

SECTION 23 00 00
MECHANICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

General Provisions of Contract, including General and Supplementary conditions and General Requirements (if any) apply to work specified in this Section.

1.02 ALTERNATES

There are no alternates that apply to this section of the project.

1.03 DEFINITIONS

ATC Automatic Temperature Control (Section 23 09 00)
EC Electrical Contractor (Division 26)
GC General Contractor
HC Heating (mechanical) Contractor
PC Plumbing Contractor (Section 22 00 00)
VFD Variable Frequency Drive

1.04 DESCRIPTION OF WORK

A. Work Included

1. Furnish all labor, materials, equipment, transportation and perform all operations required to install a complete heating, ventilating, heat recovery and air conditioning system in the building, in accordance with these specifications and applicable drawings.
2. All temperatures are expressed in degrees Fahrenheit.
3. Perform demolition and removal as required.
4. Work to be performed shall include, but is not limited to, the following:
 - a. Provide and install forced hot water heating and ventilating system in building areas indicated on drawings.
 - b. Provide and install forced air heat recovery systems in building areas indicated on drawings.
 - c. Provide and install direct expansion air conditioning system in building areas indicated on drawings.
 - d. Pipe, valve and fittings
 - e. Hot water specialties
 - f. Circulating pumps and boiler work
 - g. Radiation
 - h. Air handling units
 - i. Compressor/Condenser units
 - j. Unit heaters and cabinet unit heaters

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- k. Insulation
- l. Fans
- m. Sheetmetal
- n. Automatic Temperature Control (ATC)
- o. Tests and balance

- 5. Specifications and accompanying drawings do not indicate every detail of pipe, valves, fittings, hangers, ductwork and equipment necessary for complete installation; but are provided to show general arrangement and extent of work to be performed.
- 6. Before submitting proposal, Mechanical Contractor shall be familiar with all conditions. Failure to do so does not relieve Mechanical Contractor of responsibility regarding satisfactory installation of the system.
- 7. Mechanical contractor shall be responsible for rigging to hoist his own (and his sub-contractors') materials and equipment into place.
- 8. Mechanical contractor and his sub-contractors shall be responsible for start-up of all equipment provided under this section.

B. Related Work Described Elsewhere

- 1. Excavation and backfill
- 2. Cutting and patching
- 3. Firestopping between building construction and pipe sleeves and between building construction and ductwork.
- 4. Electrical conduit and wiring, except as noted below
- 5. Roofing, curbs, curb openings and framing of openings.
- 6. Setting of sleeves in masonry work (sleeves provided by Mechanical Contractor)
- 7. Door louvers
- 8. All finish work

C. Mechanical Electrical Work

- 1. Provide and erect all motors, temperature controls, limit switches as specified.
- 2. Power supply to switches, fused switches, outlets, VFD's, motor starters, to line terminals of equipment, and all related wiring and fuses to properly connect and operate all electrical equipment specified shall be furnished and installed under Division 26, "ELECTRICAL". Division 26 shall not mount electrical equipment to indoor mechanical equipment without the consent of Division 23. Division 26 shall not drill wiring holes in equipment casings but shall make use of factory wiring knockouts when present. Coordinate all wiring between Mechanical and Electrical to provide a complete and operating system.
- 3. VFD's shall be provided by ATC Contractor under Section 23 09 00 where indicated on mechanical plans and/or in this section.
- 4. All wiring provided under this section shall be in accordance with the latest rules and regulations of the National Fire Underwriters, National Electric code and

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Local Codes Division 26. Install all wiring under the supervision of the Division 26. Any wiring that is not installed according to these standards, and which does not match wiring installed by Division 26 in type, quality and appearance shall be corrected by Division 26 at the expense of this section.

5. Boilers

Division 26 shall provide a separate circuit breaker for each boiler and wire to line terminals on unit control. Licensed boiler contractor shall provide all other wiring, including control and safety circuits, low water cut-off and fusible switches.

6. Fans

- a. Single phase 120 volt units: Division 26 to wire to unit mounted disconnect switch with overload protection provided with unit.
- b. Three phase units: Division 26 shall provide combination disconnect switches with magnetic starters unless specifically indicated otherwise, and wire power to supply through to line terminals on unit motor. Starters shall have auxiliary contactors for Automatic Temperature Control interlocks. Temperature Control Contractor SHALL COORDINATE his requirements with Division 26 as soon as possible after award of contract.
- c. Fans shall operate as indicated on "FAN SCHEDULE", drawing M15 and as indicated in Section 23 09 00, "Automatic Temperature Control".
- d. Division 26 to provide 120 volt power from exhaust fans to motor operated dampers associated with each fan. Dampers and actuators to be provided by ATC Contractor.

7. Circulating Pumps

Division 26 shall provide and wire disconnect switch for each unit.

8. Unit Heaters

- a. Cabinet Type: Division 26 shall wire to disconnect switch provided with unit.
- b. Propeller type: Division 26 shall provide and wire service switch with overload protection.

