer 2 weeks in advance to any treatments performed on the systems. It is the Engineer's discretion whether or not this process should be monitored after notification.
- 1.5 A pre-installation meeting shall be held with the Owner, Architect, Engineer, General Contractor, Mechanical Contractor, Pipe Fitter Foreman, Geothermal Contractor and Chemical Treatment Contractor to discuss goals and expectations for cleaning, flushing, purging and chemical treatment.
- 1.6 Chemicals, equipment, testing services, and chemical application shall be supplied by a single water treatment company for undivided responsibility. The water treatment company shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years. The water treatment company shall have regional water analysis laboratories, service department, and full-time representatives located within the trading area of the job site or facility.
- 1.7 Furnish initial supply of the closed loop chemicals for each system. This contractor shall retest the systems after 3, 6 and 12 months to verify the proper dosage is in each system. Provide all closed loop chemicals and anti-freeze for the first year. Each system's water shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition. Provide any laboratory and technical assistance required to achieve a successful program.
- 1.8 As a condition of acceptance and project closeout, a summary of water quality and treatment shall be provided in writing to the Owner and/or Engineer after the water treatment services have been completed. The closeout documentation shall include dates for warranty testing.

- 1.9 Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- 1.10 Water Quality Minimum Performance Requirements:
- Closed hydronic systems shall maintain a pH value within 9 – 10.5.
  - Total Aerobic Plate Count - Maintain a maximum value of 1000 organisms/ml.
  - Total Anaerobic Plate Count - Maintain a maximum value of 100 organisms/ml.
  - Nitrate Reducers - Maintain a maximum value of 100 organisms/ml.
  - Sulfate reducers - Maintain a maximum value of 0 organisms/ml.
  - Iron Bacteria - Maintain a maximum value of 0 organisms/ml.

## PART 2 – CLEANING AND FLUSHING OF HYDRONIC PIPING:

- 2.1 This project consists of the following Hydronic Piping Loops:
- Chilled/Hot Water (4-pipe) Hydronic System W/ glycol
- 2.2 There are several precautions which must be observed during its installation. This contractor is advised to read all of the manufacturer's instructions prior to commencing the installation. This cleaning and flushing of the systems must be accomplished. Refer to Specification Section HVAC EQUIPMENT for geothermal system requirements.
- 2.3 All water circulating systems for the project shall be thoroughly cleaned before placing in operation to rid the system of dirt, piping compound, mill scale, oil and any and all other material foreign to the water. During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.
- 2.4 After each piping system is complete: (1) the Contractor shall first fill the piping loops and all runouts with clear water. The loop water shall be circulated for one hour with make-up water open and central drains open to accomplish initial flushing of the system. (2) After initial flushing, the individual terminal devices and coils may be connected permanently to the supply and return runouts conditions and then add trisodium phosphate in an aqueous solution to the system at the proportion of one pound per fifty gallons of water in the system. (4) After the system is filled with this solution, the system water shall be brought up to 95 degrees F temperature and allowed to circulate for two hours. (Equipment to be bypassed.) (5) The Chemical Treatment Contractor shall be given notice by the Contractor of scheduling this cleaning and, if the Engineer's representative deems it necessary, the operation shall be repeated. (6) After the system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable method and shall be left on the slightly alkaline side

(PH = 7.5 plus or minus). (7) If the system is found to be still on the acid side, the cleaning by use of Trisodium Phosphate shall be repeated. (8) After achieving required pH, close bypasses and circulate through equipment. (9) After the cleaning and flushing is complete, and approved, the Contractor shall provide the proper water treatment for the system.

PART 3 – CLOSED LOOP CHEMICAL TREATMENT:

- 3.1 Provide a 5-gallon pot feeder for each system and 3/4" valved and capped port for injection of the closed loop chemicals into the system. The pot feeder shall be provided with filters.
- 3.2 Provide a glycol fill tank on the sub cooling chilled water loop. Refer to the schedules for details. Provide 30% propylene glycol with rust inhibitors in the glycol water loop. The Contractor shall determine the appropriate chemical volumes for each system.
- 3.3 After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil, and any and all other material foreign to the water as previously specified.
- 3.4 Before chemical cleaning and sterilization of the entire system, the field and hydronic loop and mains shall be individually flushed and purged until free of dirt, debris, and air. During the flushing/purging and chemical cleaning processes the supply and return run-outs shall be temporarily placed in bypass operation. See SYSTEM FILLING & PURGING PLAN for additional information.
- 3.5 After chemical cleaning, the entire system shall be sterilized with a biocide added at recommended dosage to effectively kill any present microorganisms. Add glutaraldehyde to achieve 60 – 200 ppm of active ingredient or isothiazoline to achieve 10 – 13 ppm active. Do not flush biocide from system. Corrosion inhibitors shall be installed in closed loop systems containing metal piping, fittings, accessories, etc.
- 3.6 A bacteria analysis shall be performed to ascertain biological cleanliness of system. If bacteria counts are above set parameters, then sterilization process shall be repeated until bacteria counts are at or below acceptable levels. Microbiological limits are listed under "Water Quality Minimum Performance Requirements" elsewhere in this Specification Section.
- 3.7 Within 48 hours of the completion of the sterilization implement a water treatment program to passivate all metal surfaces.

END OF SECTION.

## SECTION 233200 - SHEET METAL

### PART 1 – GENERAL:

- 1.1 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 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.
- 1.3 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.
- 1.4 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.
- 1.5 Provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards.

### PART 2 – LOW VELOCITY DUCTWORK:

- 2.1 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. Utilize Aluminum in MRI Scan Rooms.
- 2.2 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 and per the following table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum. Penetrations through fire rated walls/floors require heavier gauges to meet UL listed penetrations.

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.

- 2.3 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. Contractors shall insure no exposed sharp edges or burrs on ductwork.
- 2.4 Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.
- 2.5 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.
- 2.6 Cross-break all ducts where either cross sectional dimension is 18" or larger.
- 2.7 Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. 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.
- 2.8 Double turning vanes shall be installed in square turns and/or where indicated.
- 2.9 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.
- 2.10 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.
- 2.11 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.
- 2.12 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.

- 2.13 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.
- 2.14 All fans and other vibrating equipment shall be suspended by independent vibration isolators.
- 2.15 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.
- 2.16 Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated floors and walls. Fire stop rating shall meet or exceed the rating of the floor and 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 floor penetrations are fire rated). All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.
- 2.17 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.
- 2.18 Insulated Flexible Air Duct: Thermaflex G-KM or equal. Flexible air duct shall be one (1) 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.
- 2.19 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.
- 2.20 Turning Vanes: Fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.
- 2.21 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.

