

SECTION 23 00 00

HEATING, VENTILATING AND AIR CONDITIONING

PART 1 - GENERAL

1.01 PROVISIONS INCLUDED

- A. The Conditions of the Contract including Part A of the Project Manual and Division 1 - General Requirements, apply to the Work under this Section.
- B. Examine all other Sections of the Specifications for any Requirements that affect work of this Section, whether or not such Work is specifically mentioned in this Section.
- C. Coordinate Work with that of all other Trades affecting, or affected by, Work of this Section. Cooperate with such Trades to assure the steady progress of all Work under the Contract.

1.02 SCOPE OF WORK

- A. The work described herein shall be interpreted as work to be done by the HVAC Contractor. The HVAC Contractor shall be the General Contractor for this project. Work to be performed by other trades will always be specifically referenced to a particular Contractor or Subcontractor.
- B. The work covered by this Section of the Specifications includes the furnishing of all labor and materials and in performing all operations in connection with the installation of the HVAC work.
- C. The work includes, but is not limited to, the following:
 - 1. Air-cooled Heat Pump Chillers.
 - 2. Plate and Frame Heat Exchangers.
 - 3. Chilled Water Circulating Pumps.
 - 4. Chilled Water Supply & Return Piping.
 - 5. Hot Water Circulating Pumps.
 - 6. Hot Water Supply & Return Piping.
 - 7. Condensate Drain Piping and Pumps.
 - 8. Cold water make-up piping.
 - 9. Air Separator.
 - 10. Expansion Tank.
 - 11. Piping Insulation.
 - 12. Automatic Temperature Controls.
 - 13. Testing, Adjusting and Balancing (Coordination and Access).
 - 14. Commissioning (Coordination and Access ONLY).
 - 15. O&M Manuals.
 - 16. Operating Instructions.
 - 17. Record Drawings.
 - 18. Electrical Work. (By Electrical Subcontractor. Refer to Electrical Drawings and Specifications)
 - 19. Plumbing Work. (By Plumbing Subcontractor. Refer to Plumbing Drawings and Specifications)
 - 20. Staging, Ladders, Scaffolding, Hoists and All Related Equipment.
 - 21. Coring, Cutting and Patching under 4-1/2".
 - 22. Firestopping at all penetrations.

1.03 RELATED WORK UNDER OTHER SECTIONS

- A. The following work is not included under this Section and shall be performed under the Sections indicated:
 - 1. By the General Contractor (unless otherwise noted):

- a. Temporary Heating and Air Conditioning.
 - b. Demolition (as shown on the drawings).
 - c. Excavation and backfill.
 - d. Masonry and concrete work.
 - e. Finish painting, including painting of supporting steel for mechanical equipment.
 - f. Cutting and patching (greater than 4-1/2").
 - g. Flashing and waterproofing of all new pipe penetrations through the roof and wall.
 - h. Capping and waterproofing of existing roof openings and roof curbs resulting from HVAC equipment being removed.
 - i. Coring (greater than 4-1/2").
 - j. Structural framing for support of new, roof mounted HVAC equipment.
 - k. Flashing and waterproofing of all new and pipe penetrations through roof.
2. By the Electrical Subcontractor:
- a. All power wiring required for the automatic temperature control system. Electrical Subcontractor at a minimum shall provide a 120-volt power junction box in the mechanical room for the automatic temperature control system. ATC Sub-Contractor to review with the Electrical Contractor if additional required. Automatic temperature control wiring shall be provided by the Control Sub-subcontractor under this Section.
 - b. All electrical power wiring and connections and all disconnect switches not provided with or as integral part of the HVAC equipment shall be provided by the Electrical Subcontractor.
 - c. Motor starters and VFDs shall be furnished and installed by the HVAC Contractor and wired by the Electrical Subcontractor.
 - d. Refer to Electrical specification for more information.
3. By the Plumbing Subcontractor:
- a. Refer to Plumbing specification for more information.

1.04 CODES, ORDINANCES AND PERMITS

- A. All material and work provided shall be in accordance with the following codes and standards:
1. Massachusetts State Building Code.
 2. State Department of Public Safety.
 3. Local codes, ordinances and regulations.
 4. Standards of the Underwriters Laboratories (UL).
 5. Occupational Safety and Health Act (OSHA).
 6. National Fire Protection Association (NFPA).
 7. Massachusetts and National Electrical Codes.
 8. International Mechanical Code (IMC) 2015.
 9. International Energy Conservation Code (IECC) 2021.
 10. International Plumbing Code.
 11. National Fuel Gas Code.
- B. Where the contract documents indicate more stringent requirements than the above codes and ordinances, the Contract Documents shall take precedence.
- C. All necessary permits, inspections, approvals, etc. are to be obtained and paid for by this Subcontractor.
- D. This Contractor shall be responsible for obtaining all permits and inspections required to complete all work described in this section.

1.05 CONTRACT DRAWINGS AND SPECIFICATIONS

- A. The drawings showing layout of the HVAC systems indicate the approximate location of piping, ductwork, equipment and location of services. They are schematic and are not intended to show

the exact routing or all fittings required. The final determination as to the routing shall be governed by structural conditions and other obstructions. No cutting or removal of any wood or concrete members will be allowed, unless approved in writing by the Architect.

- B. The right to make any reasonable change in the location of ducts, piping, apparatus and equipment up to the time of roughing-in is reserved by the Architect without involving any additional expense to the Owner.
- C. The specifications supplement the drawings and provide specifics pertaining to the methods and material to be used in the execution of the work.
- D. Any discrepancies between the drawings and specifications or within the drawings/specifications shall be brought to the attention of the Architect/Engineer for clarifications.
- E. HVAC Contractor shall read and understand the Contract Documents and submit the bid in accordance therewith. Failure to examine the Contract Documents and site plans shall not relieve the HVAC Contractor from any obligation under the bid as submitted.

1.06 SHOP DRAWING AND MATERIALS SCHEDULE

- A. Within fifteen days after the date of notice to proceed and before purchasing any materials or equipment, submit for approval a complete list, in six copies, of all materials to be incorporated in the work. After the list has been processed, submit complete shop drawings of all equipment. These shop drawing submittals shall be submitted within fifteen days after the processing date of original submittal list.
- B. The approval of equipment does not relieve the HVAC Contractor from the responsibility for shop drawing errors in details, sizes, quantities, wiring diagram arrangements and dimensions which deviate from the specification, contract drawings and/or job conditions as they exist.
- C. Refer to General Requirements for substitution of equipment and submittal of shop drawings. If apparatus or materials are substituted for those specified and such substitution necessitates changes in or additional connections, supports or construction, same shall be provided. The HVAC Contractor shall assume cost and entire responsibility thereof.
- D. Submit the name(s) and contact information for a minimum of two qualified vendors that are eligible to provide operations and maintenance on the installed HVAC system.

1.07 COOPERATION AND COORDINATION WITH OTHER TRADES

- A. The work shall be so performed that the progress of the entire building construction including all other trades, shall not be delayed nor interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit and must be installed promptly when and as desired.
- B. Confer with all other trades relative to location of all apparatus and equipment to be installed and select locations so as not to conflict with work of other Sections. Any conflicts shall be referred immediately to the Architect/Engineer for decision to prevent delay in installation of work. All work and materials placed in violation of this clause shall be readjusted to the Architect's/Engineer's satisfaction, at no expense to the Owner.
- C. Where work of this section will be installed in close proximity to work of other sections or where there is evidence that the work of this section will interfere with work of other sections, assist in working out space conditions to make satisfactory adjustment. Prepare and submit for approval 3/8 inch scale or larger working drawings and sections, clearly showing how this work is to be installed in relation to the work of other sections. If the work of this section is installed before coordinating with other trades or so as to cause interference with work of other trades, make changes necessary to protect conditions without extra charge.

- D. Keep fully informed as to the shape, size and position of all openings required for all apparatus and give information in advance to build openings into the work. Furnish and set in place all sleeves, pockets, supports and incidentals.
 - 1. There are numerous existing openings and penetrations in masonry construction currently utilized by existing equipment. Following the demolition of existing systems, existing openings are to be utilized to the greatest extent possible for the installation of the work of this Contract.
- E. All distribution systems which require pitch or slope such as sanitary drains and water piping shall have the right of way over those which do not. Confer with other trades as to the location of pipes, ducts, lights and apparatus and install work to avoid interferences.
- F. Where there is evidence that work of this Subcontractor will interfere with the work of other trades, this Subcontractor shall assist in working out space conditions to make satisfactory adjustments.
- G. This Subcontractor shall, with the approval of the Engineer and without extra charge, make reasonable modifications in his work as required by structural interference's, or by interference with work of other trades, or for proper execution of the work.
- H. If this Subcontractor installs his work before coordinating with other trades and his work causes interference with the work of such other trades, he shall make all necessary changes in his work to correct the condition without extra charge and as directed by the Engineer.
- I. This Subcontractor shall protect all materials and work of other trades from damage that may be caused by his work and shall make good any damages so caused.

1.08 RECORD DRAWINGS

- A. Provide two sets of black line prints to be used as working record drawings during construction. One set of prints shall be maintained at the job site and shall, at all times, be accurate, clear and complete, showing the actual location of all equipment ducts and piping. The working record drawings shall be available for review at the job site by the Architect's/Engineer's field representative. The marked up As Built Drawings required to be maintained under this section are as listed in Section 'List of Drawings'.
- B. Any addenda sketches, supplementary drawings and change orders issued during the course of construction shall be transferred to the working record drawings.
- C. At the completion of all work submit an accurate, checked set of working record drawings. Non-availability of these drawings will postpone the final inspection until the record drawings are available.
- D. The HVAC Contractor shall incorporate all changes on the original drawings. The Subcontractor shall submit to the designer, disks of drawings on Auto CAD Version 2008 format with two sets of prints and reproducible drawings. Inaccuracies in Record Drawings, as determined by the designer, shall be corrected.
- E. All costs related to these requirements shall be paid for by the HVAC Contractor .

1.09 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Provide operating instructions to the Owner's designated representatives with respect to operating functions and maintenance procedures for all equipment and systems installed. The cost of providing a manufacturer's representative at the site for instructional purposes shall be included in the contract price. The operating instructions shall be presented in scheduled, pre-arranged formal periods. The HVAC Contractor shall include in his contract price, the cost for instructions, up to eight (8) hours, which shall not necessarily be consecutive.
- B. At the completion of the project, turn over to the Architect/Engineer, two complete manuals containing the following:

1. Complete shop drawings of all equipment.
 2. Operation description of all systems.
 3. Names, addresses and telephone numbers of all major suppliers of equipment on a separate indexing sheet.
 4. Preventive maintenance instructions for all equipment.
 5. Spare parts list of all system components.
- C. The Subcontractor shall collect the operating instructions, bind them into two complete sets and deliver them to the Architect/Engineer who will check for completeness and deliver them to the Owner. All information shall be in three-ring, loose-leaf binders.
- D. All pertinent portions of the training sessions shall be video recorded with copies provided in the O&M manuals.
- E. Delivery of the operating and maintenance manuals shall be a condition precedent to final payment

1.10 GUARANTEE

- A. This Subcontractor shall obtain, in the Owner's name, the standard written manufacturer's guarantee for one year or greater of all materials furnished under this section where such guarantees are offered in the manufacturer's published product data. All these guarantees shall be in addition to, and not in lieu of, other liabilities which this Subcontractor may have by law or other provisions of the contract documents.
- B. This Subcontractor shall warranty workmanship and materials for a period of not less than one year from the date of substantial completion. Should any defects in materials or workmanship appear during this period, they shall be corrected or replaced by the Subcontractor to the satisfaction of the Architect, and at no expense to the Owner.