9. Air Handling Units

Division 26 shall provide and wire disconnect switch for each unit.

10. Branch Circuit (B.C.) Controllers

Division 26 shall provide and wire disconnect switch for each unit.

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11. Compressor/Condenser Units

Division 26 shall provide and wire disconnect switch for each unit.

12. Duct Smoke Detectors

Duct smoke detectors, where indicated, shall be furnished and wired by Division 26. Wiring shall include connection to heat recovery unit (HRU) starting circuit(s) to interrupt power to the unit fan(s) to stop unit(s) on smoke alarm. The ATC system shall not be used to stop equipment on signal from fire alarm system. Mechanical Contractor shall install detectors in ductwork.

13. Convenience Receptacles

- a. Equipment Manufacturer shall provide heat recovery units with a 120 volt GFCI duplex convenience receptacle. If a receptacle is not provided with the equipment the Mechanical Contractor shall contract with Division 26 to provide it.
- b. Division 26 is requested to provide and install duplex convenience receptacles within 12 feet of each outdoor compressor/condenser unit.

14. All motors 1/3 HP and smaller shall be wired for 120 or 200/230 volt, 1 phase, 60 hz; motors 1/2 hp and larger shall be wired for 208/230 volt, 3 phase, 60 hz, unless specifically shown otherwise. All three phase motors shall be premium efficiency and inverter ready for variable frequency drives.

1.05 PERMITS

- A. This Contractor shall be responsible for providing and filing all Plans, Specifications and other documents, pay all requisite fees and secure all permits, inspections and approvals necessary for the legal installation and operation of the systems and/or equipment furnished under this Section of the Specifications.
- B. The Contractor shall frame under glass/ clear plastic all permits, secured by him, adjacent to the respective system and/or equipment and required to be displayed by Code, law or ordinance. Those permits secured but not required to be displayed shall be laminated in plastic and included in the Owner's maintenance manual.

1.06 CODES, ORDINANCES AND PERMITS

- A. All work performed under this Section of the Specifications shall be done in accordance with applicable National, State and local Codes, Laws and Ordinances. The following abbreviations are used for reference to standards which are to be followed:

AABC	Associated Air Balance Council
ADA	Americans With Disabilities Act
AMCA	Air Movement & Control Association
ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers

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ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BOCA	Building Officials and Code Administrators
NEC	National Electrical Code
NFPA	National Fire Protection Association
NEMA	National Electrical Manufacturer's Association
OSHA	Occupational Safety and Health Act
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UL	Underwriter's Laboratories

- B. The latest issue of each Code in effect at the time of bidding shall be used. Code requirements are the minimum quality and/or performance acceptable. Where the Specifications and/or Drawings indicate more stringent requirements, these requirements shall govern.

1.07 QUALITY ASSURANCE

- A. Mechanical Contractor shall have prior experience with at least two projects of this nature, size and scope and be capable of producing references indicating as such.
- B. Use sufficient qualified workpersons and competent supervisors in execution of this portion of the work to ensure proper and adequate installation of systems throughout. Technical training and certification of workpersons installing the systems specified, by the systems manufacturer, shall be mandatory prior to commencement of work. Documentation of such certification shall be made available to the Architect upon request within 5 business days.
- C. Work performed shall conform with all Local and State Rules and Regulations, as well as those of the International Building Code and National Fire Protection Association (N.F.P.A.).
- D. Piping design shall conform to ANSI, ASME B31.9 and AWS D10.9 codes.
- E. Welding standards shall conform to ANSI Boiler Code, Section IX, B31.1

1.08 MATERIALS AND SUBSTITUTIONS

All materials and equipment shall be new and of the latest design of respective manufacturers. **All materials and equipment of the same classification shall be the product of the same manufacturer**, unless specified otherwise.

- A. Any proposal for substitution of Mechanical equipment, materials or vendors shall be made in writing PRIOR TO OPENING OF BIDS. Submit full details for consideration and obtain written approval of the Architect. The phrase "or approved equal" shall be defined to mean that the Architect, not the contractor, shall make final determination whether or not substitute materials are an equal to that which is specified. The contractor shall be responsible to certify within his submittals that any equipment to be considered as an "approved equal" meets or exceeds the requirements of this specification in all aspects and will physically fit within the space provided and still provide adequate space adjacent to the equipment for service. If requested by the Architect the contractor shall

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provide said certification in the form of scale drawings before review will be made. Architect will not be responsible to provide drawings for substituted materials unless the substitution is agreed upon prior to opening of bids. Architect's decision on acceptability of substitute materials shall be final.