- 2.22 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 galvanized 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 insure a complete project.
- 2.23 Volume Dampers (Rectangular): Ruskin MD35 or Air Balance, Pottorff, rectangular volume dampers. Frames shall be 18 gauge galvanized steel. Blades shall be opposed blade 18 gauge galvanized steel with triple crimped blades on 6" centers. Linkage shall be concealed in jamb. Bearings shall be 1/2" nylon. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 1" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point. Security Architectural Access Doors in Ceilings or Walls: Provide Kees SSAP Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 12 gauge steel for door and frame. Provide with primer finish to accept specified finish. Door shall include key-operated cylinder dead bolt lock (coordinate cylinders and keys with Owner to match facility standards) and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors and straps. 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 insure a complete project.
- 2.24 Volume Dampers (Round): Ruskin MDR525 or Air Balance, Pottorff round volume dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 22 gauge steel and 5" long. Damper blades shall be 20 gauge crimped galvanized steel. Axle shall be 3/8"x5" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabrics 1" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

### PART 3 – OUTSIDE AIR AND EXHAUST DUCTWORK:

- 3.1 Low pressure/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 branch. Straight tees are not allowed.
- 3.2 All round 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.
- 3.3 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
3-14 Inches	24 Ga.
15-26 Inches	22 Ga.

- 3.4 Duct fittings shall be constructed per the latest SMACNA 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
3-14 Inches	22 Ga.
15-26 Inches	20 Ga.

- 3.5 Duct dimensions indicated are required inside clear dimensions.
- 3.6 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.
- 3.7 Ductwork shall be installed per the latest SMACNA Manuals, whichever is applicable. Note duct penetrations through UL listed assemblies may require heavier gauges.
- 3.8 All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA.
- 3.9 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.
- 3.10 Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated floors and 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.
- 3.11 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.

- 3.12 Pressure Relief Doors: Provide a pressure relief door in the supply air ductwork at each air handling unit. 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.
- 3.13 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 galvanized 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 insure a complete project.
- 3.14 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. Security Architectural Access Doors in Ceilings or Walls: Provide Kees SSAP Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 12 gauge steel for door and frame. Provide with primer finish to accept specified finish. Door shall include key-operated cylinder dead bolt lock (coordinate cylinders and keys with Owner to match facility standards) and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors and straps. 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 insure a complete project. Access door sizes shall be as follows:

DUCT DIAMETER	OPENING SIZE
3-4 inches	4"x10"
5-6 inches	6"x10"
7-24 inches	10"x16"
26-36 inches	16"x16"
Over 36 inches	16"x22"

PART 4 – EXPOSED ROUND DUCTWORK IN OCCUPIABLE AREAS:

- 4.1 Ductwork which is exposed to view (through ceiling system, Rulon, etc) shall be provided as required for painting and carefully routed to minimize visual impact.

- 4.2 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.
- 4.3 Furnish and install double wall round supply duct in the large meeting room. 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. Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard.
- 4.4 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. Ductwork will be field painted, color as selected by architectural schemes. Coordinate with General Contractor. Ductwork shall be constructed as specified in LOW VELOCITY DUCTWORK.
- 4.5 DOUBLE WALL CONSTRUCTION:
- 4.5.1 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.
- 4.5.2 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.
- 4.5.3 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.
- 4.5.4 All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1.5 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.
- 4.5.5 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.

#### PART 5 – AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS:

- 5.1 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.

- 5.2 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.
- 5.3 The entire outside and exhaust air ductwork system shall be tested with some exceptions. On the outside air systems, the ductwork upstream of the VAV boxes shall be tested. Cap the duct at the inlet to the VAV box.
- 5.4 All exhaust air sheet metal ductwork associated with the outside 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.
- 5.5 A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the Owner, Design Team, 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.
- 5.6 It is the intent to test ductwork systems to minimize leakage. The duct systems which will require testing are as follows:
- All outside supply air duct systems.
  - All exhaust air duct systems.
- 5.7 Do not insulate the supply air systems prior to testing.
- 5.8 The maximum allowable supply air leakage rate for the outside air system is 9 CFM per 100SF of duct of the systems design CFM when the ductwork is pressurized to 1.75" WG. The outside air unit supply air fan rated capacity is 3,500 CFM, the allowable leakage is 175 CFM (5%). The maximum allowable return air and exhaust air leakage rate is also 5% of the system design when the ductwork is pressurized to 1.0" WG.
- 5.9 The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
- All ductwork as described in above paragraphs.
  - Access doors
  - Volume dampers
  - Relief air doors
  - End caps used to seal ducts
- 5.10 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 allowment at no additional cost to the Owner.

END OF SECTION.

## SECTION 233700 - HVAC EQUIPMENT

### PART 1 – GENERAL:

#### 1.1 RELATED SECTIONS:

- 1.1.1 Division 01 Section “Enhanced Transition To Operations (eTOP)” for administrative and procedural requirements associated with generating record information to be included in COBie2 worksheet.
- 1.2 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.
- 1.3 The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed with disconnect per NEC, 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.
- 1.4 All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for special warranty requirements.
- 1.5 Refer to Specification Section COMMON WORK RESULTS FOR HVAC for minimum required Schedule of Values breakdown.
- 1.6 Review the Specification Section – SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS., and provide all documentations called for therein.
- 1.7 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer’s Checklists. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements. 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. This shall include the following:
- Air Source Heat Pump Chillers
  - Outside Air Units
  - Fan Coil Units
  - Terminal Units
  - Variable Frequency Drives
  - Pumps
  - Water Flow Meters/BTUH Meters

- 1.8 All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.
- 1.9 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. Coordinate disconnect means with Division 26. All equipment shall include factory disconnects as standard manufacturer offering, otherwise, coordinate with Division 26 and provide disconnect meeting the requirements of the National Electrical Code.
- 1.10 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.
- 1.11 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, wired, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section – COMMON MOTOR ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT for additional requirements. All equipment shall be furnished for a single point electrical connection along with factory or integral disconnect switch unless specifically indicated otherwise. Field disconnects maybe acceptable, upon coordination with Division 26, and accepted by owner and engineer.
- 1.12 Review the Specification Section – TEMPERATURE CONTROLS AND SEQUENCE OF OPERATIONS 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.
- 1.13 Review the 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.
- 1.14 SUBMITTALS
  - 1.14.1 Submit unit performance data including: capacity, nominal and operating performance.
  - 1.14.2 Submit Mechanical Specifications for unit and accessories describing construction, components and options.
  - 1.14.3 Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
  - 1.14.4 Submit data on electrical requirements, disconnects, and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

1.14.5 Submit operation and maintenance data including manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data to include parts list and wiring diagrams.

#### 1.15 DELIVERY, STORAGE AND HANDLING

1.15.1 Deliver, store, protect, and handle products per manufacturer's recommendations.

1.15.2 Comply with manufacturers installation instructions for rigging, unloading and transporting units.

1.15.3 Protect unit from physical damage. Leave factory shipping covers in place until installation.

### PART 2 – PRODUCTS

#### 2.1 OUTSIDE AIR UNITS (INDOOR TYPE):

2.1.1 MANUFACTURERS: Daikin (basis of design), Carrier, and Trane. Other manufacturers require pre-approval and will only be accepted via Procurement Substitution Requests or Substitution for Cause.

2.1.2 Provide factory built and factory tested air handling units of sizes, capacities and configurations as scheduled and as specified herein. Unit layout shall be dual path, providing one path for outside air with all components arranged in series as specified and providing one path for exhaust air with all components arranged in series as specified.

2.1.3 Provide factory installed external support kit on the base of the unit. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust-inhibiting primer and finished with rust inhibiting enamel.