1.11 CUTTING, CORING AND PATCHING

- A. Cutting and patching through new construction using core drill and measuring larger than 4-1/2 inches in diameter, or 4-4/2 inches by 4-1/2 inches, shall be performed by Trades specializing in the specific surfaces affected, e.g., carpentry, masonry, metals, etc., except where noted otherwise. Notify the specific Trade(s) of exact locations and sizes for openings required. The extent of masonry walls is shown on the architectural drawings along with approximate locations and sizes of existing masonry openings. This Section's Contractor is responsible for reviewing and coordinating with other sub-contractors to use the existing masonry openings to the greatest extent possible.
1. Exposed concrete coring: Notify Contractor of exact locations and sizes for all openings required in exposed concrete, to be executed under Section 03 30 00 – Cast-in-Place Concrete.
 2. Concrete coring less than 4-1/2 inches: Any new penetration cut through existing concrete less than 4-1/2 inches in width shall be executed by the specific Trade(s) installing the work.
 3. Concrete coring 4-1/2 inches or larger: Notify Contractor of exact locations and sizes for openings larger than 4-1/2 inches in diameter required in concrete, to be executed under Section 03 30 00 – Cast-in-Place Concrete.
 4. Masonry openings less than 4-1/2 inches: Any new penetration cut through existing masonry less than 4-1/2 inches in width shall be executed by the specific Trade(s) installing the work.
 5. Masonry openings 4-1/2 inches or larger: Notify Contractor of exact locations and sizes for openings larger than 4-1/2 inches in width required in masonry, to be executed under Division 04 - Masonry, utilizing lintels, furnished per Division 05 - Metals.
 6. Exposed gypsum board: Notify Contractor of exact locations and sizes for all openings required in exposed gypsum board, to be executed under Division 09 - Finishes.
 7. Concealed gypsum board: Any new penetration cut through existing or new concealed gypsum board less than 4-1/2 inches in width shall be executed by the specific Trade(s) installing the work. Cutting and patching larger than 4-1/2 inches in diameter, or 4-4/2 inches by 4-1/2 inches to be executed under Division 09 - Finishes.

8. Notify Architect prior to any cutting or coring larger than 2 inches.

1.12 PERMITS

- A. This Subcontractor shall be responsible for obtaining and paying for all permits and inspections required to complete all work described in this section. Refer to Division 1 specifications for more information.

1.13 STORAGE OF MATERIALS

- A. Store materials prior to their installation where designated by the General Contractor. Be responsible for all stored equipment and materials and protect all installed equipment and materials from damage.

1.14 INSPECTION AND TESTS

- A. If inspection of materials installed shows defects, such defective work, materials and/or equipment shall be replaced at no cost to the Owner and the inspection and tests repeated.
- B. Make all reasonable tests as required and prove the integrity of all work and leave the entire HVAC installation in correct adjustment and ready to operate.

1.15 ELECTRICAL CHARACTERISTICS

- A. In general, and unless specifically indicated otherwise in the specifications or noted on the drawings, all HVAC equipment shall be of the HP, voltage, and phase as indicated on the drawings.
- B. Control wiring and conduit for the HVAC systems shall be furnished under this Section. Power wiring, including provisions for disconnect switches not otherwise furnished as an integral part of the mechanical equipment, is under the work of the Electrical Subcontractor.
- C. Fractional horsepower motors wired for single phase operation shall have automatic reset overload protection built into the motor.

1.16 DEFINITION OF TERMS

- A. "Furnish" or "Supply" means to purchase, procure, acquire and deliver.
- B. "Install" means to rig, erect, mount and connect, unless specifically noted otherwise.
- C. "Furnish and Install" means to supply, deliver, rig, erect, mount and connect in readiness for operation, unless specifically noted otherwise.
- D. "Provide" is synonymous with "Furnish and Install".
- E. "Piping" means pipe, tubing, fittings, flanges, unions, valves, strainers, traps, hangers and other accessories related to such piping.
- F. "Concealed" means hidden in chases, furred spaces and walls, above ceilings or enclosed in construction.
- G. "Exposed" means visible or not installed "Concealed" as defined above.
- H. "Approved Equal" or "or equal" means any equipment or material which is approved by the Engineer as equal in quality, durability, appearance, strength, design and performance to the equipment or material originally specified.
- I. "Underground" means buried exterior to or within the building.

1.17 SCAFFOLDING AND STAGING

- A. All staging, exterior and interior, required to be over eight feet in height, shall be furnished and erected by this Subcontractor and maintained in safe condition by him without charge to and for the use of all trades as needed by them for proper execution of their work, except where specified to the contrary in any filed sub-bid Section of the Specification.
 - 1. Erection and dismantling of staging shall be performed only by trained, certified, and experienced staging personnel qualified to perform such work.
 - 2. Copies of such certifications, clearly indicating qualifications, shall be provided to the Architect prior to commencement of such erecting and dismantling work.
- B. Provide, maintain and remove safe and adequate interior and exterior staging, ladders, scaffolding, hoists, and all other related equipment for proper and complete execution of the work of this section in accordance with requirements of the Contract Documents. Staging, scaffolding, hoists and all other related equipment shall comply with all applicable federal, state and local regulations.
- C. Staging, ladders, scaffolding, hoists and all other related equipment shall be provided, maintained and removed when no longer required.

1.18 CORE DRILLING

- A. All holes through the building structure for the passage of piping shall be cut by the General Contractor using an approved core boring machine with diamond edged bit and vacuum sludge removal. The size of holes shall provide for packing around a sleeve. The location of all core drilled holes shall be coordinated with all structural reinforcing and components and be approved by the Architect prior to commencing work.

1.19 WORK COORDINATION AND JOB OPERATIONS

- A. HVAC equipment shall not be installed in congested and possible problem areas without first coordinating the installation of same with the other trades. Relocate HVAC equipment should it interfere with the proper installation of equipment to be installed by the other trades.
- B. Particular attention is directed to the coordination of ductwork with the equipment of other trades being installed in and above the ceiling areas. Conflicts in mounting heights and clearances above hung ceilings shall be brought to the attention of the Architect for a decision before equipment is installed.
- C. Furnish to the other trades, all information relative to the portion of the HVAC installation that will affect them, so that they may plan their work and installations accordingly.
- D. Coordinate installation of all equipment and components (including sensors and gauges) for accessibility per manufacturer's clearance requirements for equipment maintenance and repair. Installation of building materials and components shall allow sufficient space for maintenance and service without limiting range of motion that would require deconstruction of the space or installation in order to provide required service.
- E. Duct installation procedures shall follow SMACNA Duct Cleanliness for New Construction Guidelines – Advanced Level.
- F. Valves installed above 8 ft. shall be equipped with chain falls for operation and maintenance.

1.20 REBATES

- A. HVAC Contractor shall assist the Owner in obtaining all eligible utility rebates and transferring these rebates to the Owner pertaining to this section.

1.21 SITE INSPECTION

- A. The Contractor shall be required to visit the site and to have examined the existing conditions which may affect the work under this contract. Failure to do so shall be the contractor's responsibility and no claims for extra compensation or extension of time shall be allowed because of it.

1.22 DEMOLITION

- A. This contractor shall demolish, remove and dispose of properly, existing equipment and appurtenances as specified herein and as indicated on the drawings. Demolition shall include, but not be limited to the following.
 - 1. The existing cooling towers located at grade and associated and controls.
 - 2. The existing water-cooled chiller and associated controls.
 - 3. Noted chilled water and condenser water piping and pumps.
- B. The Owner reserves the right to maintain ownership of certain HVAC system components that are scheduled to be removed. The Contractor shall coordinate this with the Owner.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. Hot water and chilled water piping 2" diameter and smaller shall be type "L" hard drawn copper tubing with wrought copper fittings.
- B. Hot water and chilled water piping 2-1/2" diameter and larger shall be Schedule 40 black steel pipe, ASTM A-53, Grade B, ERW.
- C. Fittings for copper tubing shall be wrought copper fittings. Provide dielectric fittings for all connections between ferrous and non-ferrous piping.
 - 1. At the option of the Contractor, copper piping 2" and under shall be joined with ProPress fittings as manufactured by Viega LLC or approved equal. Piping fittings and components shall be capable of withstanding 150 psig. Working pressure at 200 deg F. Piping and fittings shall be installed per manufacturer's installation instructions. Housing shall be copper or bronze. Sealing element shall be EPDM. Pipe and fittings shall be installed using manufacturer's specific tools and using smart connect technology.
- D. Fittings for piping 2-1/2" diameter and larger shall be standard welding fittings as manufactured by Tube-Turns, Grinnell, Crane or approved equal. Elbows shall be long radius elbows. Branch connections reducing two sizes or less shall be made with welding tees of the same manufacturer as the fittings. Branch connections reducing more than two sizes shall be made with weldolets, threadolets, or with welding tees. Unless otherwise indicated or approved, all reduction in pipe size shall be made with eccentric reducers. Flanges shall be 150 pound weld neck flanges.
- E. At the option of the contractor, piping 2-1/2" and larger may be joined with Victaulic fittings and flanges in lieu of welding. Piping shall be Schedule 40 black steel pipe, ASTM A-53, Grade B, ERW. Victaulic couplings, fittings, supports, valves, strainers and supports shall be installed in strict accordance with the manufacturer's recommendation (Victaulic "Fit-Fittings" will not be accepted).
 - 1. Grooved coupling shall consist of two pieces of ductile iron with synthetic rubber gaskets with a central cavity pressure responsive design. Coupling bolts and nuts shall be physical properties of ASTM A-449 and A-183. All couplings shall comply with ASTM F1476: Standard for Performance of Gasketed Mechanical Couplings in Piping Applications.
 - a. Rigid Type: Housings cast with offsetting, angle-pattern, bolt pads to provide system rigidity and support and hanging in accordance with ANSI B31.1 and B31.9. Installation-Ready for complete installation without field disassembly, complete with grade EHP gasket suitable for water service to 250 deg F. Basis of Design: Victaulic Style 107N.

- b. Flexible Type: For use in locations where vibration attenuation and stress relief are required. Basis of Design: Victaulic Installation-Ready Style 177 or Style 77.
 - c. Installation-Ready gaskets are "center-leg" with pipe stop to ensure proper groove engagement, alignment, and pipe insertion depth.
 - d. AGS two-segment couplings for pipe sizes 14" and larger, with wide-width FlushSeal® gasket and lead-in chamfer on housing key. Basis of Design: Victaulic Style W07 (rigid) and Style W77 (flexible).
- 2. Full size branch connections shall be made with manufactured grooved end tees. Branch connections with locating collar engaging into hole or Style 72 outlet connection shall be used to join grooved pipe branch connections shall be Victaulic Grade "E" EPDM compound with working temperature of -30 degrees F to 230 degrees F.
 - 3. Flanges shall be Vic-Flange Style 741 and W741. Flanges and standard fittings shall be ductile iron conforming to ASTM A-536 Grade (65-45-12), painted with a rust inhibiting modified vinyl alkyd enamel or hot dip galvanized to ASTM A-153 or Zinc Electroplated to ASTM B-633 as required.
- F. Screwed fittings shall be 125-pound cast iron fittings. Unions shall be 150-pound ground joint units. All reducers shall be eccentric reducers.
 - G. Provide relief valve discharge piping from valves to floor of mechanical room.
 - H. Cold water make-up piping shall be Type L hard-drawn copper tubing with wrought copper fittings.

2.2 BOLTS, GASKETS AND JOINTS

- A. All screwed joints shall be made tight with teflon tape.
- B. All flanges shall be faced and drilled to US Standards and fitted with machine bolts of proper number and size, having semi-finished hexagon nuts and a washer under each nut. All flanged joints shall be fitted with Johns-Manville Service, Cranite or Durable ring gaskets.
- C. All solder joints shall be made with 95-5 solder and shall make perfect adhesion between pipe tubing and fitting.
- D. Provide dielectric fittings for all connections between ferrous and non-ferrous piping.

2.3 HANGERS AND SUPPORTS

- A. Provide pipe supports, hangers, and other devices necessary to support firmly and substantially the piping and the apparatus described in the specifications and shown on the drawings.
- B. Hangers shall be arranged to maintain the required grading and pitch, to prevent vibration, and to provide for expansion and contraction.
- C. Each vertical line shall be supported at its base using a suitable hanger placed in the horizontal line near the riser.
- D. Where the weight of piping or other apparatus makes it impracticable to support same from the ceiling alone, flange pipe standards shall be installed to support the weight of piping, valves and fittings.
- E. Brackets of approved type may be used along walls.
- F. Piping 2-inch diameter and smaller shall be supported by "A" bands with one 3/8-inch adjustable steel rod with concrete insert or beam clamp.
- G. Piping 2-1/2 and above diameter shall be supported by clevis hangers with one 1/2-inch adjustable steel rod and one concrete insert or beam clamp.