- B. Approval by Architect for such substitution shall not relieve Mechanical Contractor from responsibility for a satisfactory installation and shall not affect his guarantee covering all parts of work
- C. Any material or equipment submitted for approval which are arranged differently or is/are of different physical size from that shown or specified shall be accompanied by shop drawings indicating different arrangements of size and method of making the various connections to equipment. Final results will be compatible with system as designed.
- D. Materials and equipment determined as an "approved equal" and/or substitutions must meet the same construction standards, capacities, code compliances, etc. as the equipment (i.e. Manufacturer, model, etc.) specified.
- E. Any additional cost(s) resulting from the substitution of equipment, regardless of acceptance by the Architect or Engineer, shall be paid by this Contractor. Additional costs may include, but not be limited to, electrical and/or structural alterations from the contract documents. Contractor shall be solely responsible to verify that substitutes will fit within the designated spaces provide while permitting adequate clearances for servicing of equipment as required by the manufacturers. Contractor shall, upon request from the Architect or Engineer of record, provide such verification of ample space and clearances in the form of drawings or any other manner requested.
- F. All materials not specified otherwise shall be manufactured within the United States and supplied locally (within the State of Maine) when available. It is preferable to obtain materials that are manufactured within 500 miles of the work site when practical.

1.09 PLANS AND SPECIFICATIONS

Mechanical Contractor shall provide his sub-contractors with a copy of the ENTIRE portion of Part 1 of this specification, portions of this specification and copies of drawings which pertain to the equipment to be supplied at no cost to the sub-contractor. Provide ATC Contractor with entire set of Electrical plans and specifications. Provide Testing and Balancing sub-contractor with copies of shop drawings indicating coil gpm's, air handling unit air volumes, etc. Failure to do so may result in the Architect providing the required materials at the Contractor's expense.

Sketches pertaining to changes and amendments during construction (ASI's, RFI's and RFP's for example) shall be contract form documents issued by the Architect and/or Engineer for use during construction and it shall be the Architect's and/or Engineer's discretion to provide sketches or full size drawings. Requests for documentation other than what is provided (full size revised drawings for instance) and deemed suitable for the particular situation shall be paid for by the contractor making the request. The cost(s) shall include, but not limited to, drafting time and reproduction costs.

1.10 ELECTRONIC DRAWINGS AND FILE SHARING

Plans and specifications may be made available in electronic format on request. Plans may be provided in either Adobe (.pdf) or CAD (.dwg or .dxf) formats and will be compressed using WinZip (.zip format). Recipient is responsible to obtain the necessary software to open the files. Note: CAD (.dwg and .dxf) files will be made available to successful bidders only after a contract is awarded.

CAD drawings are produced with AutoCAD 2006 and 2010 and may be provided in the 2004 or 2010 file format. Upon request for CAD files a release form will be provided which must be signed and returned to the Engineer prior to transmission of electronic files. Physical mailing address, telephone numbers and e-mail address for this office are indicated on each drawing. A signed release will not be required for Adobe based files.

All contract documents are copyrighted material. No portion of materials may be reproduced or duplicated except as indicated in the release form. Where release forms are not required (Adobe based files), materials may be printed for use by the intended recipient only and may not be reproduced or copied in any other manner or for any purpose other than for use pertaining to the construction of this project unless written permission is obtained.

1.11 SHOP DRAWINGS & SUBMITTALS

- A. As soon as possible after award of contract (*but not longer than 21 calendar days*), before any material or equipment is purchased, Mechanical Contractor shall submit shop drawings for review. Unless prior arrangements are made with the Architect all shop drawings must be submitted to the General Contractor who in turn will forward them to the Architect. The quantity of copies shall be as outlined in Division 01. If shop drawings are rejected or returned for re-submittal, Mechanical Contractor shall provide said re-submittals within 14 calendar days of receipt of original submittals with engineer's comments. If original or re-submitted shop drawings are not submitted within the allotted time frames indicated all substitutions included in the late shop drawings will be invalid and the equipment primarily specified must be provided. Any costs resulting from delays in the project schedule due to failure to submit shop drawings related to this section in a timely manner shall be the responsibility of the Mechanical Contractor. Mechanical Contractor's and vendor's name, address, telephone & fax numbers and e-mail addresses shall be provided with every shop drawing submission. Capacities indicated are minimums. Equipment submitted with capacities below specified parameters will be refused.
- B. Shop drawings shall be properly identified and shall describe in detail the material and equipment to be provided, including all dimensional data, performance data clearly indicated, fan curves, pump curves, computer selection print-outs, etc. Capacities indicated are minimums. Equipment submitted with capacities below specified parameters will be refused.
- C. Corrections or comments made on the shop drawings do not relieve the contractor from compliance with requirements of the drawings and specifications. Shop drawing review is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The contractor is responsible for confirming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction; coordinating his work with that of

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all other trades and performing his work in a safe and satisfactory manner.