#### 2.1.4 UNIT CASING

- Unit manufacturer shall ship unit in segments as specified by the contractor for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.
- Casing performance - Casing air leakage shall not exceed leak class 6 (CL = 6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft<sup>2</sup> of casing surface area) = CL X P<sup>0.65</sup>.
- Air leakage shall be determined at 1.00 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

- Under 55°F supply air temperature and design conditions on the exterior of the unit of 95°F dry bulb and 76°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.
- Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8-inch w.g., whichever is less, and shall not exceed 0.0042 per inch of panel span (L/240).
- Floor panels shall be double-wall construction and designed to support a 250-lb load during maintenance activities and shall deflect no more than 0.0042 per inch of panel span.
- Unit casing panels shall be 2-inch double-wall construction, with solid galvanized exterior and solid galvanized interior, to facilitate cleaning of unit interior.
- Unit casing panels (roof, walls, floor) and doors shall be provided with a minimum thermal resistance (R-value) of 13 Hr\*Ft<sup>2</sup>\*°F/BTU.
- Unit casing panels (roof, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.
- Casing panel inner liners must not extend to the exterior of the unit or contact the exterior frame. A mid-span, no-through-metal, internal thermal break shall be provided for all unit casing panels.
- Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.
- Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.

#### 2.1.5 ACCESS DOORS:

- Access doors shall be 2-inch double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.
- All doors downstream of the cooling coil shall be provided with a thermal break construction of door panel and door frame.
- Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.
- Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.
- Handle hardware shall be designed to prevent unintended closure.
- Access doors shall be hinged and removable without the use of specialized tools to allow.
- Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions.
- Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.
- All doors shall be a 60-inch high when sufficient unit height is available, or the maximum

height allowed by the unit height.

- Multiple door handles shall be provided for each latching point of the door necessary to maintain the specified air leakage integrity of the unit.

#### 2.1.6 FAN SECTIONS:

- Fan sections shall have a minimum of one hinged and latched access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section 2.04.
- Provide fans of type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans that are selected with inverter balancing shall first be dynamically balanced at design RPM. The fans then will be checked in the factory from 25% to 100% of design RPM to insure they are operating within vibration tolerance specifications, and that there are no resonant frequency issues throughout this operating range. Inverter balancing that requires lockout frequencies inputted into a variable frequency drive to in order to bypass resonant frequencies shall not be acceptable. If supplied in this manner by the unit manufacturer, the contractor will be responsible for rebalancing in the field after unit installation. Fans selected with inverter balancing shall have a maintenance free, circumferential conductive micro fiber shaft grounding ring installed on the fan motor to discharge shaft currents to ground.
- All fans, including direct drive plenum fans, shall be mounted on isolation bases. Internally-mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with 2 inch spring isolators. A flexible connection shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the installing contractor in order to avoid transmission of noise and vibration through the ductwork and building structure.

#### 2.1.7 MOTORS AND DRIVES:

- All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly.
- Motors shall meet or exceed all NEMA Standards Publication MG 1 - 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.
- Fan Motors shall be heavy duty, open drip-proof operable at 208 volts, 60Hz, 3-phase. Motor efficiency shall meet or exceed NEMA Premium efficiencies.

- Direct driven fans shall use 2-pole (3600 rpm), 4-pole (1800 rpm) or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation capable to operate continuously at 104 deg F (40 deg C) without tripping overloads.
- Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.
- Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in start up and service personnel in maintenance a. Fan and motor sheave part number b. Fan and motor bushing part number c. Fan design RPM and motor HP.
- Motors that are provided with integral variable frequency drives shall remote reset contacts tied directly to the BAS.

2.1.8 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 EPACK efficiency requirements. Refer to Specification Section – 230513 – COMMON MOTOR ELECTRICAL REQUIREMENTS 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. Equipment with integrated VFDs shall be provided with wired remote reset. All VFDs and integrated drives shall communicate with Siemens BAS.

2.1.9 COIL SECTIONS AND DRAIN PANS:

- 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 assure 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.
- Coils section header end panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.
- Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.
- Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
- Construct coil casings of stainless steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
- All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.
- All cooling coil sections shall be provided with an insulated, double-wall, stainless steel drain pan.

- The drain pan shall be designed in accordance with ASHRAE 62.1 being of sufficient size to collect all condensation produced from the coil and sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when unit is installed level and trapped per manufacturer's requirements. See section 2.07, paragraph F through H for specifications on intermediate drain pans between cooling coils.
  - The outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.
  - All drain pan threaded connections shall be visible external to the unit. Threaded connections under the unit floor shall not be accepted.
  - Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2-inch beyond the base to ensure adequate room for field piping of condensate traps.
  - The installing contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.
  - Coil support members inside the drain pan shall be of the same material as the drain pan and coil casing.
- 2.1.10 DAMPERS: Provide internally mounted ultra low leak outside air dampers. Provide return air damper section for full airflow during recirculating mode. 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.
- 2.1.11 FACE AND BYPASS SECTION: Face and bypass section shall include chilled water coil. A horizontal blank off wall shall be factory installed to bypass coil when damper is in the bypass position.
- 2.1.12 ENERGY RECOVERY SECTION: Manufacturers: Thyvent, Fresh Air Solutions, Semco, Novellaire, XETEX. Energy Recovery Modules shall be installed in casing structure to match the OA unit construction throughout. A removable panel shall be provided to access the energy recovery cassette for service and inspection. Energy recovery wheel shall be mounted in a slide out cassette. A wiring box shall be provided for permanent connection of a power source. The Energy Recovery Cassette shall contain a 4 Angstrom total energy recovery wheel for sensible and latent energy recovery. A wheel drive motor having permanently sealed ball bearings shall be provided with plug-in connection to a receptacle mounted within the cabinet. Provide the ERW with a factory installed starter/disconnect. The total enthalpy wheel shall be supplied by the module manufacturer and be constructed of a light weight polymer material with a permanently bonded silica gel desiccant coating. Eight energy transfer sections shall be removable from the energy recovery wheel without the use of special tools. The units shall not require a condensation pan. Energy transfer ratings must be ARI Certified to Standard 1060 and bear the ARI certification symbol for ARI Air-to-Air Energy Recovery Ventilation Equipment Certification Program based on ARI 1060.
- 2.1.13 FILTERS: Filters shall be 4" thick, 35% efficient (min.) Merv 14, 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. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for Temporary Use of Equipment Requirements and filter quantities.

2.1.14 ELECTRICAL:

- The unit control box shall contain all necessary devices to allow heating and cooling operation to occur from a building DDC control system utilizing sensors and control components. These devices shall be as follows:
  - 75 VA transformer
  - A low voltage terminal strip is located inside the control panel behind the service access panel. This terminal strip may be used for low voltage control connections.
- Units shall include integral disconnect.

2.1.15 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section GENERAL PROVISIONS - MECHANICAL. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements.

2.1.16 Provide eight (8) hours of onsite training for this system. All training to occur after building completion. System shall function properly and O&M staff shall be able to operate the system prior to turnover.

2.2 VARIABLE AIR VOLUME TERMINAL BOXES:

2.2.1 ACCEPTABLE MANUFACTURERS: ETI, Trane, Titus, Carrier, JCI/York, Price, Nailor Industries.

2.2.2 Terminals shall be certified by ARI and bear the ARI 880 seal.

2.2.3 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. Unit shall have right or left hand access to controls and coil connections (refer to drawings). Maintain clearance as required by code and indicated on the drawings.