- H. 1A bands and clevis hangers shall be installed outside the thermal insulation. Provide 18 gauge, 12" long pipe covering protection shields on insulated piping at 1A bands and clevis hangers.
- I. Two rod roll hangers shall be used in lieu of the hanger type specified where space limitations necessitate.
- J. The maximum spacing between pipe supports shall be the following:

<u>Pipe Size</u>	<u>Maximum Spacing (ft.)</u>
1" and smaller	7
1-1/2"	9
2"	10
3" and above	10

- K. These spans apply to straight runs of piping without concentrated loads. Spans shall be shorter as required by changes in direction or by concentrated loads such as strainers, valves, etc.
- L. Supplementary steel shall be furnished and installed as required to support piping and equipment.
- M. Piping shall not be supported from ductwork, breeching, equipment, ceiling suspension systems or other piping.
- N. Provide galvanized metal shields between pipe hangers and insulation where saddles are not required and where hangers are installed outside of insulation.
- O. All hangers and supports shall be in compliance with seismic requirements of the State Building Code.
- P. Provide spring loaded pipe hangers for piping around the circulating pumps to prevent transfer of vibration to building structure. Contractor shall use necessary means to install all piping and equipment with minimal vibration and sound that is normal to the pumps as verified by the pump manufacturer.

2.4 EXPANSION LOOPS, OFFSETS AND ANCHORS

- A. Provisions for expansion in mains and risers shall be made by the installation of offsets or pipe loops.
- B. All expansion loops and offsets shall be constructed as shown on the drawings or as required. All mains and risers having expansion loop or offsets shall be securely anchored to the building construction in such a manner as to throw all expansion toward the expansion loops or offsets. Furnish and install guides as necessary to properly fulfill the function of expansion loops.

2.5 SLEEVES, INSERTS AND ESCUTCHEONS

- A. All piping passing through masonry walls, slabs, floor partitions or other building construction shall be provided with pipe sleeves at least two pipe sizes larger than the pipe passing through them or the insulation jacket on covered pipes. Sleeves shall be flush on either side of masonry walls or partitions. All sleeves in floor slabs shall extend 1/2" above finished floors. All sleeves shall be standard weight steel pipe.
- B. Where exposed pipes pass through floors, finished walls or finished ceilings, they shall be fitted with neat, heavy spun or stamped steel, chrome plated escutcheons, firmly secured to the pipes. In unfinished areas, escutcheons shall be cast iron, split and painted to match the adjacent surfaces. Escutcheons shall be of sufficient outside diameter to amply cover the sleeved openings for the pipe.

- C. Where pipes penetrate fire rated assemblies, walls or floors, openings shall be firestopped. At all partition penetrations, walls or floors, openings shall be firestopped per the requirements of Section 07 8413.

2.6 VALVES

- A. Furnish and install valves as indicated on the drawings and specified herein. All valves in each class shall be manufactured by the same manufacturer.
- B. Isolating valves on piping 2" diameter and smaller shall be ball valves, Victaulic Series P89, Apollo Series 70-100 or 70-200 or equal as manufactured by Hammond, Jenkins or Stockham.
- C. Unless otherwise specified, isolating valves on piping 2-1/2" and larger shall be 300-psi CWP grooved end butterfly as manufactured by Victaulic or 150-pound lug type butterfly valves as manufactured by Hammond, Jamesbury, Keystone or approved equal. Valves shall conform to MSS SP-67.
 - 1. Valve seat shall be pressure responsive in sizes through 12", rated for water service to +250 degrees F. For 14" and larger sizes, seal shall be disc mounted for water service to +230 degrees F.
 - 2. Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating.
- D. Balancing valves on hot water piping 2" diameter and smaller shall be sweat end or screwed end DZR brass (Ametal®) copper alloy valves with provisions for connecting a portable differential pressure meter. Each meter connection shall have pressure/temperature probes. Valves shall be Tour and Andersson Model STAD, STAS or approved equal. Valves shall provide flow measurement, flow balancing, positive shut-off with no drip seat and drain connection with protective cap.
 - 1. Victaulic Koil-Kits Series 799, 79V, 79A, and 79B may be used at coil connections. The kit shall include a Series 786/787/78K circuit balancing valve, Series 78Y Strainer-Ball or Series 78T Union-Ball valve combination, Series 78U Union-Port fitting, and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required. A meter shall be provided by the valve manufacturer that shall remain with the building owner after commissioning.
- E. Unless otherwise specified, balancing valves 2-1/2" diameter and larger shall be iron-body flanged valves or grooved with provision for connecting a portable differential pressure meter. Each meter connection shall have pressure/temperature probes. Valves shall be Victaulic Series 788 (Tour and Anderson Model STAF) and Victaulic Series 789 (Tour and Anderson Model STAG) or engineer approved equal. Valves shall provide flow measurement, flow balancing, positive shut-off with no drip seat.
- F. Check valves on piping 2" diameter and smaller shall be Class 150 bronze, threaded regrinding swing check valves with bronze disc and screw-in cap as manufactured by Hammond, Jenkins or Crane.
- G. Check valves 2-1/2" diameter and larger shall be:
 - 1. Grooved end, ductile iron body with stainless steel spring and shaft, suitable for vertical or horizontal installation. Victaulic Series 716 (rated to 300-psig CWP in sizes through 12") and AGS Series W715 (rated to 230-psig CWP in sizes 14" and larger).
 - 2. 125-pound, iron body, bronze mounted, horizontal swing check valves with regrind-renew bronze disk and seat ring, flanged end, Fig. 624.
- H. Drain valves shall be provided on all low points of water piping. Drain valves shall be 3/4" bronze drain valves with solid bronze cap and chain, Jenkins Fig. No. 314, or equal as manufactured by Hammond or Crane.

- I. Control valves shall be pressure-independent type as specified under the Controls Specifications.

2.7 PRESSURE REDUCING AND RELIEF VALVES

- A. Furnish and install pressure reducing and relief valves as indicated on the drawings.
- B. Pressure reducing valves shall be 3/4" brass valves, Bell & Gossett Model 7 set for 25 psig or equal as manufactured by Taco or Amtrol.
- C. Relief valves shall be 1/2" brass valves, Bell & Gossett Model A3 set for 50 psig or equal as manufactured by Taco or Amtrol.

2.8 STRAINERS

- A. Furnish and install full size, Y-pattern, self-cleaning strainers where specified and where indicated on the drawings. A strainer shall be provided upstream of each temperature control valve and each pump.
- B. Strainers shall have cast-iron bronze bodies of ample strength for the pressure to which they shall be subjected, removable cylindrical or conical screens of nickel, copper or brass and rated for 250 PSI non-shock. Strainers 2" and smaller shall have screwed ends. Strainers 2-1/2 inch and larger shall have flanged ends faced and drilled to conform to American Standard Association. Strainers shall be of such design as to allow blowing out of the accumulated dirt, and to facilitate removal. All strainers shall be furnished with ball valve and hose end connections for blow down service. Valves and strainers shall be as manufactured by Crane, Jenkins, or Walworth.
- C. Strainers shall have stainless steel screens with perforations recommended by the manufacturer for the intended service.
- D. A valved dirt blow out connection shall be made to each strainer with a ball valve located 6" to 12" below the strainer. Blow off valves shall be 3/4" on strainers 2" and smaller. Blow off valves shall be 1" on strainers 2-1/2" and larger. The blow out connections shall terminate at a point where there will be no risk of danger to personnel or damage.

2.9 PRESSURE GAUGES

- A. Furnish and install pressure gauges where indicated on the drawings and specified herein. The gauges shall be Bourdon spring type pressure gauges as manufactured by Trerice, Wexler, Taylor Instruments or approved equal.
- B. Unless otherwise specified, the gauges shall have 4-1/2" dials.
- C. The gauges shall have white faces with black filled engraved figures. The body of the gauge shall be dull black with the bezel or rim chrome plated. The accuracy of the gauges shall be plus or minus 1% of the scale range. The gauges shall be suitable for pressures to which they are subjected.
- D. Each gauge shall be provided with a ball valve on the system side of the gauge.
- E. Gauges on the suction and discharge of each pump shall be provided with a snubber.
- F. Gauges on the suction of hot water pumps shall have a range of 0 to 60 psi.
- G. Unless otherwise noted, all other pressure gauges on water lines shall have a range of 0 to 60 psi.

2.10 THERMOMETERS AND WELLS

- A. Furnish and install where shown on the drawings and where specified herein, separable well type, industrial stem thermometers as manufactured by Trerice, Wexler, Taylor Instruments or approved equal.

- B. Unless otherwise specified, the thermometers shall have a 9" scale and a white face with black filled engraved letters. They shall be angle or straight stem type as conditions necessitate.
- C. All thermometer wells shall be installed in such a manner that a minimum of restriction will be caused to the flow in the pipes and so that the thermometers can be easily read.
- D. The scale range for thermometers in hot water piping shall be 35° to 240°F.

2.11 AIR VENTS

- A. Furnish and install manual and automatic air vents where specified and where indicated on the drawings. Air vents shall be as manufactured by Bell & Gossett, Taco, Amtrol or approved equal.
- B. Automatic air vents shall be provided at each air separator and at each high point in the new hot water piping mains.
- C. Automatic air vents shall be rated for a maximum operating temperature of 240°F at 150 psig. Vents shall be Bell & Gossett No. 87, Taco 418 Hy-Vent, or Amtrol 706. A ball valve shall be installed on the system side of each automatic air vent. Furnish and install a copper drain line from each automatic air vent down to 6" above the boiler or mechanical room floor.
- D. Manual air vents shall be Taco No. 423 or equal.

2.12 WATER SPECIALTIES

- A. Furnish and install, where indicated on the drawings and in accordance with the manufacturer's recommendations, the following equipment as manufactured by Taco, Bell & Gossett, or Watts Regulator Company.
- B. Provide for each system a 3/4-inch Taco combination pressure reducing and relief valve. Furnish and install with the valve a one-inch bypass fitted with a ball valve. All piping and fittings on the make-up water and bypass shall be one-inch copper as indicated on the drawings.
- C. Furnish and install a diaphragm type expansion tank as shown on the drawings. For the glycol chilled water and heating hot water loops the expansion tanks shall be Taco, Model #CBX with a tank volume and an acceptance volume as noted in the mechanical schedules or approved equal as manufactured by Bell & Gossett. Tank shall be constructed of carbon steel with a heavy-duty butyl rubber diaphragm. Tank shall be ASME rated.
- D. Air Separator:
 - 1. Furnish and install as shown on the drawings, a coalescing type air eliminator and dirt separator on the hot water system, Model #VDT as manufactured by Spirovent, or approved equal as manufactured by TACO, or Bell & Gossett. Pipe size is not a factor and all units should be selected at the point of peak efficiency per the manufacturer's recommendations. All combination units shall be fabricated steel, rated for 150 psig working pressure with entering velocities not to exceed 4 feet per second at specified GPM. Spirovent AHV@ units specifically designed for high velocity systems may have an entering velocity of up to 10 feet per second. Units shall include an internal tube bundle filling the entire vessel to suppress turbulence and provide high efficiency. The bundle must consist of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connections and equal distance for dirt separation. Air eliminators shall be Spirovent Dirt models manufactured by Spirotherm, Inc. or approved equal as manufactured by Taco or Bell and Gossett and be capable of removing 100% of the free air, 10% of the entrained air, and up to 99.6% of the

dissolved air nit he system fluid. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.