- D. Should any materials or products be purchased and/or installed without prior review and comment the contractor shall be required to remove or replace those products and/or materials, if directed by the Architect, at his expense. If the materials are not removed (or replaced) or if the project is delayed as a result of the contractor's actions, the Architect reserves the right to order the withholding of payment until the situation is resolved in a manner satisfactory to the Architect.
- E. Mechanical shop drawings shall be separate from Plumbing shop drawings. Submittals not separated from plumbing shop drawings will be refused for re-submittal.
- F. Electronic submission of shop drawings is encouraged. Electronic files must be accessible and in an open format, meaning files must not be locked and comments may be added without altering the original content, or have interactive fields intended specifically for commenting. Locked files will not be reviewed. Hard copies of shop drawings must be original documents or good quality photocopies of original documents (photocopies of color samples are not acceptable). Faxed copies of submittal sheets will be refused unless prior arrangements are made.
- G. Review must be obtained on the following items:
1. Ductwork and Accessories
 - a. Registers, diffusers, and grilles
 - b. Duct access doors
 - c. Volume control dampers (manual and automatic)
 - d. Duct sealant
 - e. Fire dampers and sleeves
 - f. Turning vanes
 - g. Side takeoff fittings
 - h. Flexible duct
 - i. Backdraft dampers
 - j. Relief and intake hoods
 - k. Manual dampers
 - l. Louvers and brick vents - provide color chips (photocopies not acceptable) – provide samples if substituting
 - m. Filters
 - n. Vents from gas heating appliances
 2. Mechanical Equipment (sound data must be provided with all interior motorized equipment).
 - a. Full warrantee information must be included with all submittals.
 - b. Air conditioning units and accessories
 - c. Air handling units and accessories - provide curves for fan wheels submitted and computer selection printouts.
 - d. Boiler/Burner units and accessories.
 - e. Cabinet unit heaters - provide color chips (photocopies not acceptable)
 - f. Compressor / condenser units
 - g. Equipment identification tags

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- h. Fans and accessories - provide full fan curves and computer selection printouts.
 - i. Heat recovery units and accessories - provide computer selection printouts.
 - j. Horizontal unit heaters
 - k. Pumps and accessories - provide full pump curves and computer selection printouts.
3. Piping and Accessories
- a. Pipe, valves, unions and flanges
 - b. Air separator
 - c. Air vents (automatic and manual)
 - d. Backflow preventer
 - e. Balancing valves with read-out gauge and pressure tappings. Provide a schedule clearly indicating every valve, its location, GPM, size and pressure drop.
 - f. Expansion tank and accessories
 - g. Flow meters
 - h. PEX tubing, fasteners, connectors and accessories
 - i. Pipe and valve markers
 - j. Pipe hangers and insulated pipe supports
 - k. Pipe sleeve wall closure devices
 - l. Pressure gauges and thermometers
 - m. Pressure reducing valves
 - n. Relief valves
4. Terminal Units
- a. Duct hot water heating coils - provide computer selection printouts.
5. Insulation
- a. Duct
 - b. Equipment
 - c. Pipe
 - d. Pipe fittings
 - e. Smoke pipe and air separator
6. All submittals shall include a disclosure stating the content of recycled and recyclable materials contained within the products submitted.

1.12 PRODUCT HANDLING

A. Protection

Use all means necessary to protect heating, ventilating and air conditioning materials before, during and after installation and to protect the installed work and materials of all other trades.

B. Replacements

In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect at no additional cost to the Owner.

1.13 AS-BUILT DRAWINGS

Keep in good condition at the job, apart from all other prints used in actual construction, one complete set of all blueprints furnished for this job. On this special set of blueprints, record *completely and accurately* all differences between the work as actually installed and the design as shown on the drawings. These record prints must be kept up to date by recording all changes within one week of the time that the changes are authorized. At the completion of the work, this set of drawings shall be delivered to the Architect for the Owner electronically in the form of CAD drawings. If a complete record of changes is not made and electronic CAD drawings not provided by the Mechanical Contractor, a record shall be made by the Engineers, and *the cost of the record shall be the responsibility of the Mechanical Contractor*. Copies of the mechanical CAD drawings (minus professional engineering stamps) may be made available at no cost to the Mechanical Contractor of record if desired. Drawings shall be dated accordingly and clearly identified as "AS-BUILT". See par. 1.10, "ELECTRONIC DRAWINGS AND FILE SHARING" for additional information.

1.14 MAINTENANCE MANUAL

A. On completion of this portion of the work, and as a condition of its acceptance, submit for approval two copies of a manual describing the system. Mechanical equipment manuals shall be separate from plumbing manuals. All manuals shall be original copies, not photocopies or they will be refused for re-submittal. Prepare manuals in durable 3-ring binders approximately 8½ inches by 11 inches in size with at least the following:

1. Identification on the front cover and spine stating general nature of the manual.
2. Neatly typewritten index.
3. Complete instructions regarding operation and maintenance of all equipment involved.
4. Complete nomenclature of all replaceable parts, their part numbers, current cost, and name, address and telephone number of nearest vendor of parts.
5. Copy of all guarantees and warranties issued.
6. Where contents of manuals including manufacturer's catalog pages, clearly indicate the precise item included in this installation and delete, or otherwise clearly indicate, all manufacturers' data with which this installation is not concerned.

B. In addition to above, provide two (2) separate offset style binders properly identified, each containing a copy of all reviewed shop drawings and catalog cuts. (NOTE: May be incorporated in Maintenance Manuals, if binders are of adequate size.)