2.2.4 Casing shall be insulated with 1" thick fiberglass insulation, rated for a maximum air velocity of 5000 f.p.m. Maximum thermal conductivity shall be 0.24 (BTU · in) / (hr · ft<sup>2</sup> · °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.

2.2.5 Additionally, the air terminals shall be double wall insulated. The insulation shall be covered by an interior liner made of 26-gage galvanized steel. All wire penetrations shall be covered by grommets. There shall be no exposed edges of insulation (complete metal encapsulation).

2.2.6 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.

2.2.7 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.

2.2.8 ELECTRICAL:

- The unit control box shall contain all necessary devices to allow heating and cooling operation to occur from a building DDC control system utilizing sensors and control components. These devices shall be as follows:
  - 75 VA transformer
  - Units shall include integral disconnect.

2.3 CEILING CASSETTE FAN-COIL UNITS

A. Basis-of-Design Product: AIREDALE or a comparable product by one of the following:

B. Available Manufacturers:

- Airtherm; a Mestek Company.
- Carrier Corporation.

- Engineered Air Ltd.
  - Environmental Technologies, Inc.
  - First Co.
  - International Environmental Corporation.
  - Marlo Coil; Subsidiary of Engineered Support Systems, Inc.
  - Marshall Engineered Products Co., LLC (MEPCO); Dunham-Bush, Inc.
  - McQuay International.
  - Rosemex.
  - Trane.
  - USA Coil & Air.
  - YORK International Corporation.
  - MultiAqua.
- C. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
- D. Coil Section Insulation: 1-inch (25-mm) thick foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
- Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- F. Chassis: Galvanized steel where exposed to moisture.
- G. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
- Steel recessing flanges for recessing fan-coil units into ceiling or wall.
- H. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
- Washable Foam: 70 percent arrestance and 3 MERV.
  - Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
  - Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
- I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.
- J. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
- K. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
- Two-way, two-position control valve for chilled-water coil.

- Two-way, two-position control valve for heating coil.
  - Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
    - a. Length: 24 inches (600 mm)
    - b. Minimum Diameter: Equal to fan-coil-unit connection size.
  - Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
  - Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
  - Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
  - Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
  - Wrought-Copper Unions: ASME B16.22.
- L. Control devices and operational sequence are specified in Division 23 Section "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
- M. Basic Unit Controls:
- Control voltage transformer.
  - Wall-mounting thermostat with the following features.
    - a. Heat-cool-off switch.
    - b. Fan on-auto switch.
    - c. Fan-speed switch.
    - d. Automatic changeover.
    - e. Adjustable deadband.
    - f. Exposed set point.
    - g. Exposed indication.
    - h. Degree F indication.
  - Wall-mounting humidistat.
    - a. Exposed set point.
    - b. Exposed indication.
  - Wall-mounting temperature sensor.
  - Unoccupied-period-override push button.
  - Data entry and access port.
    - a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

N. **DDC Terminal Controller:**

- Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
- Unoccupied Period Override Operation: One hour.
- Unit Supply-Air Fan Operation:
  - a. Occupied Periods: Fan runs continuously.
  - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
- Hydronic-Cooling-Coil Operation:
  - a. Occupied Periods: Open control valve to maintain room temperature.
  - b. Unoccupied Periods: Close control valve.
- Heating-Coil Operation:
  - a. Occupied Periods: Open control valve to provide heating if room temperature falls below thermostat set point.
  - b. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature.
- Reheat Operation:
  - a. Humidity Control for Occupied Periods: Humidistat opens control valve to provide heating. As room temperature rises above the set point, cooling coil valve modulates to maintain room temperature.
  - b. Humidity Control for Unoccupied Periods: Close control valve.
  - c. Occupied Periods:
    - 1) Heating Operations: Open control valve to provide heating if room temperature falls below thermostat set point.
    - 2) Humidity-Control Operations: Humidistat opens control valve to provide heating. As room temperature rises above the set point, cooling coil valve modulates to maintain room temperature.
  - d. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature. Humidity control is not available.
- Controller shall have volatile-memory backup.

O. **BAS Interface Requirements:**

- Interface relay for scheduled operation.
- Interface relay to provide indication of fault at the central workstation.
- Provide BACnet interface for central BAS workstation for the following functions:
  - a. Adjust set points.
  - b. Fan-coil-unit start, stop, and operating status.
  - c. Data inquiry, including supply- and room-air temperature and humidity.
  - d. Occupied and unoccupied schedules.

P. **Electrical Connection:** Factory wire motors and controls for a single electrical connection.

## 2.4 DUCTED FAN-COIL UNITS

A. **Basis-of-Design Product:** Enviro-Tec or a comparable product by one of the following:

- B. Available Manufacturers:
- Carrier Corporation
  - Engineered Air Ltd.
  - Trane
  - First Co.
  - International Environmental Corporation.
  - Marlo Coil; Subsidiary of Engineered Support Systems, Inc.
  - Marshall Engineered Products Co., LLC (MEPCO); Dunham-Bush, Inc.
  - McQuay International.
  - Rosemex.
  - USA Coil & Air.
  - YORK International Corporation.
- C. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
- D. Coil Section Insulation: 1-inch (25-mm) thick foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
- Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- F. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.
- G. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
- Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis, aluminum.
  - Return-Air Plenum: Sheet metal plenum finished to match the chassis.
- H. Filters: MERV 13 24"x20"x4" shall be duct mounted.
- I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.
- J. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
- K. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
- Two-way, two-position control valve for chilled-water coil.
  - Two-way, two-position control valve for heating coil.

- Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
    - a. Length: 24 inches (600 mm)
    - b. Minimum Diameter: Equal to fan-coil-unit connection size.
  - Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
  - Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
  - Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
  - Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
  - Wrought-Copper Unions: ASME B16.22.
- L. Control devices and operational sequence are specified in Division 23 Section "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
- M. Basic Unit Controls:
- Control voltage transformer.
  - Wall-mounting thermostat with the following features.
    - a. Heat-cool-off switch.
    - b. Fan on-auto switch.
    - c. Fan-speed switch.
    - d. Automatic changeover.
    - e. Adjustable deadband.
    - f. Exposed set point.
    - g. Exposed indication.
    - h. Degree F indication.
  - Wall-mounting humidistat.
    - a. Exposed set point.
    - b. Exposed indication.
  - Wall-mounting temperature sensor.
  - Unoccupied-period-override push button.
  - Data entry and access port.
    - a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

N. DDC Terminal Controller:

- Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
- Unoccupied Period Override Operation: One hour.
- Unit Supply-Air Fan Operation:
  - a. Occupied Periods: Fan runs continuously.
  - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
- Hydronic-Cooling-Coil Operation:
  - a. Occupied Periods: Open control valve to maintain room temperature.
  - b. Unoccupied Periods: Close control valve.
- Heating-Coil Operation:
  - a. Occupied Periods: Open control valve to provide heating if room temperature falls below thermostat set point.
  - b. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature.
- Reheat Operation:
  - a. Humidity Control for Occupied Periods: Humidistat opens control valve to provide heating. As room temperature rises above the set point, cooling coil valve modulates to maintain room temperature.
  - b. Humidity Control for Unoccupied Periods: Close control valve.
  - c. Occupied Periods:
    - 1) Heating Operations: Open control valve to provide heating if room temperature falls below thermostat set point.
    - 2) Humidity-Control Operations: Humidistat opens control valve to provide heating. As room temperature rises above the set point, cooling coil valve modulates to maintain room temperature.
  - d. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature. Humidity control is not available.
    - Controller shall have volatile-memory backup.