- E. Glycol Feed System: Furnish and install duplex glycol feed system serving chilled water and heating water systems as indicated on the drawings. Glycol feed systems shall be as manufactured by Axiom, J.L. Wingert, Neptune, Skidmore, Wessels, or approved equal.
1. Tank: 55 gallons polyethylene tank with hinged cover and steel bottom mounting stand.
 2. Pump: The package shall consist of two independent autonomous pumping assemblies. Provide with a ball valve and wye strainer on the pump suction, and a check valve and pressure gauge on the pump discharge. An adjustable pressure switch on the pump discharge shall engage the pump on a loss of pressure in the system. A pre-piped pressure relief valve shall be located near the connection to the hydronic system, with the valve discharge piped to the tank.
 3. Controls: NEMA 4X panel with two-position main power switch, hand/off/auto switch, low level indicator, audible alarm and silence switch, and dry contacts for passing of alarms to the building BAS.

2.13 FLEXIBLE CONNECTIONS

- A. Furnish and install flexible pipe connections in the suction and discharge of each pump. Connections shall be Type MFTNC as manufactured by Mason Industries or approved equal. The connections shall be installed in strict accordance with the manufacturer's recommendations.
- B. Three Victaulic flexible type couplings may be used in lieu of a flexible connector for vibration attenuation at equipment connections in applicable piping systems. The couplings shall be placed in close proximity to the source of the vibration.

2.14 SUCTION DIFFUSERS AND MULTI-PURPOSE VALVES

- A. Suction diffusers shall be furnished and installed on all pump suction lines. Triple service valves shall be furnished and installed on all pump discharge lines.
- B. The suction diffusers shall be Victaulic 731 / AGS W731 Series or TACO Model SD or equal.
- C. The triple service valves shall be TACO Triple Service valves Model MPV or Victaulic Tri-Service Valve Assembly.

2.15 WATER CIRCULATING PUMPS

- A. Furnish and install circulator pumps with capacities as shown on the drawings. Pumps shall have cast iron casing, steel housing and stainless steel replaceable cartridge. Refer pump schedule on the design drawings for model numbers. Pumps shall be as manufactured by Bell and Gossett, or comparable product as manufactured by Grundfos or Armstrong.
- B. Base Mounted Pumps:
1. Furnish and install pumps where indicated on the drawings. The pumps shall be single stage, end suction, base mounted centrifugal pumps as scheduled and manufactured by Bell and Gossett, Taco, Amtrol, Weinman or approved equal. The pumps shall have the capacity and characteristics indicated on the drawings. The motors shall be controlled by variable frequency drives (VFD). Motors shall be premium efficiency inverter duty motors.
 2. Piping and equipment installed under this contract shall be cleaned, flushed and chemically treated. It shall be the responsibility of the HVAC Contractor to coordinate with the cleaning specialist and the pump manufacturer to ensure that chemicals and other material used for cleaning are not injurious to the pumps seals.
 3. Shop drawings and performance curves shall be submitted to the Architect for approval.

4. The pump curve shall rise continuously from maximum capacity to shut off. Shut off head shall be approximately 10% greater than design head.
 5. The pumps shall operate at or near peak efficiency.
 6. The pumps shall be capable of operating at 25% beyond design capacity without exceeding break-off point.
 7. Motors shall operate over the entire range of the pump without exceeding horsepower rating.
 8. The pumps shall have leakless mechanical seals and be factory mounted and tested. The base mounted pumps and motor shall be mounted on a cast iron base with drip rim.
 9. Shafts shall be provided with cupro-nickel or bronze removable shaft sleeves. Suction and discharge connections shall be flanged suitable to accept 150 psig ANSI flanges.
- C. Contractor shall install the pumps such that the associate sound and vibration are minimal and within the manufacturer approved levels.
- D. Contractor shall coordinate the controls platform with the ATC Sub-subcontractor and provide all required control components to provide a complete working system as specified in the ATC section.

2.16 DIFFERENTIAL PRESSURE VALVE

- A. Furnish and install Differential pressure by-pass valve where indicated on the drawings. Valve shall be Model #519700A as manufactured by Caleffi, Taco, and Honeywell or approved equal. Differential pressure by-pass valve shall have threaded connections 2" FNPT x 2" MNPT outlet, 2" FNPT x 2" sweat outlet, brass body, brass valve plug, EPDM valve plug gasket, EPDM O-Ring seals, asbestos free NBR union seals, ABS control knob, and stainless-steel spring. Valve shall be rated for a temperature range 32–230°F, maximum working pressure 150 psi (10 bar). Setting range shall be 2–10 psi and 2" flow up to 70 gpm.

2.17 MODULAR SCROLL AIR-SOURCE SIMULTANEOUS HEAT PUMP

- A. General: Furnish and install Factory-assembled and performance-tested modular heat recovery heat pump chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories. Heat pump chiller shall be as manufactured by WaterFurnace or approve equal as manufactured by Aermec, Johnson Controls etc.
- B. Description:
1. Air-cooled 4-pipe multipurpose unit should be for simultaneous but independent production of hot and cold water. The 4-pipe unit is designed for systems where hot and cold water can be produced simultaneously. Each module should be capable of operating in 3 distinct modes (chilled water only, hot water only, and combined): Unit should have 3 heat exchangers, one is fully dedicated to chilled water, one is dedicated to hot water, and one is dedicated to environmental side. Cycle reversing valve will divert refrigerant flow through the circuits and choose operating demand based on load demand. One module can produce chilled water or hot water or chilled water with heat recovery and another module can do same operation based on load requirements. Each module should be able to produce chilled and hot water simultaneously.
 2. PRODUCTION OF CHILLED WATER ONLY: The multipurpose unit acts as a classical chiller producing cold water at a system water side plate heat exchanger acting as an evaporator. Heat is disposed outside through finned air side coils acting as a condenser.
 3. PRODUCTION OF HOT WATER ONLY: The multipurpose unit acts as a heat pump producing hot water at a system water side plate heat exchanger acting as a condenser. The air side finned coil acts as evaporator.
 4. The main difference from traditional cycle reverse heat pumps is that the heated water is produced in a different heat exchanger from the one used to produce cold water. This

- separates the two hot-cold sections required for 4-pipe systems. The cold side is dedicated to cold production, and the hot side is dedicated to hot production.
5. **COMBINED PRODUCTION (HEAT RECOVERY):** If the building requires simultaneous hot and cold water, each module acts as a water-to-water heat pump, controlling condensation and evaporation across the two distinct plate heat exchangers associated to circulation of cold and hot water in the system. It automatically changes from one configuration to another (managed by on-board microprocessor) to optimize the spent energy depending on the demand by the utility. The system is capable of modulating the percentage of water-to-water recovery and air-to-water heat transfer, providing a 0 to 100 percent range of recovery.
- C. Cabinet.
1. Base: Galvanized-steel base extending the perimeter of heat pump. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
 2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other heat pump components not directly supported from base.
 3. Casing: Galvanized steel.
 4. Finish: Coat base, frame, and casing with rustproof polyester paint.
- D. Modulating DC Inverter Scroll Compressors.
1. Description: Positive-displacement direct drive with hermetically sealed casing.
 2. Vapor injection compressors. Refrigerant controlled with TEVI sensor.
 3. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 4. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
 5. Capacity Control: Modulating DC Inverter
 6. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
 7. Vibration Isolation: Individual compressors mounted on vibration isolators.
 8. Compressors must be enclosed in acoustically insulated and weatherproof thick galvanized steel compartment.
 9. Compressor compartment must be accessible from the front and both sides of the heat pump via lift-off style access doors.
 10. Lead compressors within an individual unit shall switch to a lag position approximately every 100 hrs of unit operation.
- E. Compressor Motors:
1. Hermetically sealed and cooled by refrigerant suction gas.
 2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
 3. Compressor motors must not exceed 15 horsepower.
- F. Refrigeration:
1. Refrigerant: R-454B
 2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 4. Each module shall have two refrigeration circuits. Each refrigeration circuit must be limited to an aggregate compressor horsepower of 15.

5. Refrigerant Isolation: Factory installed positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the heat pump condenser.
 6. 4-way reversing valve for heating/cooling changeover.
- G. Evaporator:
1. Brazed Plate:
 - a. Direct-expansion, single-pass, brazed-plate design.
 - b. Type 316 stainless-steel construction.
 - c. Heat exchanger shall have two independent refrigerant circuits, one cooling water circuit
 - d. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 2. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator.
 3. Evaporator shall be provided with a factory installed inlet strainer.
- H. Water Circuit and Modularity
1. Modules must require clearance on only two sides in order to perform all service functions.
 2. Each module must be capable of being completely isolated electrically and hydraulically without impacting the operation of the rest of the modules on the set.
 3. Headers shall be provided with Victaulic connections between modules. Headers shall be factory installed and incorporated into the frame of the heat pump. Headers that run outside the frame of the heat pump and/or field installed headers are not acceptable.
 4. Shut off valves shall be provided between evaporator and header of each module.
 5. All modules shall be factory mounted on a common structural steel frame with lifting lugs. All water connections between the modules shall be done at the factory.
- I. Air-Cooled Condenser:
1. Condenser shall be Copper tubes with Aluminum fins.
 2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
 3. Fan Motors: Inverter driven totally enclosed non-ventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection. In order to avoid freezing of the fan motor shaft to the motor frame in weather below 34°F, the fan should be turned on in every 2 hours for 30 seconds to warm up the motor frame.
 4. Fan Guards: Steel safety guards with corrosion-resistant coating.
- J. Defrost
1. The units must include intelligent defrost. This allows the unit to go in defrost only when is needed, avoiding unnecessary defrost cycles. This shall be achieved by monitoring the suction pressure decay and the OAT.
 2. Timed defrost is not allowed.
 3. Heat pumps performance and efficiency should take into consideration of defrost cycles.
 4. Defrost cycle should not usually be less than 2 minutes and not more than 6 minutes.
 5. During defrost cycle, condenser fan should be off.
 6. Defrost will start only when external air temperature is less than 50F .
 7. Low pressure threshold on the coil should be less than 5.2 bar/75.42 Psi.
 8. When the pressure variations between clean and uncleaned coil is 0.6 bar/8.70 psi, defrost will start automatically.

9. Minimum time between two defrost cycles should be greater than 15 minutes.

K. Electrical Power:

1. Factory installed and wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to each module.
2. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.
3. Electrical enclosure shall be mounted on hinges in order to maximize serviceability to components located behind.
4. Wiring shall be numbered and color-coded to match wiring diagram.
5. Install factory wiring outside of an enclosure in a raceway.
6. Field power interface shall be heavy-duty, nonfused disconnect switch.
7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water heat pump control microprocessor.
9. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
10. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate controls
11. Control Relays: Auxiliary and adjustable time-delay relays.
12. Indicate the following for water heat pump electrical power supply:
13. Current, phase to phase, for all three phases.
 - a. Voltage, phase to phase and phase to neutral for all three phases.
 - b. Three-phase real power (kilowatts).
 - c. Three-phase reactive power (kilovolt amperes reactive).
 - d. Power factor.
 - e. Running log of total power versus time (kilowatt hours).
 - f. Fault log, with time and date of each.
14. Each bank of modules shall be provided with a single point power connection at a 65,000-amp SCCR. All the wiring from the bank single point power panel to each individual module shall be done at the factory. Single point power panel shall include a disconnect switch and shall be factory mounted on the common steel frame supporting the modules.

L. Controls:

1. Each set of modules shall be provided with a single master controller that will interface with each module's controller in order to stage capacity and orchestrate the operation of all modules in order to maximize efficiency and resiliency.
2. Each module shall be provided with a microprocessor-based controller that communicates via BACNet.
3. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
4. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Operating hours.
 - d. Outside-air temperature if required for chilled-water reset.
 - e. Temperature and pressure of operating set points.
 - f. Entering and leaving temperatures of chilled water.
 - g. Refrigerant pressures in evaporator and condenser.
 - h. Saturation temperature in evaporator and condenser.