1.15 OBJECTIONABLE NOISE AND VIBRATION

Mechanical equipment shall operate without objectionable noise and vibration. Should objectionable noise or vibration be transmitted to any occupied part of the building by apparatus, piping or ducts, as determined by the Architect, the necessary changes eliminating the noise or vibration shall be made by this Mechanical Contractor at no extra cost to the Owner.

1.16 GUARANTEE

This Contractor shall guarantee all materials and workmanship furnished by him or his sub-contractors to be free from all defects for a period of no less than one (1) year from date of final acceptance of completed system and shall make good, repair or replace any defective work which may develop within that time at his own expense and without expense to the Owner. Any additional costs required to extend manufacturer's guarantee and warranty for the period specified, shall be included in Contractor's base bid.

1.17 DEVIATIONS AND DISCREPANCIES

- A. The drawings are intended to indicate only diagrammatically the extent, general character and approximate locations of mechanical work. Work indicated, but having minor details obviously omitted, shall be furnished complete to perform the functions intended without additional cost to the Owner. Follow the architectural, structural, plumbing and electrical drawings so that work under this section is properly installed and coordinated with other Sections.
- B. The drawings and specifications are complimentary to each other and what is called for in one, shall be as binding as if called for by both. In the event of conflicting information on the mechanical drawings, or between drawings and specifications, or between trades, that which is better, best or most stringent shall govern.
- C. Questions to the Architect or Engineers are encouraged, however any answers and/or advice is non-binding unless incorporated into the contract documents in the form of addenda, change order, etc. Inquires requiring an answer prior to opening of bids should be made at least 4 days prior to when bids are due to allow time for a clarifying addendum to be issued.
- D. Any conflicts arising from duplication of equipment specified in different portions of the specifications shall be brought to the attention of the Architect prior to submitting bids. Failure to do so does not relieve the Contractor from responsibility of providing said materials and equipment and a credit will be taken for the duplicated item(s).
- E. Should unforeseen job conditions require re-arrangement of piping and/or ductwork resulting in deviation from the intent of the contract documents or potentially compromising the integrity of the mechanical systems, the Architect shall be notified immediately prior to commencement of work. Failure to do so will result in the contractor being responsible to correct any work installed that is contrary to the contract documents at his own expense.

1.18 CHANGE ORDERS

- A. No change shall be made from the work, equipment, or materials under this section except as directed in writing by Engineer.
- B. All requests for change in contract price and scope shall be accompanied by a breakdown list of materials with unit and extended prices and labor hours with unit and extended price, plus markups that have been applied.

1.19 COORDINATION

- A. Contractor shall be responsible to coordinate his work with that of other trades to adjust to field conditions prior to commencing work. It is also this contractor's responsibility to coordinate locations of his own piping and ductwork to ensure the two do not conflict. If a reasonable solution cannot be achieved without compromising the integrity of the intended design or would result in additional cost the Architect must be notified immediately prior to commencement of work. Failure to do so does not relieve the Contractor from providing and installing the systems to the satisfaction of the Architect at no additional cost.
- B. Contractor shall be responsible to review job conditions and identify conflicts and/or obstructions to ductwork and piping prior to fabrication. If conflicts and/or obstructions are noted the Architect must be notified immediately prior to commencement of work. The cost of any fabrication work performed without confirmation and notification of conflicts and/or obstructions shall be the responsibility of the contractor.

1.20 REQUESTS FOR INFORMATION

Requests for Information (RFI) or other correspondences which are submitted electronically must be in an open format, meaning files must not be locked and comments may be added without altering the original content, or have interactive fields intended specifically for commenting. Locked files will not be accepted.

1.212 WORKPLACE SAFETY

Mechanical contractor shall be responsible for the safety of his workpeople.

PART 2 - PRODUCTS

2.01 PIPING

A. General

Provide and erect in accordance with best practice of trade all hot water supply and return, refrigerant, drain and vent piping shown on the plans and as required to complete intended installation. Contractor shall make offsets as shown or required to place all piping in proper position to avoid other work, and to allow application of insulation and finish painting.

B. Pipe Materials:

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| 1. | Hot water | Schedule 40 standard weight black steel, ASTM 120 |
| 2. | Heating water, 200°F. maximum. | PEX crosslinked flexible tubing, ASTM F876 and F877. |
| 3. | Cold water, drains from relief valves and automatic vents. | Type "L" hard drawn copper tubing |
| 4. | Condensate | CPVC Plastic |
| 5. | Refrigerant | Type "L" hard drawn copper tubing. |

C. Pipe Fittings:

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| 1. | Screwed | 125# cast iron screwed pattern ASTM A126, ASA B16.1 |
| 2. | Welded | Standard weight butt weld carbon steel ASTM A234, ANSI B16.9 from A106 Gr. B. seamless Tube |
| 3. | Unions | 250 malleable iron, brass to iron seats |
| 4. | Flanges | 150# forged steel slip-on ASTM A234 |
| 5. | Sweat with 95-5 solder | Cast bronze or wrought copper made up |
| 6. | Connections to equipment | 2 inches and smaller - screwed unions
2½ inches and larger – flanged |
| 7. | Refrigerant | Cast bronze or wrought copper, long radius elbows, made up with Sil-Fos silver solder. |

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8. Dielectric fitting Steel or copper pipe to ASTM A-53, zinc electroplated body with non-corrosive thermoplastic lining, thread connections. Victaulic Style 47-TT or approved equal.