O. BAS Interface Requirements:

- Interface relay for scheduled operation.
- Interface relay to provide indication of fault at the central workstation.
- Provide BACnet interface for central BAS workstation for the following functions:
  - a. Adjust set points.
  - b. Fan-coil-unit start, stop, and operating status.
  - c. Data inquiry including supply- and room-air temperature and humidity.
  - d. Occupied and unoccupied schedules.

P. Electrical Connection: Factory wire motors and controls for a single electrical connection.

Q. Characteristics:

- Filters:
  - a. Filters shall be duct mounted, 4" thick.
- Electrical Characteristics for Single-Point Connection:
  - a. Voltage/Phase/Hertz: SEE SCHEDULE

- b. Full-Load Amperes: SEE SCHEDULE
  - c. Maximum Circuit Amperes: SEE SCHEDULE
  - d. Maximum Overcurrent Protection: SEE SCHEDULE
- 2.5 Filter media installed during construction: Minimum MERV 8 (or Class F5).
- 2.6 Filter media installed prior to occupancy: Minimum MERV 13 (or Class F7).

### PART 3 – EXECUTION

#### 3.1 EXAMINATION

- 3.1.1 Verify that required utilities are available, in proper location, and ready for use.
- 3.1.2 Beginning of installation means installer accepts existing surfaces.

#### 3.2 INSTALLATION – UNITARY EQUIPMENT

- 3.2.1 Install in accordance with manufacturer's instructions.
- 3.2.2 Locate units as indicated, level and shim units, and anchor to structure.
- 3.2.3 Protect units with protective covers during balance of construction.
- 3.2.4 Provide units with shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing.
- 3.2.5 Provide all condensate piping, include trap per manufacturer's installation requirements, with condensate piping routed to the nearest floor drain.

#### 3.3 INSTALLATION - AHU/FCU

- 3.3.1 The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.
- 3.3.2 The AHU manufacturer shall provide all screws and gaskets for joining of sections in the field.
- 3.3.3 The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the AHU manufacturer's final inspection and start up:
  - All spring-isolated components have had their shipping restraints removed and the components have been leveled.
  - On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.

- All water and steam piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.
  - All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
  - All power wiring, including motor starters and disconnects, serving the unit has been completed.
  - All automatic temperature and safety controls have been completed.
  - All dampers are fully operational.
  - All shipping materials have been removed.
  - All (clean) filter media has been installed in the units.
  - Include all condensate piping, include trap per manufacturer's installation requirements, with condensate piping routed to the nearest floor drain.
  - Provide 3/4" Neoprene isolation pad under the entire base rail of the unit.
  - All ductwork connection to the AHU shall be a flared connection, a minimum of 12" wider (6" each side) and 6" higher/deeper (3" each side) utilizing 30 to 45 degree transitioning connection to the AHU.
- 3.3.4 The Mechanical Contractor shall level all unit sections in accordance with the unit manufacturer's instructions. The Mechanical Contractor shall provide and install all necessary permanent shim material to ensure individual sections and entire assembled units are level.
- 3.3.5 After the Mechanical Contractor has provided all water and steam piping connections, ductwork connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the Mechanical Contractor shall inspect the installation. The Mechanical Contractor shall then perform startup of the equipment.
- 3.3.6 The Automatic Temperature Control (Building Direct Digital Control) Contractor shall be scheduled to be at the job site at the time of the equipment start up.
- 3.3.7 The Mechanical Contractor, shall perform the following tests and services and submit a report outlining the results:
- Record date, time, and person(s) performing service.
  - Lubricate all moving parts.
  - Check all motor and starter power lugs and tighten as required.
  - Verify all electrical power connections.
  - Conduct a start up inspection per the AHU manufacturer's recommendations.
  - Record fan motor voltage and amperage readings.
  - Check fan rotation and spin wheel to verify that rotation is free and does not rub or bind.
  - Check fan for excessive vibration.
  - Check V belt drive or coupling for proper alignment.
  - Check V belt drive for proper tension. Tighten the belts in accordance with the AHU manufacturer's directions. Check belt tension during the second and seventh day's operation and re-adjust belts, as may be required, to maintain proper tension as directed by the AHU manufacturer.

- Remove all foreign loose material in ductwork leading to and from the fan and in the fan itself.
- Disengage all shipping fasteners on vibration isolation equipment.
- Check safety guards to insure they are properly secured.
- Secure all access doors to the fan, the unit and the ductwork.
- Switch electrical supply "on" and allow fan to reach full speed.
- Physically check each fan at start up and shut down to insure no abnormal or problem conditions exist.
- Check entering and leaving air temperatures (dry bulb and wet bulb) and simultaneously record entering and leaving chilled water temperatures and flow, steam pressures and flow, and outside air temperature.
- Check all control sequences.

3.3.8 Flush piping systems and clean strainers.

### 3.4 CLEANING

3.4.1 Clean work.

3.4.2 After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

3.4.3 Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials available from manufacturer.

3.4.4 Install new filters.

### 3.5 INSTALLATION OF FAN COIL UNIT

- Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.
- Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.
- Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.6 INSTALLATION

- Install fan-coil units level and plumb.
- Install fan-coil units to comply with NFPA 90A.
- Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above finished floor.
- Install new filters in each fan-coil unit within two weeks after Substantial Completion.

### 3.7 CONNECTIONS

3.7.1 Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

- Install piping adjacent to machine to allow service and maintenance.
- Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
- Connect condensate drain to indirect waste.
  - Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

3.7.2 Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

3.7.3 Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7.4 Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 3.8 FIELD QUALITY CONTROL

- Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.
- Perform the following field tests and inspections and prepare test reports:
  - Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- Remove and replace malfunctioning units and retest as specified above.

### 3.9 ADJUSTING

- Adjust initial temperature and humidity set points.
- Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.10 DEMONSTRATION

- Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION.

## SECTION 233723 - PUMPS

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL 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 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 – ELECTRIC MOTORS, ETC.
- 1.3 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.
- 1.4 Pumps shall be factory tested, cleaned and painted prior to shipment. Size, type, capacity and electrical characteristics are listed in the pump schedule.
- 1.5 Insofar as possible, all pumps shall be by the same manufacturer.

### PART 2 – NOT USED.

### PART 3 – END SUCTION BASE MOUNTED PUMPS:

- 3.1 End Suction Base Mounted Pumps shall be Series 1510 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.
- 3.2 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.
- 3.3 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.
- 3.4 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.

- 3.5 Provide all pumps with neoprene couplers. EPDM shall not be acceptable.
- 3.6 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.
- 3.7 Provide shaft guard with slotted window. Guard to be removable. Guard to meet ANSI B15.1, Section 8 and OSHA 1910.219 requirements.
- 3.8 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.
- 3.9 Comply with pump and coupling manufacturers' written instructions.
- 3.10 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."
- 3.11 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.
- 3.12 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

END OF SECTION.