- i. No cooling load condition.
 - j. Elapsed time meter (compressor run status).
 - k. Antirecycling timer status.
 - l. Percent of maximum motor amperage.
 - m. Current-limit set point.
 - n. Number of compressor starts.
5. Control Functions:
- a. Manual or automatic startup and shutdown time schedule.
 - b. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water or outside-air temperature.
 - c. Current limit and demand limit.
 - d. External water heat pump emergency stop.
 - e. Antirecycling timer.
 - f. Automatic lead-lag switching.
6. Manual-Reset Safety Controls: The following conditions shall shut down water heat pump and require manual reset:
- a. Low evaporator pressure or high condenser pressure.
 - b. Low chilled-water temperature.
 - c. Refrigerant high pressure.
 - d. High or low oil pressure.
 - e. High oil temperature.
 - f. Loss of chilled-water flow.
 - g. Control device failure.
- M. Insulation:
1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
 2. Thickness: 3/4 Inch
 3. Factory-applied insulation over cold surfaces of heat pump components.
 - a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 4. Apply protective coating to exposed surfaces of insulation.
- N. Source Quality Control
1. Heat pumps shall be manufactured in an ISO 9001 certified facility.
 2. Each module shall be factory performance tested on a third party certified test stand to ensure proper operation in heating and cooling design conditions, full load efficiency and full load capacity. Test reports shall be made available to owner and engineer upon request. AHRI certification does not preclude heat pump from performance test requirement.
 - a. Functional Test
 - i. Pre-charge unit with nitrogen and test for leakage
 - ii. Establish a vacuum to remove all gas and to eliminate moisture inside the refrigerant circuit
 - iii. Charge the unit with refrigerant
 - iv. Connect the evaporator and condensers inlet and outlet water connections to the testing room plant
 - v. Set the water flow to the design flow rate
 - vi. Connect power to the unit and carry out test of voltage and frequency on the electrical panel
 - vii. Program the microprocessor control with basic working parameters
 - viii. Set up the valves and trim the refrigerant charge

- ix. Start up each compressor and test electrical data
- x. Set up all the pressure switches
- xi. Calibrate the various temperature and pressure probes on the circuit
- b. Performance Test
 - i. Test the following alarms on the microprocessor through run test
 - 1) High pressure alarm
 - 2) Low pressure alarm
 - 3) Compressors alarm
 - 4) Evaporator freeze alarm
 - ii. Test probe failures
 - iii. Run the heat pump in the production climatic test chamber at full load conditions at design conditions (each circuit):
 - iv. Record the performance data on the test report sheet and provide a copy to engineer and owner.
 - v. Each compressor circuit will be run separately.
- O. Options:
 - 1. Both compressors of a module shall be variable speed/capacity.
 - 2. All modules shall be mounted on a common steel frame provided by the manufacturer. Provide 18" high stand.

2.18 PLATE AND FRAME HEAT EXCHANGER

- A. Furnish as shown on the plans, a plate and frame heat exchanger as manufactured by Alfa-Laval or approved equal. The Plate Heat Exchanger manufacturer shall not subcontract or purchase for resale the plates. He shall press his own patterns of plates.
- B. AHRI LLHE Certification - Plate heat exchangers shall be certified according to AHRI Standard 400 and listed on the AHRI.net.org site. If heat exchanger is not AHRI certified, then the manufacturer shall provide an independent third-party field performance test using the mapped ratings, limits and tolerances of AHRI Standard 400 to verify performance to specification. Any and all cost associated with correcting a non-performing heat exchanger to meet the performance requirements shall be the responsibility of the supplier. Any cost associated with the field performance test shall be included in the price of the heat exchanger. As an alternate, if heat exchanger is not AHRI certified, then the manufacturer shall provide 110% of the heat transfer area of an AHRI certified heat exchanger and provide written verification of performance to specification. Any and all cost associated with correcting a non-performing heat exchanger to meet the performance requirements shall be the responsibility of the supplier.
- C. ASME Certification: Plate heat exchangers shall be designed, constructed, and tested in accordance with Section VIII, Division I of the ASME Pressure Vessel Code, and shall be code stamped.
- D. Warranty: The warranty period shall be 3 years from date of shipment for AHRI certified plate heat exchangers.
- E. Frame Components
 - 1. The fixed and movable covers shall be of sufficient thickness for the design pressure and code requirements and shall have no welded reinforcements or stiffeners.
 - 2. The movable cover shall be provided with a steel roller bearing for units greater than 52" in height (from bottom of feet). This allows the movable cover to be moved without additional rigging or handling equipment.
 - 3. The carrying and guide bars shall be designed to allow for expansion of at least 15%.
 - 4. The carrying and guide bars guiding system shall be precision manufactured of stainless steel to prohibit corrosion and facilitate movement of the plates. Painted or plated surfaces are not permitted.

5. Entire frame shall be bolted together to allow unit to be field assembled to permit rigging into place. Welding of the frame components is not permitted.
 6. Plate and carrying bar design shall permit the removal or access to any plate in the plate pack without the need to remove any other plates.
 7. Provide lifting lugs designed to allow lifting of the entire units flooded weight.
 8. All steel surfaces shall be thoroughly cleaned and prepared for painting per SSPC-SP6, painting over mill scale is not acceptable. All steel components shall be Aliphatic Polyurethane coated.
- F. To avoid leakage on port area, studded port design should be provided on heat exchangers with connections greater than 2". Flanged nozzle connections are not acceptable. Stud bolts must be installed at each studded port.
- G. To avoid leakage on port area, studded port design should be provided on heat exchangers with connections greater than 2". Flanged nozzle connections are not acceptable.
- H. Compression Bolts
1. Compression bolts shall not require special tools and shall be equipped with lock washers at the movable cover to facilitate opening and closing of the unit from the fixed cover.
 2. Compression bolts shall be equipped with captive nuts at the fixed cover and threaded nuts at the movable cover. Welding of the nut to the closure bolt is prohibited.
 3. Bolts shall be provided with rolled threads to reduce galling and double width hex nuts to adequately distribute the load, plus ball bearing box washers at all critical closing bolts on all units greater than 52" in height and connections 6" and larger.
 4. Tightening bolts shall be liberally coated with LUBRIPLATE FGL-2 for lubrication and rust prevention and covered with a plastic protective sleeving for protection from the environment and to prevent bodily injury. Zinc plating is prohibited.
 5. The bolting system shall be designed so that only (4) compression bolts are required opening and closing of the unit.
- I. Plates
1. The plate and frame heat exchanger shall consist of pressed type ALLOY 304 or 316 to provide the required heat transfer area to meet the operating conditions specified.
 2. Individual plates shall be pressed from a homogeneous single metal sheet in one step. No multi-stage pressing of one sheet is allowed.
 3. Each heat transfer plate to be with herringbone corrugations to optimize heat transfer with nominal pressure losses. Corrugations to be designed to provide support to adjacent plates at evenly distributed support points to allow pressurization of each circuit to a full differential of 1.3 times the design pressure for one hour without buckling or deformation of the heat transfer plates.
 4. All plates and gaskets shall be permanently marked to identify quality and material.
 5. Each heat transfer plate shall have a built-in self-aligning system to accurately locate the plates in the frame assembly and prevent lateral plate movement and maintain maximum gasket contact under pressure.
 6. Plates shall be reinforced on the upper and lower mounting slots to avoid bending hangers on the plates.
 7. The plate and frame heat exchanger shall be designed to perform the capacities and pressure drops as shown on the schedule. Plates to be with II B finish and tapered gasket grooves.
 8. The plate pack shall be covered with a aluminum shroud in accordance with OSHA.
- J. Gaskets

1. Gaskets shall have relieving grooves to prevent intermixing of fluids across a gasket and create a leak path to outside of unit.
2. One-piece molded CLIP-AD NBR gaskets are required and shall fit around both the heat transfer area and the port holes.
3. All gaskets shall be permanently marked to identify material and traceability, including date stamp.
4. Preference shall be given to non-glued gasketing systems.
5. If an adhesive is necessary, it shall be compatible with the gasket material and the fluids. The adhesive shall be a 2-component epoxy glue and heat cured.

K. Inspection and Testing

1. The plate heat exchanger shall be designed to withstand full test pressure in one circuit with zero pressure in the alternate circuit.
2. Hydrostatic test pressure shall be 1.3 time the design pressure in accordance with ASME Section VIII, Division 1, paragraph UG-99.
3. Plate heat exchanger shall be ASME U Stamped.

L. Preparation for Shipment

1. A stainless-steel nameplate shall be securely attached to the exchanger in a location that is easily accessible and visible after installation. The nameplate must include the following items:
 - a. ASME U or UM Stamp
 - b. Maximum allowable working pressure
 - c. Minimum design metal temperature
 - d. Serial number
 - e. Year in which the unit is manufactured
 - f. Model number
 - g. Surface area
 - h. Plate pack tightening dimension
 - i. Manufacturer's order number
 - j. Customer's purchase order number.
2. The plate heat exchanger shall be fully drained? flushed clean at factory prior to shipment. All connections shall be factory sealed to prevent the entrance of foreign material during transit.

2.19 INSULATION

- A. Provide pipe covering and duct insulation of the type hereinafter specified on the following: hot water piping, cold water make-up piping, refrigerant piping and sheet metal ducts. All sealers, solvents, tapes, adhesives and mastics used in conjunction with this section of the specifications shall possess the maximum safety quantities available and Standards #90A and #90B. Insulation shall be fiberglass except as specified hereinafter having a minimum density of four pounds per cubic foot. Insulation shall be as manufactured by Owens/Corning Fiberglass Corporation, Armstrong, Johns-Manville or equal and installed in accordance with the manufacturer's recommendations.
- B. Piping: All new piping and fittings throughout the building, as shown on the drawings, shall be insulated with Owens/Corning Fiberglass, or equal, 25 ASJ glass fiber insulation in molded sections. Glass fiber insulation shall have a minimum density of 3-1/4 pounds per cubic foot with a thermal conductivity ("K" value) of 0.23 at 75°F mean temperature. All piping shall have a factory applied all service vapor barrier jacket. The end joints of the insulation shall be sealed with factory furnished end joint sealing tape. Longitudinal seams shall be sealed with Benjamin Foster 85-75 adhesive. The thickness of insulation to be applied to piping shall be as follows:

1. All new hot water supply and return piping less than 1.5" in diameter shall be insulated with 1.5" thick insulation and piping 1.5" and greater in diameter shall be insulated with 2" thick insulation. Staples shall not be used in any part of this installation.
2. Chilled water supply and return piping less than 6" in diameter shall be insulated with 1.0" thick insulation and piping 6" and greater in diameter shall be insulated with 1.5" thick insulation. Staples shall not be used in any part of this installation.
3. All cold-water make-up piping shall be covered with 1" fiberglass pipe covering with factory applied flame resistant vapor barrier adhesive. End joints shall be finished with 4" wide matching vapor barrier strips, sealed with adhesive. Staples shall not be used in any part of this installation.
4. The end joints of insulation shall be tightly butted and covered with factory furnished end joint sealing tapes. The jacket overlap shall be sealed with an approved sealer which shall not mar the jacket finish. Staples shall not be used for fastening insulation.
5. All fittings, valves and flanges shall be insulated with the same thickness of fiberglass as on the piping, with mitered segments of pre-molded F/G fittings wired in place after which a one mil aluminum foil vapor barrier shall be wrapped tightly over the insulation with all laps sealed with the manufacturer's vapor seal mastic. Wet coats of vapor seal mastic with imbedded glass fabric shall be applied to fittings, etc., per the manufacturer's recommendations. Staples or tacks shall not be used.
6. Provide PVC plastic pipe jacket over pipe insulation for all exposed piping on the roof or at locations indicated on drawings. Jacket shall be 10 mil thickness, ASTM C921, sheet material, off-white color, ASTM E96; 0.002 perm-inches. Adhesives and mastic shall be compatible with insulation. Pipe jacketed shall be rated for sunlight and provide shielding from solar radiation.