- D. All mains 2½ inches and larger shall have welded connections using standard factory-fabricated tees, elbows, reducers, and caps. Branch outlets in welded sizes shall be made with tees for full size or one size reduction and with either "Weldolets" and "Threadolets" or factory shaped nipples for all other sizes. All welds shall be made by welders certified by the State of Maine and shall be capable of welding in any position "in the field". All welds shall conform with the rules set forth in the Standard Manual on Pipe Welding of the Heating, Piping and Air Conditioning Contractors national Association. All slip on fittings shall be back welded. Fire extinguishing equipment shall be kept within 25 feet of welding areas at all times. Contractor shall take additional measures when welding close to wood structures to protect the wood from igniting.
- E. Steel piping 2 inches and smaller shall have screwed connections. All threads on piping must be full length and clean-cut with inside edges reamed smooth to the full inside bore.
- F. The Mechanical Contractor may, at his option, use type "L" hard drawn copper tube for piping 2 inches and smaller in lieu of steel. His option of steel or copper must be stipulated in his bid and thereafter no deviation will be acceptable. If copper is to be used, the piping system shall be 100% copper with no mixture from copper to steel. New piping which is to be connected to existing shall be schedule 40 steel.
- G. The Mechanical Contractor may also, at his option, use Victaulic grooved piping products in lieu of welded and screwed joints on steel piping. This option MUST be stipulated in his bid and thereafter no deviation will be acceptable. All grooved components shall be of one manufacturer and conform to local code approval and/or as listed by ANSI B-31.1, B-31.9, ASME, UL-FM, IAPMO or BOCA. Grooved end product manufacturer to be ISO-9001 certified.

Pipe to be grooved in accordance with Victaulic current listed standards conforming to ANSI/AWWA C-606.

Mechanical couplings shall be Victaulic Style 107H QuickVic™ "Installation Ready" stab-on coupling and Victaulic Style 07 Zero-Flex standard rigid coupling. Victaulic Style 177 QuickVic and Victaulic Style 77 or 75 standard coupling shall be used where system flexibility is desired at pumps and other mechanical equipment to reduce noise and vibration and eliminate flexible connectors. Vic-Flange adapter Style 741 shall be used for connections to ANSI class 125/150 flanged components. Gasket shall be Grade EHP EPDM compound with a temperature operating range -30°F to +250°F and Grade E EPDM compound with a temperature operating range -30°F to +230°F.

AGS mechanical couplings 14" through 60" shall be Victaulic Style W07 rigid and Style W77 flexible. Couplings shall consist of two ductile iron housings cast with a wide key profile and flat bolt pads for metal-to-metal contact. Gaskets shall be wide-width Grade E EPDM compound of a FlushSeal® design and temperature operating range -30°F to +230°F. Vic-Flange adapter Style W741 shall be used for connections to ANSI Class 125/150 flanged components.

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Fittings shall be cast ductile iron conforming to ASTM A 536, forged steel conforming to ASTM A 234, or fabricated from carbon steel pipe conforming to ASTM A 53 with factory grooved ends designed to accept Victaulic stab-on, standard, and AGS "W" series couplings.

Bolted branch outlet - branch reductions on 2" through 8" header piping shall be made with Victaulic Style 920/920N Mechanical-T outlet.

Ball valves 1½ inches to 6 inches in size shall be Victaulic Series 721 or Series 726 standard port valve. Ductile iron body, TFE coated seats, 800 PSI.

Miscellaneous Components - Checks, strainers and other components as recommended by the manufacturer for a minimum rating of 300 PSI for the intended service.

H. Use dielectric fittings when connecting dissimilar metals.

2.02 VALVES

A. General

1. Valves shall be provided as shown and as required to make the installation and its apparatus complete in operation, locate to permit easy operation, replacement and repair. All pressures specified are steam working pressure.
2. All valves must be so constructed that they may be repacked under pressure while open.
3. Globe valves shall be installed in all lines where regulation is required.
4. Check valves shall be installed in all lines where flow may reverse from intended direction.
5. Except for above or as otherwise noted on drawings, ball valves shall be installed in all water supply and return lines and on all drain lines.
6. All valves to comply with federal specifications and be so listed.
7. All valves 2½ inches and larger shall be O.S.&Y. type with exception to ball valves.
8. Gate valves shall be installed in all steam and condensate piping. Ball valves shall not be used for steam or condensate service.
9. Butterfly valves shall not be used.

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B. Types and Manufacturers

All valves shall be of one manufacturer and by one of the manufacturers listed. The following list is provided as a means of identifying the quality and type required.