SECTION 233725 – DIFFUSERS, REGISTERS, GRILLES, & LOUVERS

PART 1 – GENERAL:

- 1.1 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.

PART 2 – REGISTERS, GRILLES AND DIFFUSERS:

- 2.1 Acceptable R, G & D manufacturers are Price, Titus, Metal Aire, Nailor Industries or Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect. If Architect elects not to select color, all colors shall be white. Factory color samples shall be submitted with shop drawings.
- 2.2 Include with the shop drawings a room-by-room schedule with performance data, throw, pressure loss, etc. indicating devices to be installed. Also note ceiling types and installations.
- 2.3 Refer to drawings for schedule.

PART 3 – LOUVERS:

- 3.1 Acceptable louver manufacturers are Basis of Design as scheduled, Mechanical drawings. Refer to architectural specification 089119 – FIXED LOUVERS for additional requirements. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Materials, Finishes and installation shall be selected by the Architect and Architectural requirements. Refer to architectural drawings for wall and curtain wall construction for proper installation. Provide all necessary accessors and components as required. Provide complete coordination of louver installation with general contractor.
  - 3.1.1 Factory color samples shall be submitted with shop drawings.
  - 3.2 Refer to mechanical drawings for schedule.
  - 3.3 Refer to architectural drawings for coordination.
  - 3.4 Refer to architectural specifications for additional information.

END OF SECTION.

## SECTION 238241 - WATER-TO-WATER HEAT PUMPS

### PART 1 - GENERAL

#### 1.01 REFERENCE STANDARDS

- A. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- C. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.
- D. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

#### 1.02 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Manufacturer's data sheets for each product furnished, including:
  - 1. Electrical and performance data showing compliance with specifications.
  - 2. Required water flow rates and temperatures for inflow and outflow.
  - 3. Detailed electrical wiring diagrams.
  - 4. Storage and handling requirements and recommendations.
  - 5. Installation instructions.
  - 6. Start-up, troubleshooting, and TAB instructions.
  - 7. Specimen warranty.
- C. Shop Drawings: Show piping connections and interface to source-side and load-side piping, circulator pumps, hot water piping, and drains. Include control wiring diagrams prepared specifically for this project, including unit controls interface.
- D. Manufacturer's qualification statement.
- E. Installer's qualification statement.
- F. Field test reports.

- G. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- H. Operation and Maintenance Data: Include replaceable parts lists, parts sources, and troubleshooting guide.
- I. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- J. LEED Submittals:
  - 1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - 2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

#### 1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with not less than three years of documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified in this section and approved by manufacturer.

#### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Verify upon delivery that equipment nameplate data, including electrical data, matches specified and ordered equipment. Verify that refrigerant charge has been retained during shipping.
- B. Store products in manufacturer's unopened packaging until ready for installation.
- C. Store products under cover and elevated above grade.

#### 1.05 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide 5-year manufacturer warranty for compressors and motors, expansion devices, heat exchangers, and reversing valves.
- C. Provide a parts-only coverage shall be provided for the heat pumps compressors for a period of five years.

- D. The warranty period shall commence either on the equipment start-up date or six months after shipment, whichever is earlier.
- E. Service Warranty
  - 1. Contractor to provide 10 years warranty of parts & labor. Scope of warranty shall include but not limited to: compressor inspections, valve maintenance, and all other items within the 10 years of preventative maintenance requirements as outlined in the manufacturers' O&M literature.

## PART 2 - PRODUCTS

### 2.01 GENERAL WATER-TO-WATER HEAT PUMP FABRICATION REQUIREMENTS

- A. Energy Efficiency: ASHRAE Std 90.1 I-P EER and COP ratings, minimum.
- B. Factory assemble internal components, safety-controls, accessories, filters, piping, cable, and wires, then charge with R-454B refrigerant prior to testing.
- C. Include marked terminal strip to interface field mounted components and accessories.
- D. Comply with UL 1995, place service and caution labels on unit in appropriate locations.
- E. Cabinet Assembly:
  - 1. Construct of zinc-coated, heavy-gauge, galvanized steel with exposed edges rounded.
  - 2. Finish: Factory apply electrostatic powder paint or baked enamel finish. Coordinate with Engineer for specific color finish requirements of console units or other units installed within occupied spaces.
  - 3. Provide access panels for inspection, cleaning, and servicing of refrigerant, controls, and heat exchangers.
  - 4. Interior Insulation: Minimum 1/2 inch thick, dual density, bonded glass fiber.
  - 5. Provide flame spread of less than 25, and smoke developed classification of less than 50 when tested in accordance with ASTM E84 and UL 723.
  - 6. Sound and Noise Suppression:
    - a. Mechanical Rooms: 18 gauge, 0.05 inch, minimum.
    - b. Occupied Spaces: 16 gauge, 0.06 inch, minimum.
    - c. Compressor enclosure lined with 1/2 inch thick insulation.
    - d. Include vibration isolation between compressor and heat exchanger.
    - e. Include length-wise unit base stiffeners.

- f. Foam gasket sealant around compressor and end panel perimeter.
- F. Compressor Section:
- 1. Provide rubber mounting vibration isolation devices underneath mounting base.
  - 2. Safety Interlocked Devices:
    - a. Thermal overload protection.
    - b. High pressure switch for protection against excessive discharge pressure.
    - c. Low pressure safety for protection against loss of refrigerant charge.
- G. Refrigerant Tubing Lines:
- 1. Tubing made of copper with service pressure ports on high and low pressure sides.
  - 2. Free from contaminants and conditions such as drilling fragments, dirt, and oil.
  - 3. Include drier, thermal expansion valve, and other related components.
  - 4. Freeze Protection: 30 degrees F, thermistor based.
- H. Water-to-Refrigerant Heat Exchanger:
- 1. Coaxial Type: Provide aluminum or copper tube and fins.
  - 2. Brazed-Plate Type: Stainless steel, with bidirectional liquid line filter drier.
  - 3. Insulate heat exchanger, water lines, and refrigerant suction lines for prevention of condensation at temperatures below 60 degrees F.
  - 4. Provide rubber isolation to the heat exchanging device for enhanced sound attenuation.
  - 5. Freeze Protection: 35 degrees F by thermistor sensing.
  - 6. Minimum Working Pressure: 400 psi water side, 600 psi DX side.
  - 7. End Connections: Copper NPT. Provide flow shut-off ball valves.
  - 8. Accessories:
    - a. Strainer, PT test plug, and flow regulator.
    - b. Unit-controlled, return-water-side solenoid valve.
- I. Electrical:
- 1. Provide factory-installed phase loss safety device for 3-phase units.
  - 2. Configure unit for single point connection, include terminal for field-installed components.
- J. Unit Controls: DDC.
- 1. Application Specific Controller; see Section 250400 unless factory-provided.