2.20 MOTOR STARTERS

- A. Furnish and install all motor starters required for HVAC equipment under this section if not factory installed by the equipment manufacturer. The starters shall be wired by a licensed Electrician.
- B. Motor Controls – Manual and Magnetic:
 1. The individually mounted magnetic starters indicated on the plans and as required shall be magnetic across-the-line starters with thermal overload on each phase.
 2. Starters shall be of the size and type required for particular motor horsepower and voltage. Minimum size starter to be Size 0.
 - a. All starters shall have OL reset button, pilot light to indicate on or off and hand-off-auto switch in cover, unless indicated otherwise.
 - b. All starters to have 120-volt control via individual control transformers fused on the secondary, where not fed at 120 volts.
 3. Manual motor starters shall be furnished with thermal overloads on each phase. Thermal switches shall be provided with pilot lights.
 4. Three (3) auxiliary contacts shall be furnished and installed in all motor starters (1 NC, 2 NO).
 5. Motor starters shall be all manufactured by the same company and shall be one of the following: Square D Company, Allen Bradley, General Electric, Cutler Hammer or ITE.

2.21 HEAT TRACE

- A. Provide electric heat trace for all chilled water and hot water piping exposed on the roof. Acceptable heat trace manufacturers: Cromalox, Emerson, Thermon or approved equal
- B. Self-regulating heating cables are designed to provide freeze protection to metallic and nonmetallic piping.

1. Construction: Nickel I-plated copper bus wires (16 AWG), Radiation cross-linked semiconductive heating matrix, Radiation cross-linked dielectric insulation, Tinned copper braid, Polyolefin overjacket.

- C. Provide a temperature control and monitoring module. The module shall provide control and monitoring capabilities with a digital information display for one or two heat tracing circuits with input from up to two RTDs per circuit. The control module shall be capable of interfacing with the BAS for status and alarms.

2.22 WATER TREATMENT

- A. The water treatment contractor shall provide complete water treatment service designed to minimize corrosion and scale formation in the hot water heating system. This service shall be provided for a period of one year and shall include the following:
 1. Liquid chemical bypass type feeder of approximately 5-gallon capacity, complete with valves, fittings and shall be connected in the hot water heating systems as indicated on the drawings.
- B. The system shall be thoroughly flushed and cleaned with chemicals as recommended by the water treatment contractor.
- C. The water treatment contractor shall recommend the chemicals for the piping systems with control limits of 800 to 1,000 PPM to be maintained or as recommended by the water treatment contractor.
- D. The water treatment contractor shall provide all water analysis as required to determine the chemicals for the water piping system.
- E. Provide the necessary training of plant personnel in the use of test kits, chemical usage and log back entries.
- F. System shall be tested and treated a minimum of two times during the one-year service period in addition to the initial treatment during the system installation/start-up.

2.23 VARIABLE FREQUENCY DRIVE (VFD):

- A. The pump motor for water circulating pumps shall be controlled by variable frequency drives to insure maximum operating efficiency. Base mounted water circulating pumps shall be provided with remote VFDs.
- B. Acceptable VFD manufacturers: Hitachi, Reliance, Sumitomo, Toshiba or approved equal.
- C. Provide VFDs with microprocessor-based inverter logic isolated from power circuits, pulse-width-modulated inverter system, ability to operate controller with motor disconnected from output, integral digital display, Status Indicators, door and safety interlocks, output filter, and 5% AC line reactor.
- D. Contractor shall furnish and install the wall mounted VFDs for the supply and return fans. Electrical Subcontractor shall wire them.

2.24 AUTOMATIC TEMPERATURE CONTROL SYSTEM

- A. General:
 1. Furnish and install, as hereinafter specified, a complete electronic temperature control system as manufactured by Honeywell, SIEBE, Johnson, or approved equal. Contractor shall note that the existing Building Management System (BMS) is by Delta Controls with a BACnet protocol. The Owners Control contractor is R.P. O'Connell, Inc., 3 Huron Dr., Natick, MA 01760, phone # (508) 650-9400 and email rpoconnell@rpoconnell.com. The new control components shall be compatible with the existing BMS and shall interface with the BMS seamlessly. The new control components shall include native BacNet controls.

2. The control system shall be furnished and installed by competent control engineers and mechanics. All control equipment shall be the product of one manufacturer.
3. **IT IS THE RESPONSIBILITY OF THE HVAC CONTRACTOR TO VERIFY THE CONTROL COMPONENTS BEING PROVIDED BY THE VARIOUS EQUIPMENT MANUFACTURERS AS PART OF THE EQUIPMENT AND REVIEW THIS INFORMATION WITH THE ATC SUBCONTRACTOR TO ENSURE WHAT EXTRA CONTROL COMPONENTS WOULD BE PROVIDED BY THE ATC SUBCONTRACTOR TO INSTALL A FULLY FUNCTION SYSTEMS AS NOTED IN THIS SECTION. NOTE THAT THE EQUIPMENT IS BEING SPECIFIED WITH BASIC CONTROLS STANDARD TO THE UNITS. ATC SUBCONTRACTOR IS RESPONSIBLE TO PROVIDE ALL CONTROL COMPONENTS FOR INSTALLATION AND OPERATION OF THE VARIOUS EQUIPMENT AS PER THIS SPECIFICATION.**

B. Scope:

1. The control system shall consist of all hardware and software and not limited to, temperature sensors, thermostats, temperature transmitters, controllers, automatic valves, pressure sensors, DDC control panels, operator devices, and other accessory equipment, relays, transformers, automatic dampers and damper operators, along with a complete system of electrical & control wiring to fulfill the intent of the specification and provide for a complete and operable system. All control equipment shall be fully proportioning, except as noted otherwise. A well-defined component naming convention shall be established to clearly identify all the control components. The object naming convention shall be approved by the building Owner before controls installation and programming begins.
2. The existing Direct Digital Control System is capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, and historical data (trends) collection and archiving. The new control components associated with the systems being upgraded as part of this project shall tie-into the existing BMS to provide the same.
3. Stand-alone DDC panels shall be able to access any data from or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device. Stand-alone DDC panels shall also be able to send alarm reports to operator workstation without dependence upon a central processing device.
4. Install and/or wire all control devices furnished with equipment which is not factory installed and/or wired. Furnish all control devices required for equipment which is not furnished with the equipment.

C. Related Work:

1. Cutting, Patching and Painting.
2. Openings in walls, roofs/flashing.
3. Equipment foundations and bases.
4. All temporary cooling and heating.

D. The following incidental work shall be furnished by the designated contractor under the supervision of the control contractor:

1. The HVAC Contractor shall:
 - a. Coordinate the work required for the ATC system with other contractors.
 - b. Install automatic valves, instruments wells, taps, flow stations and other similar devices specified to be furnished by the ATC Subcontractor.
 - c. Provide, on magnetic starters furnished, all necessary auxiliary contacts, with buttons and switches in required configurations.
 - d. Furnish and install access doors or other approved means of access through ceiling and walls for service to control equipment.

2. The Sheet Metal Contractor shall:
 - a. Install all automatic dampers and airflow stations that are specified to be supplied by the ATC Subcontractor.
 - b. Provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
 - c. Assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.
 - d. Furnish and install access doors or other approved means of access through ducts for service to control equipment.
 3. The General Contractor shall provide all necessary cutting, patching and painting.
 4. The Electrical Subcontractor shall,
 - a. Provide 120v power to all facility management and/or temperature control panels.
 - b. Wire all power feeds through all disconnect starters to electric motor.
 - c. Wire and remote start/stop switches and manual or automatic motor speed control devices not furnished by the ATC manufacturer.
 - d. Wire any electrical sub-metering devices not provided by the ATC manufacturer.
 - e. Provide and wire to the fire alarm system all required smoke detectors. Detectors shall be installed by the Sheetmetal Contractor and wired to shut down the unit by the ATC Subcontractor.
- E. Electric Wiring:
1. All electric wiring and wiring connections, either line voltage or low voltage, required for the installation of the temperature control system, as herein specified, shall be provided by the temperature control contractor unless specifically shown on the electrical drawings or called for in the electrical specifications. The wiring installation shall be in accordance with National and local codes and with the electrical portion of these specifications. All wiring shall be run concealed wherever possible. Exposed wiring in occupied spaces shall be run in raceways. Raceways shall be Wiremold 200 Series with all elbows, raceways, covers, mounting stops, box extensions and wiring for a complete and neat installation. 120-volt power shall be provided by the Electrical Subcontractor. Exposed wiring in the Mechanical spaces shall be run in EMT conduit.
 2. All wiring shall comply with the requirements of the state and National Electric Code.
 3. All control wiring required for the automatic control system shall be provided from these points by the ATC Subcontractor who shall provide transformers and all control devices required for the control system. The wiring installation shall be in accordance with National and Local Codes. All wiring shall be run concealed wherever possible. Exposed wiring in occupied spaces shall be run in raceways. Raceways shall be Wiremold 200 Series with all elbows, raceways, covers, mounting stops, box extensions and wiring for a complete and neat installation. Exposed wiring in the Mechanical spaces shall be run in EMT conduit. Provide control wiring between indoor air handling unit and remote-control panels, between boilers and remote-control panels, and between control panels and remote sensors. Provide all interfaces for air handling unit, boilers and all HVAC equipment with the DDC system.
- F. Submittal Brochure: The following shall be submitted for approval:
1. Control drawings with detailed piping and wiring diagrams, including bill of material and description of operation for all systems.
 2. Panel layouts and nameplate lists for all local and central panels.
 3. Valve and damper schedules showing size, Cv, configuration, capacity and location of all equipment.
 4. Data sheets for all control system components.

5. Control strategies (software flow charts) shall be included within the first ATC shop drawing submittal. The listing of each strategy shall be in English and demonstrate the desired ATC sequence of operation. Submittal shall be complete with proposed schedules, listing of setpoints and end device point listing and address.
 6. Sequence of operations.
 7. Point names and addresses.
 8. System riser diagrams.
 9. Data sheets for all control system components.
- G. Instruction and Adjustment: Upon completion of the project, the ATC Subcontractor shall:
1. Completely adjust, ready for use, all thermostats, controllers, valves, damper operators, relays, etc., provided under this section. Include a points check-out report.
 2. Furnish three (3) instruction manuals covering the function and operation of the control systems on the project for the use of the Owner's operating personnel. A competent technician shall be provided for instruction purposes and Contractor shall provide eight (8) hours of instruction to Owner's designated representatives on operation of the control system. Two (2) owners representatives should be trained. The training shall include but not limited to login and navigate the system, adjust set points and schedules, clear alarms, back up data, add or modify control points, add or modify graphics, add or modify trends, and to use any troubleshooting software tools.
- H. Guarantee: The control system designated on drawings and plans and herein specified shall be guaranteed to be free from original defects in both material and workmanship for a period of eighteen (18) months or normal use and service, excepting damages from other causes. This guarantee shall become effective starting the date the owner begins to receive beneficial use of the system. During the eighteen (18) month guarantee period, Contractor shall provide programming changes to the installed system as requested by the Owner for a maximum of forty (40) hours.
- I. Programmed Maintenance:
1. Upon completion of the installation, the control contractor shall submit to the owner, an agreement to provide the necessary programmed maintenance to keep the various control systems in proper working condition.
 2. This programmed maintenance agreement shall fully describe the maintenance work to be performed and shall advise the cost of this work during the guarantee period, as well as for subsequent years thereafter. For tow (2) thru five (5) years, Contractor shall advise the cost breakdown for annual service, discount on parts, miscellaneous programming and telephone support.
- J. Remote Alarming:
1. Alarm Reporting shall be able to do the following:
 - a. Listen to and acknowledge alarm details
 - b. Max tag limit of 20K
 - c. Four contact devices per operator
 - d. Compatible with SuiteLink and DDE protocols
 - e. Capable of e-mailing alarm log files at scheduled intervals
 - f. Broadcast alarms over speakers, intercoms, radios and multimedia systems
 - g. Send alphanumeric and numeric messages to pagers and mobile phones
 - h. Ability to group alarms and prioritize individually
 - i. Human voice recording
 - j. Multiple operator clearance levels
 - k. Daily schedule and personal calling preferences for each operator
- K. Real-Time Trending

1. Real-Time trend displays shall support up to 4 trend pens and unlimited trend windows per display.
2. Real-Time time trend displays shall be able to continue to update regardless of whether the operator is currently viewing the trend window. Trend displays shall also support the option to update trends only when displayed in the active window.
3. Real-Time trend displays shall support any local tag name or an expression that contains one or more local tag names including add, multiply, divide, etc. to permit proper scaling of variables.