1. Gate Valves 2 inches in size and smaller shall have bronze bodies, rising stem, solid wedge, union bonnet, rated for 150# WSP, 300# WOG:

	<u>Soldered Ends</u>	<u>Screwed Ends</u>
Milwaukee	1169	1151
Stockham	B-124	B-120
NIBCO	S-134	T-134
Hammond	IB648	IB629

2. Gate Valves 2½ inches in size and larger shall have iron bodies, bronze trim, OS&Y, solid wedge, bolted bonnet and flanged ends. Rated for 125# WSP, 200# WOG:

	<u>Flanged Ends</u>
Milwaukee	F-2885
Stockham	G-623
NIBCO	F-617-0
Hammond	JR1140

3. Globe Valves 2 inches in size and smaller shall have bronze bodies, union bonnet, renewable composition disc for service intended, rated for 150# WSP, 300# WOG:

	<u>Soldered Ends</u>	<u>Screwed Ends</u>
Milwaukee	1590-T	590-T
Stockham	B-24-T	B-22-T
NIBCO	S-235-Y	T-235-Y
Hammond	IB423	IB413T

4. Globe Valves 2½ inches in size and larger shall have iron bodies, union trim, OS&Y, bolted bonnet, solid disc, gland packed, flanged ends. Rated for 125# WSP, 200# WOG:

	<u>Flanged Ends</u>
Milwaukee	F-2981
Stockham	G-512
NIBCO	F-718-B
Hammond	IR116

5. Plug type Globe valves 2 inches in size and smaller shall have bronze bodies, union bonnet, stainless steel plug type disc and seat. Rated for 150# WSP, 300# WOG:

	<u>Soldered Ends</u>	<u>Screwed Ends</u>
Milwaukee	591-A	
NIBCO	T-256-AP	

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6. Ball valves 1¼ inches in size and smaller shall have bronze bodies, brass stems and chrome plated brass balls, reinforced Teflon seats and seals, blow-out proof stems and adjustable stem gland. Shall be equipped with suitable packing for service intended. Ports shall be "full port". Rated for 400# WOG and 350°F:

	<u>Soldered Ends</u>	<u>Screwed Ends</u>
Milwaukee	BA-350	BA-300
Apollo	82-200	82-100
Watts	B-6081	B-6080
NIBCO	-----	-----
Hammond	8614	8604

7. Ball valves 1½ and 2 inches in size shall have bronze bodies, two piece, standard port, brass stems and chrome plated brass balls, reinforced Teflon seats and seals, blow-out proof stems and adjustable stem gland. Shall be equipped with suitable packing for service intended. Rated for 400# Bar non-shock cold working pressure.

	<u>Soldered Ends</u>	<u>Screwed Ends</u>
Apollo	70-200	70-300
Watts	B-6000	B-6001
NIBCO	S-580-66	T-580-66
Hammond	8513	8503

8. Ball valves 2½ inches in size and larger shall have carbon steel bodies, Type 316 stainless steel stems, Type 351 stainless steel balls (vented), glass filled Teflon seats and seals and blow-out proof stems. Shall be equipped with suitable packing for service intended. Rated for 150# WOG and 350°F:

	<u>Flanged Ends</u>
Apollo	88-140
Watts	CF-1500-150-02-T316
NIBCO	F-510-CS-R-66-FS

9. Check Valves 2 inches in size and smaller shall be horizontal swing type with bronze body, Teflon disc. Rated for 125# WSP, 200# WOG:

	<u>Soldered Ends</u>	<u>Screwed Ends</u>
Milwaukee	1509-T	509-T
Stockham	B-310-T	B-320-T
NIBCO	S-413-Y	T-413-Y
Hammond	IB945	IB904

10. Check valves 2½ inches in size and larger shall be horizontal swing type with iron body, bronze trim and flanged ends. Rated for 125# WSP, 200# WOG:

	<u>Flanged Ends</u>
Milwaukee	F-2974
Stockham	G-931
NIBCO	F-918-B
Hammond	IR1124

2.03 PIPE HANGERS AND SUPPORTS

A. General

1. All hangers and supports shall be specially manufactured for that purpose and shall be the pattern, design and capacity required for the location of use.
2. Piping specified shall not be supported from piping of other trades.
3. Hangers shall be steel, adjustable clevis type; plain for steel pipe and copper plated for copper tubing. Carpenter & Paterson, Inc., Fig. 100 (Fig. 100 CT copper plated) or approved equal. Hangers on hot water and drain piping shall be sized for the piping only (not including insulation). Hangers on steam, chilled water piping, cold water piping, and where specifically indicated on drawings, shall be sized to include the insulation and include thermal hanger shields (insulated pipe supports).
4. Thermal hanger shields shall be Carpenter & Paterson, Inc., Fig. 265P or approved equal.
5. Exposed vertical risers $\frac{3}{4}$ inch and smaller shall be supported at the mid-point between floor and ceiling with split ring type hangers; copper plated for copper tubing. Carpenter & Paterson, Inc., Fig. 81 (Fig. 81 CT copper plated) or approved equal.
6. Attachments to wide flange steel members shall be adjustable beam clamp, Carpenter & Paterson, Inc., Fig. 82 or approved equal.
7. Piping suspended from walls, trench walls and partitions shall be supported by steel support bracket. Carpenter & Paterson, Inc., Fig. 69 or approved equal.