2. Tested to monitor and handle sequencing functions and other operational modes using supplied field mounted sensors and switches.
3. Controller Interface:
  - a. Wall mounted device with monitoring display.
  - b. Pushbutton or key operated for local control and configuration.
4. Coordination and Sequencing:
  - a. Internal Devices: Include compressors, sensors, switches, valves, safeties, other components.
  - b. Field-Installed Devices: Solenoid valves, EWT sensors, LWT sensors, load-pump contact, source pump contact, and other devices required for operation.
  - c. Safeties: At minimum include anti-short-cycle compressor protection, condensate overflow, refrigerant high-pressure, refrigerant low-pressure, loss-of-charge, and refrigerant freeze protection.
5. Power:
  - a. Factory-mounted and internally-wired into nonfused electrical disconnect.
  - b. Configure safety-lockout circuits to be reset either using reset switch or power cycling.
  - c. 24 VAC/VDC, include minimum of 10 VA spare load capacity for potential field use.

## 2.02 AIR-TO-WATER HEAT PUMP WITH INTEGRAL HEAT RECOVERY

### A. Operating Conditions

1. Provide outdoor packaged heat pump with integral heat recovery with the Hot water and Chilled Water capacities as scheduled on drawings at job site elevation listed in Section 15050.
2. Heat pump shall be designed to operate using R-454B Refrigerant.
3. Heat pump shall be designed for parallel water flow through both the chilled water and hot water piping supplies to each module.
4. The liquid to be conditioned (both Chilled Water and Hot Water) will be water containing corrosion inhibitors and antifreeze solution as required.

### B. Outdoor Packaged Water-to-Water Heat Pump Heat Recovery Heat pump

1. System Description:

- a. Heat pump shall incorporate Scroll type compressors and can consist of multiple nominal 30-ton modules. Each refrigerant circuit shall consist of an individual compressor set, dedicated brazed plate chilled water evaporator, dedicated brazed plate hot water condenser, air to refrigerant heat exchanger, electronic expansion valve(s), motorized refrigerant valves, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical standpoint. The multi-module heat pump must be able to produce chilled water and hot water even in the event of a failure of one or more refrigerant circuits.
2. General
    - a. Heat pump Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.
    - b. Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified or 3rd party verified water test loop.
    - c. Compressors, heat exchangers, condenser fans, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module. Module shall be provided within a steel enclosure suitable for outdoor use. All steel surfaces shall be provided with a powder coat paint finish.
3. Piping:
    - a. Chilled Water Mains: Each module shall include supply and return mains for chilled water. Cut grooved end connections are provided for interconnection to six-inch standard (4.5", 6.625", 8.25") outside diameter) piping with grooved type couplings. Rolled grooved shall be unacceptable.
    - b. Hot Water Mains: Each module shall include supply and return mains for hot water. Cut grooved end connections are provided for interconnection to six-inch standard (4.5", 6.625", 8.25") outside diameter) piping with grooved type couplings. Rolled grooved shall be unacceptable.
4. Refrigerant to Water Heat Exchangers:
    - a. Dedicated Evaporator: Each module contains an evaporator which shall be a brazed plate heat exchanger constructed of 316 stainless steel; designed, tested, and

stamped in accordance with UL 1995 code for 650 psig working pressure. The evaporator heat exchanger shall not be mounted above the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.

- b. Dedicated Condenser: Each module contains a condenser which shall be a brazed plate heat exchanger constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig working pressure.
- c. Variable Flow Operation - Chilled Water & Hot Water: As standard, modules are provided with variable flow functionality through the application of an actuated valve on the dedicated heating and cooling brazed plate heat exchangers. Butterfly type isolation valves shall incorporate appropriate accessories and controls to allow the chiller to operate efficiently in a variable primary flow system. Motorized valve per module shall operate for variable flow. Constant flow applications may also be applied.
- d. Integral Module Level Proof of Flow: An IFM thermal dispersion flow switch per module shall be applied on each dedicated brazed plate heat exchanger (chilled and hot water). Flow switches shall be integral to each module and powered by the module for individual module proof of flow and flow safety. IFM Thermal dispersion flow switches shall be capable of detecting flow in chilled water loops and hot water loops ranging in temperature from 14°F to 176°F. Modules without independent IFM switches per module are not acceptable alternates.
- e. Each module shall contain two inverter scroll compressors with refrigerant injection technology. The compressors have active map management to monitor discharge temperature, resulting in safe compressor operation and maximizing lift capabilities. Compressors are in a tandem piping arrangement mounted to the module with rubber-in-shear isolators. Each system also includes high discharge pressure and low suction pressure safety cut-outs.
- f. Air-To-Refrigerant Heat Exchanger: Each module contains a source/sink evaporator/condenser which shall be fin and tube construction of aluminum fins and enhanced copper tubes. The source/sink fin and tube heat exchanger shall have proper means for refrigerant distribution for operation as an evaporator in the

dedicated heating mode. The source/sink fin and tube heat exchanger shall be pressure rated and UL certified for 650 psig working pressure.

- g. Source/Sink Fans: Each module shall contain dual fans for each refrigerant circuit. These fans shall be a single assembly of ECM motor, blade, shroud and guard. Blades are aluminum construction owlet design blade axial fan with integral EC motor (direct drives with external VFD driven motors are not acceptable). Efficiency exceeds criteria set out in the ErP 2015 directive. Individual fans are factory tested. Encapsulation required. Encapsulation is a process of filling a complete electronic assembly with a solid compound for resistance to shock and vibration, and for exclusion of moisture and corrosive agents.

5. Central Control System.

- a. Scheduling of the various compressors shall be performed by a microprocessor-based control system (Master Controller). Run time optimization shall be included to ensure even distribution of compressor run time.
- b. The Master Controller shall monitor and report the following on each refrigeration system:
  - 1) Discharge Pressure Fault
  - 2) Suction Pressure Fault
  - 3) Compressor Winding Temperature
  - 4) Suction Temperature
  - 5) Evaporator Leaving Chilled Water Temp
  - 6) Condenser Leaving Hot Water Temp
- c. The Master Controller shall be powered by the heat pumps single point power connection and shall monitor and report the following system parameters:
  - 1) Chilled Water Entering and Leaving Temperature
  - 2) Discharge Refrigerant Temperature
  - 3) Proof of Chilled Water Flow
  - 4) Hot Water Entering and Leaving Temperature
  - 5) Discharge Refrigerant Temperature
  - 6) Proof of Hot Water Flow

- d. An out of tolerance indication from these controls or sensors shall cause a “fault” indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor.
- e. In the case of a System Fault the entire heat pump will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller’s 2 line by 40 character back-lit LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).
- f. Individual monitoring of leaving chilled water temperatures from each refrigeration system shall be programmed to protect against freeze-up. Individual monitoring of leaving hot water temperatures from each refrigeration system shall be programmed to protect against high head pressure conditions.
- g. Operation:
- h. The control system shall monitor entering and leaving chilled water and hot water temperatures to determine both the chilled water and hot water system demand. The control system will use the demand to make staging mode (cooling, heating, or simultaneous heat recovery) decisions and select the number of compressor circuits required to operate. Mode decisions shall be available from the controller as well as via remote input. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, so as to optimize the heat pump performance to different existing building loads.
  - 1) Modules shall be able to provide the following capabilities:
    - (a) Full cooling capacity with zero need for hot water
    - (b) Full simultaneous heat recovery, providing full heating and cooling capacities
    - (c) Full heating capacity with zero need for chilled water
  - 2) Assembled arrays of two or more modules shall be able to provide the following capabilities:
    - (a) Full cooling capacity with zero need for hot water