L. Historical Trending

1. Historical trend display should allow the user to zoom in and out in time from 1 second up to 6 weeks in one display. It shall be possible to activate the zoom-in and zoom-out features using action scripted command buttons available to the operator.
2. The operator shall have the capability to pan backward and forward in time to view historically logged data.
3. The operator should have the capability to print out historically trended information in the form of a printed record for documentation purposes.

M. Reports:

1. System server shall be capable of periodically producing reports of trend-logs, alarm history, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

N. Sensors:

1. Electronic Temperature Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. Resistance Temperature Detectors: Platinum, thermistor, or balco.
 - a. Accuracy: Plus or minus 0.2 percent at calibration point; thermistors shall have a maximum 5 year drift of no more than .225°F maximum error of no more than .36°F.
 - b. Wire: Twisted, shielded-pair cable.
 - c. Insertion Elements in Ducts: Single point, 6 inches long; use where not affected by temperature stratification or where ducts are smaller than 4 sq. ft.
 - d. Averaging Elements in Ducts: 60 inches, long, flexible for use where prone to temperature stratification or where ducts are larger than 4 sq. ft.; 264 inches long, flexible for use where prone to temperature stratification or where ducts are larger than 16 sq. ft; length as required.
 - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
 - f. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
 - g. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.
3. Humidity Sensors: Bulk polymer sensor element.
 - a. Accuracy: 2 percent at 10-90% RH with linear output.
 - b. Room Sensors: Range of 0 to 100 percent relative humidity
 - c. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

4. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: +/- 1 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA, 0-5 vDC, 0-10 vDC.
 - c. Building Static-Pressure Range: -.1 to .1, -.025 to 0.25, -.5 to .5, -1.0 to 1.0 IN WC., jumper selectable.
 - d. Duct Static-Pressure Range: 0 to 1, 0 to 2.5, 0 to 5, 0 to 10 IN WC., jumper adjustable.
 - e. Water Differential Pressure Transmitter: Low differential pressure transducer for wet-wet application. 4-20 milliamp output signal. Setra C230 or equal.
 5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
 6. Equipment operation sensors as follows:
 - a. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 IN WC
 - b. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
 - c. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
 7. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 8. Water-Flow Switches: Pressure-flow switches of bellows actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless steel or bronze paddle.
- O. Equipment
1. Stand-alone DDC Panels: Shall be microprocessor based multi-tasking, multi-user, real time digital control processors. Each stand-alone DDC panel shall consist of modular hardware and plug in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the attached point list. Each DDC panel shall have sufficient memory to support its own operating system and data bases, including:
 - a. Control process.
 - b. Energy management applications.
 - c. Alarm management.
 - d. Historical/trend data for all points.
 - e. Maintenance support applications.
 - f. Custom processes.
 - g. Manual override monitoring.
 2. Pump Sequencer: For the system chilled water and hot water circulating pumps, Contractor shall provide all required control components for the BMS to operate the system pumps if not provided by the pump manufacturer. The BMS shall automatically energize the stand-by pump on failure of the primary pump and shall alternate the primary and stand-by pumps and ensure runtime averaging.
 3. Automatic Control Valves:
 - a. All automatic control valves shall be fully proportioning with modulating or two position plug or V-port inner guides, unless otherwise specified. The valves shall be quiet in operation and fail-safe in normally open position in the event of power failure. All valves shall be capable of operation in sequence when required by the sequence of operation. All control valves shall be sized by the control manufacturer and shall be guaranteed to meet the heating loads as specified. All control valves shall be suitable for the pressure

- conditions and shall close against the differential pressure involved. Valve operators shall be of the molded synthetic rubber diaphragm type. Body pressure rating and connection type (screwed or flanged) shall conform to pipe schedule in this specification.
- b. All valves sequenced with other valves or control devices shall be equipped with pilot positioners.
 - c. Hot water control valves shall be single-seated type with equal percentage flow characteristics. The valve discs shall be composition type with bronze trim.
4. Local Control Panels:
- a. All controllers, relays, switches, etc., for equipment located within the mechanical equipment rooms shall be mounted on enclosed control panel with hinge lock type door mounted adjacent to the system controlled. All temperature setting, adjustments and calibrations shall be made at the system control panel. Each panel shall have a canopy light and on/off switch.
 - b. Details of each panel shall be submitted for approval prior to fabrication. Location of each panel shall be convenient for adjustment and service. Provide engraved nameplates beneath each panel mounted control device and air gauge clearly describing the function of said device and range of operation. All manual switches, dial thermometer and indicating air gauges shall be flush mounted on the hinged door.
 - c. All electrical devices within the panels shall be factory pre-wired to a number terminal strip. All wiring within the panel shall be in accordance with NEMA and UL standards and shall meet all local codes.
 - d. Provide a DDC controller for the air handling unit and boiler. The DDC controller shall be installed in the Mechanical Room containing the unit which is being controlled. The DDC controllers shall be interlocked with the EMS.
5. Miscellaneous Devices: Provide all the necessary relays, cumulator, temperature and humidity sensors, carbon dioxide sensors, air flow measuring devices, positioners, transformers, etc., to make a complete and operable system. Provide all the necessary switches, clocks, etc., to make a complete and operable system. Time clocks shall be seven day electronic programmable with override feature.
6. Control Cable
- a. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Division 16 Section "Control/Signal Transmission Media."
7. System Software:
- a. General:
 - 1) All necessary software to form a complete operating system as described in this specification shall be provided.
 - 2) The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher-level computer for execution.
 - b. Control Software Description:
 - 1) Two position control.
 - 2) Proportional control.
 - 3) Proportional plus integral control.
 - 4) Proportional, integral, plus derivative control.
 - 5) Automatic control loop tuning.
 - c. Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

- d. The system shall provide protection against excessive demand situations during start up periods by automatically introducing time delays successive start commands to heavy electrical loads.
 - e. Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.
8. The control system shall have the ability to control, adjust and monitor each system as described below through the Building Management System. Historical data shall be recorded and archived for all control points listed below unless otherwise noted. The temperature, airflow and CO2 control point shall be displayed graphically on the BMS.
- a. Air-Cooled Heat Pump Chiller:
 - 1) Chiller enable/disable.
 - 2) Chiller status. No. of modules active.
 - 3) No. of modules active and operating in heating, cooling or combined mode.
 - 4) Chilled water flow gpm.
 - 5) Hot water flow gpm.
 - 6) Chilled water supply temperature set point.
 - 7) Chiller water discharge temperature.
 - 8) Chiller water entering temperature.
 - 9) Hot water supply temperature set point.
 - 10) Hot water discharge temperature.
 - 11) Hot water entering temperature.
 - 12) Chilled and hot water reset control.
 - 13) Chiller evaporator load in Tons (calculated)
 - 14) Low water temperature alarm.
 - 15) Chiller alarms.
 - b. Hot Water Circulator pumps:
 - 1) Pump status.
 - 2) Lead/lag control.
 - 3) Pump stage (1 through 8).
 - 4) System flow GPM. Flow shall step based on number of active modules. Steps shall be 1 – 44.1 gpm, 2 – 88.2 gpm, 3 – 132.3 gpm, 4 – 176.4 gpm, 5 – 220.5 gpm, 6 – 264.6 gpm, 7 – 308.7 gpm and 8 – 352.8 gpm.
 - 5) Variable frequency drives % command.
 - 6) Pump failure alarms.
 - 7) System (building) and Heat Pump (glycol loop) hot water supply temperature.
 - 8) System (building) and Heat Pump (glycol loop) hot water return temperature.
 - 9) Bypass valve position.
 - c. Chilled Water Circulator pumps:
 - 1) Pump status.

- 2) Lead/lag control.
 - 3) Pump stage (1 through 8).
 - 4) System flow GPM. Flow shall step based on number of active modules. Steps shall be 1 – 68.8 gpm, 2 – 137.6 gpm, 3 – 206.4 gpm, 4 – 275.2 gpm, 5 – 344 gpm, 6 – 412.8 gpm, 7 – 481.6 gpm and 8 – 550.4 gpm.
 - 5) Variable frequency drives % command.
 - 6) Pump failure alarms.
 - 7) System (building) and Heat Pump (glycol loop) chilled water supply temperature.
 - 8) System (building) and Heat Pump (glycol loop) chilled water return temperature.
 - 9) Bypass valve position.
 - d. Heat Exchanger – Chilled Water Glycol Loop:
 - 1) Building CHW entering temperature.
 - 2) Building CHW leaving temperature.
 - 3) Heat Pump Chiller CHW entering temperature.
 - 4) Heat Pump Chiller CHW leaving temperature.
 - e. Heat Exchanger – Hot Water Glycol Loop:
 - 5) Building HW entering temperature.
 - 6) Building HW leaving temperature.
 - 7) Heat Pump Chiller HW entering temperature.
 - 8) Heat Pump Chiller HW leaving temperature.
 - f. Global Points:
 - 9) Outdoor air temp. (DB/WB)
 - 10) Outdoor air humidity. (Rh)
 - g. General
 - 1) Optimal Start - Stop
 - 2) Occupied - Unoccupied cycles.
 - 3) Alarm conditions for failure.
- P. Sequence of Operation:
1. Outdoor Air Sensor:
 - a. Provide an outdoor air sensor on the North side of the building to provide the control functions related to outdoor air temperature for the Automatic Temperature Control System.
 2. Heat Pump Chiller: The occupied and unoccupied cycles of operation shall be provided by the existing BMS. The unit shall be interfaced with the existing BMS for start/stop status, control points and alarms. Install all control equipment furnished with the unit which are not factory installed, including remote control panels and potentiometer switches with dials, which shall be installed in the Mechanical Room.
 - a. Heating Mode: On a call for heat as directed by the existing BMS, the heat pump chiller will activate modules as required to maintain a discharge water temperature setpoint to the building. As the module(s) get called, the required minimum flow as noted in the steps above for the module(s) shall be maintained in the HW header. The glycol loop hot water

pumps shall be stepped to provide the required minimum flow at the header. The flow shall be proven at the flow measuring station located on the entering side of the chiller before the module(s) shall energize to operate. Provide new flow measuring station as required. This should be achieved maintaining the required time delays for response to prevent the chiller module to low/no flow situation. Based on the variable capacity requirement of the module(s), to meet the discharge water setpoint the water will be bypassed through the integral chiller bypass valve assembly provided by the chiller manufacturer. Control for this bypass is internal to the chiller controls.

- Note that the heat pump chiller shall provide heating only when the return water temperature from the building shall be below 120°F (adjustable). When the return water temperature is below 120°F (adjustable) and discharge water temperature falls below the setpoint, the heating shall switch to the existing boilers. The heat pump chiller heating models shall be locked out and the associated 3-way valves in the HW piping to the heat exchanger building side loop shall close. When the boilers are in operation, the existing sequence of operation shall be maintained.
 - b. Cooling Mode: On a call for cooling as directed by the existing BMS, the heat pump chiller will activate modules as required to maintain a discharge water temperature setpoint to the building. As the module(s) get called, the required minimum flow as noted in the steps above for the module(s) shall be maintained in the CHW header. The glycol loop chilled water pumps shall be stepped to provide the required minimum flow at the header. The flow shall be proven at the flow measuring station located on the entering side of the chiller before the module(s) shall energize to operate. Provide new flow measuring station as required. This should be achieved maintaining the required time delays for response to prevent the chiller module to low/no flow situation. Based on the variable capacity requirement of the module(s), to meet the discharge water setpoint the water will be bypassed through the integral chiller bypass valve assembly provided by the chiller manufacturer. Control for this bypass is internal to the chiller controls.
 - c. Simultaneous Heating and Cooling Mode: This mode shall be similar to the heating/cooling models with regards to stepping the flow as required to meet the chiller sequence to maintain the discharge water temperatures.
3. The new glycol loop cooling and heating hot water system pumps shall be controlled by the BMS in a stepped fashion as noted above. The automatic pump sequencer shall automatically rotate the pumps based on run time and energize the stand-by pump upon failure of the lead pump. Provide a flow switch on the discharge side of the pumps. Pumps shall be provided with variable frequency drives.
 4. The new building chilled water system pumps shall be controlled by the BMS. The existing sequence shall be maintained. The automatic pump sequencer shall automatically rotate the pumps based on run time and energize the stand by pump upon failure of the lead pump. Provide a flow switch on the discharge side of the pumps as shown on the boiler schematic. Below 60°F (adjustable), outside air temperature the pumps shall be off. Pumps shall be controlled by variable frequency drives. Provide a pressure sensor, controls and wiring to vary flow, by means of the VFD, in response to load changes and to maintain the necessary pressure at the end of the supply main.