- (b) Full cooling capacity with simultaneous heating
      - (c) Full heating capacity with zero need for chilled water
      - (d) Full heating capacity with simultaneous cooling
    - 3) The Heat pump shall be capable of interfacing to a building automation system. Interface shall be accomplished using an Interoperability Web Portal and shall be capable of communication over BACNet, Ethernet Modbus or LON.
  - i. Heat pump shall have external inputs and outputs to be compatible with the building management system to include Remote Start/Stop capability and Cooling Alarm output.
  - j. Each refrigerant circuit shall include all refrigerant specialties including a properly sized receiver to provide reliable operation down to 40°F Ambient.
  - k. Power Connection:
  - l. Heat pump shall be provided with a dual point power connection at a 5,000-amp SCCR. This will include pre-engineered wiring for field installation and connection to a factory mounted heat pump junction box. Junction box shall include branch circuit protection for each module and provide a single point of connection to building power.
    - 1) DIRECT CONNECT Power Heat pump shall be provided with a DIRECT CONNECT Power connection at a 5,000-amp SCCR.
  - m. Lifting Frame: Optional six-inch (W6X15) I-beam painted steel frame will be provided with all modules mounted upon it. Typically, all water and wiring connections will be made between the modules at the factory. Depending on heat pump length or customer requests, larger I-beams can be furnished, or multiple bolt together sections may be used.
- C. Safeties, Controls & Operations
- 1. The heat pump safety controls shall be provided (minimum) as follows:
    - a. Low evaporator refrigerant pressure
    - b. Loss of water flow through the evaporator
    - c. High condenser refrigerant pressure
    - d. High compressor motor temperature

- e. Low suction gas temperature
- f. Low leaving evaporator water temperature
2. Failure of heat pump to start or heat pump shutdown due to any of the above safety cutouts shall be annunciated by display of the appropriate diagnostic description at the unit control panel. This annunciation will be in plain English. Alphanumeric codes shall be unacceptable.
3. The heat pump shall be furnished with a Master Controller as an integral portion of the heat pump control circuitry to provide the following functions:
4. Provide automatic heat pump shutdown during periods when the load level decreases below the normal operating requirements of the heat pump. Upon an increase in load, the heat pump shall automatically restart.
5. Provisions for connection to automatically enable the heat pump from a remote energy management system.
6. The control panel shall provide alphanumeric display showing all system parameters in the English language with numeric data in English units.
7. Normal Heat Pump Operation
  - a. When heat pump is enabled, the factory supplied Master Controller modulates the heat pump capacity from minimum to maximum as required by building load.
8. The Heat pump control system shall respond to Leaving Water Temperature for both Chilled Water and Hot Water.
9. The Master Controller shall have an adjustable setting that limits the number of modules in defrost mode at any time. This shall be adjustable from one module to maximum number of modules.

### PART 3 - EXECUTION

#### 3.01 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Ensure electric utility connections are achieved in an orderly and expeditious manner.
- C. Verify that equipment is undamaged, including refrigerant components and shipped loose items.

### 3.02 INSTALLATION

- A. Install equipment in accordance with manufacturer's written installation instructions.
- B. Unit Mounting:
  - 1. Ground or Surface-Mount: Include vibration-isolated support base; see Section 230529.
  - 2. Above Finished Floor: Include hangers and supports; see Section 230529.
  - 3. Do not obstruct maintenance access to equipment by any type of piping, electrical conduit, or any other utility.
- C. Piping Flushing Procedure
  - 1. Prior to connecting the heat pump to the building chilled water loop, the piping shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organic residue. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.
  - 2. During the flushing, 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The use of on-board heat pump strainers shall not be acceptable. The flushing process shall take no less than 6 hours or until the strainers, when examined after each flushing, are clean.
  - 3. Systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer's instructions. After flushing with the detergent and/or dilute acid concentrations, the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.
  - 4. Prior to supplying water to the heat pump, the Water Treatment Specification shall be consulted for requirements regarding the water quality during heat pump operation. The appropriate heat pump manufacturer's service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

D. Water Treatment Requirements

1. Supply water for the chilled water circuit shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the heat pump’s heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for modular heat pumps using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

pH	Greater than 7 and less than 9
Total Dissolved Solids (TDS)	Less than 1000 ppm
Hardness (CaCO <sub>3</sub> )	30 to 500 ppm
Alkalinity (CaCO <sub>3</sub> )	30 to 500 ppm
Chlorides	Less than 200 ppm
Sulfates	Less than 200 ppm

E. Ground-Water Source:

1. Fit-in and install externally interconnected equipment and device components such as pumps and heat exchanger(s) as applicable to specific selections.
2. Flush and clean piping before placing in operation; take precautions to prevent introduction of debris into piping systems.

F. Electrical: Provide equipment raceway, wiring, and cables; see Section 260583.

G. Start system and adjust controls and equipment for satisfactory operation.

H. Adjust water temperature control system and place in operation so that water quantities circulated are as required.

3.03 FIELD QUALITY CONTROL

- A. Upon completion and before final acceptance of work, test each system to demonstrate compliance with the contract requirements.
  1. Adjust controls and balance systems prior to final acceptance of completed systems.
  2. Test controls through every cycle of operation.
  3. Test safety controls to demonstrate performance of required function.
  4. Furnish water, electricity, instruments, connecting devices, and personnel for tests.

5. Clean equipment, piping, strainers, ducts, and filters.
  6. Coordinate testing with testing of related piping, specified elsewhere.
  7. Correct defects in work and repeat tests.
- B. Coordinate BAS, BMS, or Integrated Automation linking between unit controller(s) and remote front-end interface.
- C. Operational Testing: After demonstration of satisfactory operation perform operational testing:
1. Notify Engineer in writing at least 15 calendar days prior to the testing.
  2. Test each item of equipment in operation for continuous period of not less than 24 hours under every condition of operation in accordance with equipment manufacturer's recommendations.
  3. Verify that each item of equipment operating parameters are within limits recommended by the manufacturer.
  4. Manufacturer's Recommended Test: Conduct the manufacturer's recommended field testing; provide a factory trained field representative authorized by and to represent the equipment manufacturer during the complete execution of the field testing.
- D. See Section 230995 for additional testing, adjusting, and balancing (TAB) requirements of piping, equipment, and controls.
- E. After acceptable completion of testing, submit each test report for review and approval; include:
1. Unit nameplate data and actual voltage and ampere consumption.
  2. Load-side supply and return water flow and temperatures and measurement equipment.
  3. Source-side supply and return water flow and temperatures and measurement equipment.
  4. Ambient air temperature at heat pump unit.
  5. Date, name, and signature of person testing and reporting.

### 3.04 CLOSEOUT ACTIVITIES

- A. Training: Upon completion of work and at time designated by Engineer, provide services of water source heat pump manufacturer's technical representative for period of not less than

one 8-hour working day for instruction of Owner's operating personnel in proper operation and maintenance of equipment.

### 3.05 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair, or replace damaged products before Date of Substantial Completion.

### 3.06 START UP

- A. Manufacturer shall provide the services of a Factory Authorized Service Engineer to provide complete start-up supervision.

END OF SECTION