PART 3 - EXECUTION

3.1 PIPING

- A. Provide and erect in a workmanlike manner all piping systems shown on plans or as required to complete the installation as intended. All piping shall be installed so as to provide access to all valves and equipment.

- B. The drawings are schematic and do not indicate all offsets and fittings which may be required. The HVAC Contractor shall carefully investigate the structural and finish conditions of other trades affecting all his work and arrange his work accordingly.
 - C. All piping, valves, fittings and appurtenances shall be installed at sufficient distances from other work to permit clearance of not less than 1/2" between the finished covering of such piping and all adjacent work whether under this or any other section of the specifications.
 - D. All mains and risers shall be securely anchored to the building construction. Anchors shall be constructed from heavy, forged wrought iron secured to the piping and the building construction.
 - E. This Contractor shall be held responsible for the quick and free circulation of water in all piping under actual working conditions. System shall be free from noise due to pipe expansion or contraction or from air.
 - F. Runouts to equipment connections and risers shall be so piped and valved that any one may be shut off without interfering with the system. A plugged drain cock shall be provided at each low point of each supply and each return so that the piping which is shut off may be drained. In making such connections, care shall be taken to provide sufficient pitch to vent the system. Water runouts shall pitch up to equipment above and pitch down to equipment below the main or branch. A 3/4" brass drain cock shall be placed on the return lines at circulators and capped 1/2" brass hose bibs shall be placed at all low points as necessary for complete drainage of all piping, leaving no pockets. Cocks shall be taken off tees.
 - G. High points in all new water piping shall be vented.
 - H. All openings in pipe and fittings shall be capped or plugged until permanent connections are made. Use care to keep foreign materials out of the system.
 - I. Where pipe or tubing cutters are used, or where the pipe is threaded, the burr shall be reamed out to the full inside diameter of the pipe.
 - J. All piping within the building shall be so installed that it shall in no way be strained or distorted by expansion and contraction.
 - K. All welding shall be performed in accordance with the standard of workmanship set forth in the National Certified Pipe Welding Bureau, "Specification for the Fabrication and Erection of Piping Systems". Assume full responsibility for all deposited welds and repair all defects in welds developing within one year after final acceptance of the building, without additional cost to the Owner.
 - L. In general, pitch all hot water piping up in the direction of flow.
 - M. Where piping passes through fire rated walls and floors, the HVAC Contractor shall repack the openings with a fire-retardant material so as to maintain the integrity of the fire rated wall assemblies to the satisfaction of the Architect and as per the requirements of Section 07 8413.
 - N. Grooved joints shall be installed in accordance with the manufacturer's latest published instructions. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. Factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.
- 3.2 MATERIALS AND WORKMANSHIP
- A. All specified materials and equipment shall be furnished new and free of defects.

- B. Store all equipment and materials in a clean, dry place to preserve initial quality.
- C. Protect installed materials and equipment against damage and corrosion. All equipment shall be left in a first-class condition. The Architect shall determine the adequacy of equipment condition and appearance and it shall be the responsibility of this Contractor to rectify any deficiencies. This shall include, but is not limited to furnishing and applying paint in accordance with the manufacturer's recommendation.
- D. All work shall be installed in a first-class manner consistent with the best current trade practices. All devices, materials and equipment shall be securely installed plumb and/or level.

3.3 PROTECTION AND CLEANUP

- A. Protection:
 - 1. Be responsible for the maintenance and protection of all material and equipment furnished during all phases of construction from loss, damage or deterioration until final acceptance by the Owner.
 - 2. All materials and equipment on the job site shall be suitably stored and protected from the weather.
 - 3. During the progress of the work all pipes, ducts and equipment openings shall be temporarily closed so as to prevent obstruction and damage.
- B. Cleanup:
 - 1. After installation, equipment with factory finished surfaces shall be cleaned and damaged spots touched up with the same type paint applied at the factory.
 - 2. Keep the job site free from accumulation of waste material and rubbish, construction equipment and surplus materials from the site and leave the premises in a clean condition.

3.4 SYSTEM START-UP AND OPERATION

- A. After completion of the installation and before acceptance by the Owner, this Contractor shall start-up, operate and thoroughly check the entire HVAC system to assure complete adherence to the design intent.
- B. It is intended that the start-up/operational endeavor shall conclusively establish that all systems are functioning properly with respect to rotation of equipment, wiring interlocks, control interlocks and sequential control.
- C. Should any portion of system performance be found to be contrary to the specified intent, same shall be corrected as required, at no cost to the Owner.
- D. After completion of the system check procedure and when the Contractor is firmly convinced that all systems are performing properly and efficiently, he shall submit in writing to the Architect a certified statement to that effect.

3.5 SYSTEMS IDENTIFICATION

- A. All valves on the new hot water piping system shall have circular brass valve tags of at least 1-1/2" in diameter, attached with brass hooks to each valve stem. Stamp number of the valve and the service, such as "HWS" and "HWR" for hot water supply and hot water return respectively. The numbers of each service shall be consecutive and shall correspond with the numbers indicated for valves and controls on the record drawings and on three printed valve lists. These printed lists shall state number and locations of each valve and control and the equipment which it controls and other necessary information, such as sequencing of valves.
 - 1. These printed lists shall be prepared in a form to meet the approval of the Architect and one copy shall be framed under glass mounted in an approved location.

- B. All new hot water piping shall be identified by semi-rigid plastic pipe markings which shall be provided under this contract. Markers shall be applied on supply and return sides of pumps and boiler, on supply and return lines leaving the boiler room and on branch piping to the boiler room unit heater. Markings shall indicate pipe content and direction of flow. The basic marker shall be in color as called for under the ANSI Specifications A-13.1. Also, an identification of the pipe content and flow arrows shall be shown in black.
 - 1. Brush applied paint and adhesive marking systems shall not be used on this installation.
- C. All items of mechanical equipment such as heat pump chillers, expansion tanks, air separators and pumps shall be identified by approved nameplates provided by this Subcontractor.
 - 1. The nameplates to be aluminum 2-1/2" x 3/4" with a black background with etched or engraved natural aluminum lettering. The nameplates shall bear notations corresponding to the same unit notations indicated on the design drawings.
 - 2. All equipment nameplates shall be conspicuously visible externally.

3.6 SAFETY PRECAUTIONS

- A. Furnish, place and maintain proper guards for the prevention of accidents and any other necessary construction required to secure safety of life and property. Conform to all OSHA requirements.

3.7 SUPPLEMENTARY STEEL, CHANNELS AND SUPPORTS

- A. Furnish and install all supplementary steel, channels and supports required for the proper installation, mounting and support of all equipment. Method of attachment to the building structure shall be in a manner approved by the Architect. Type and size of supports shall be determined by the Contractor and shall allow only a minimum amount of deflection.
- B. All supplementary steel and channels shall be installed in a neat and workmanlike manner parallel to the walls, floor and ceiling construction. All turns shall be made with 90 degree and 45-degree fittings, as required to suit the construction and installation conditions.

3.8 TESTING, BALANCING AND CLEANING

- A. The HVAC Contractor shall engage a Certified Balancing Contractor to balance and adjust the hot water systems and air handling units and exhaust systems, using methods and procedures which have been developed and employed to accomplish this service. The HVAC Contractor shall coordinate with the Testing & Balancing Contractor and provide required information, access and clearances.
 - 1. Piping System Pressure Testing, Balancing and Cleaning:
 - a. After completion of the installation of the entire water system and prior to acceptance, the system shall be adjusted and balanced to deliver the water quantities indicated on the drawings.
 - b. Water balancing report shall include pumps size, horsepower, RPM, delivered amperage, brake horsepower, delivered system pressure differential and delivered GPM. Submit to the Architect six copies of the complete water balance report.
 - c. All equipment and piping shall be thoroughly cleaned of foreign matter as they are installed. Cleaning and flushing of the systems with the main circulators operating and all trapped air removed shall be carried out until all indications of excessive dirt are removed.
 - 2. Air System Balancing and Cleaning:
 - a. Before the systems are tested and balanced, all ducts and equipment shall be thoroughly cleaned so that no dirt, dust or other foreign matter will be deposited in or carried through systems. All filters shall be renewed after air handling systems have been cleaned.
 - b. Each air supply, return and exhaust system shall be balanced to deliver within 10% the air quantities specified on the drawings.

- c. Submit to the Architect six copies of the complete air balancing report. Air balancing report shall include for each fan system the fan size, make, model, fan and motor RPM, delivered amperage, CFM, fan static pressures and CFM at each air inlet and outlet.
- d. Final air quantities shall be achieved by adjusting fan outlet dampers and fan RPM. Final damper settings shall be permanently marked after air balance report.

3.9 COMMISSIONING

- A. The Owner shall engage a Commissioning Agent to provide commissioning for all new equipment installed as part of this project. The HVAC Contractor shall coordinate with the Commissioning Agent and provide required information, access and clearances.

3.10 FIRESTOPPING

- A. The Work of this Section shall include, but not be limited to, furnishing and installation of through-penetration firestop systems for penetrations through fire-resistance-rated assemblies.
- B. For penetrations through fire-resistance-rated assemblies, provide through-penetration firestop systems that are produced and installed to resist spread of fire, resist passage of smoke and other gases, and maintain original fire-resistance rating of the assembly being penetrated.
 - 1. Fire-resistance-rated assemblies include firewalls, fire partitions, fire barriers, smoke barriers, floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.
- C. Provide Shop Drawings for each through-penetration firestop system, indicating each type of assembly penetrated, relationships to adjoining construction, and type of penetrating item. Include UL through penetration firestop system design designation and qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.
- D. Provide a drawing(s) and schedule(s) identifying the locations of penetrations and associated UL through penetration firestop systems, along with the following information:
 - 1. Type of penetrating item including but not limited to material, size, bare or insulated, insulation material, insulation thickness, etc.
 - 2. Type of assembly penetrated identified by a UL assembly designation.
 - 3. Through-penetration firestop system to be used for each location identified by UL firestop design designation.
- E. All through-penetration firestop systems, for each combination of penetration and assembly, shall be obtained from a single manufacturer.
- F. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to the specific UL through penetration system designation requirements. Particular attention shall be paid to the annular space between penetrants and assemblies.
- G. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate the UL through-penetration firestop systems. Particular attention shall be paid to the annular space between penetrants and assemblies.
- H. Provide through-penetration firestop systems that are compatible with one another; with the substrates forming openings; and with any items penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by the approved through-penetration firestop system manufacturer based on testing and field experience.
- I. Provide accessory components for each through-penetration firestop system as required by the approved manufacturer to install fill materials. Use only components specified by the approved through-penetration firestop system manufacturer and approved by a qualified testing and inspecting agency for firestop systems indicated. Accessories shall include, but not be limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:
 - a. Slag or rock wool fiber insulation.
 - b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
 - c. Fire-rated form board.
 - d. Fillers for sealants.
 2. Temporary forming materials.
 3. Substrate primers.
 4. Intumescent collars.
 5. Sleeves.
- J. Drawings, schedules, and shop drawings shall be reviewed and approved by the General Contractor and Architect prior to submission to the Engineer for review, proof of which shall accompany such submission. Failure to provide proof of the General Contractor's and/or Architect's review and approval will be grounds for immediate rejection of the submission.

END OF SECTION

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