B. Hanger Rods

1. Hanger rods shall be galvanized all thread rod. Rod size shall be as follows:

<u>Pipe Size</u>	<u>Rod Size</u>
$\frac{1}{2}$ " to 2"	$\frac{3}{8}$ "
$2\frac{1}{2}$ " to $3\frac{1}{2}$ "	$\frac{1}{2}$ "
4" & 5"	$\frac{5}{8}$ "

2. Provide toggle bolts for fastening to concrete blocks and compound anchor shields for bolts for fastening to poured concrete.
3. Provide lag points with rod couplings or side beam connectors with drive screws for fastening to wood.
4. All nuts for hanger rod to be stainless steel.

C. Supports

Provide and install angle iron supports for pipe hangers as required. Angle iron supports shall be adequate size for span and piping or equipment load.

2.04 PIPE SLEEVES AND ESCUTCHEONS

A. Interior Sleeves

1. Mechanical Contractor shall set sleeves for all piping penetrating interior concrete and masonry walls and floors. Sleeves shall be schedule 40 steel pipe, two sizes larger than the carrying pipe. Pipes passing through walls and floors of frame construction need not be provided with sleeves.
2. Sleeves set in floors shall finish flush with the underside, but extend a minimum of 1 inch above the finish floor. Sleeves set in walls shall finish flush with each side. General Contractor shall grout between sleeves and surrounding masonry.
3. Spaces between sleeves and pipes shall be sealed fire and smoke tight. Spaces between pipes and floors and between pipes and fire rated walls in frame construction shall also be sealed fire and smoke tight. Sealant material shall be 3M brand fire barrier caulk CP25 or putty 303, Ciba-Geigy CS240 Firestop Sealant, or approved equal and shall be U.L. listed.

B. Exterior Sleeves

Where piping passes through exterior walls, provide and install a complete pipe sleeve/hydrostatic wall closure system as shown on drawings.

1. Wall sleeve shall be schedule 40 steel pipe, two pipe sizes larger than carrier pipe. Sleeve shall be the same length as the thickness of the wall served.
2. The hydrostatic closure device shall consist of identical interlocking links of solid synthetic rubber compounded to resist ozone, water, chemicals and extreme temperature variations. Each link shall be connected by corrosion resistant bolts and nuts to form a belt which is to fit snugly around the pipe. Under each bolt and nut there shall be a metal pressure plate so that when each nut is tightened the rubber links will expand between the pipe and sleeve to form a continuous, air tight and water tight seal.
3. Units to be Link-Seal system Model LS wall seal by Thunderline Corp. or approved equal.

C. Escutcheons

Where uninsulated piping passes through finish walls, floors, ceilings and partitions, provide and set two piece nickel plated steel floor and ceiling plates. Provide deep type floor plates as required for projecting sleeves. Piping through walls with insulation shall not require escutcheons.

2.05 ANCHORS

Anchors shall be provided and installed as detailed and shown on the drawings, or as required to control expansion.

2.06 POLYETHYLENE HEATING HOT WATER PIPING

A. General

Furnish and install complete system of pre-manufactured piping as shown on plans. The system shall consist of flexible crosslinked polyethylene tubing known in the trade as PEX. Tubing shall meet ASTM F876 and F877 standards and shall be capable of service temperatures up to 200°F. and working pressure to 100 psi.

B. Construction and Components

The carrier pipe shall be PEX flexible crosslinked tubing, internal diameter as indicated on drawings. Connections to copper piping shall be sweat connectors and connections to steel piping shall be threaded connectors, all provided by the tubing manufacturer and installed in strict accordance with manufacturer's instructions.

Insert fittings shall be copper or brass, ASTM F 1807

Crimp rings shall be copper (black for PEX systems), ASTM F 1807

C. PEX tubing must be labeled (on the tubing) as follows:

1. The manufacturer's name or trademark
2. The standard to which it conforms (ASTM F876, F877, or both)
3. Tube size and CTS
4. Material designation code (PEX0006)
5. Pressure/temperature rating(s)
6. SDR9

The marking interval shall be not more than five feet.

2.07 REFRIGERANT SPECIALTIES

A. Sight glass and moisture indicator shall be provided and installed in the liquid line at each compressor-condenser unit if not factory installed.

B. A complete charge of R-410A shall be provided for the system.

C. The liquid line shall be provided with removable core type filter-dryer and refrigerant valves if not factory installed.

D. Suction and liquid refrigerant piping shall be provided and installed. The refrigerant piping shall be run in an approved manner providing traps where necessary to maintain the proper gas velocities and to keep the system free of oil.

2.08 HOT WATER SPECIALTIES

A. Manual (Adjustable) Balancing Valves

1. Heating hot water return mains, where indicated, shall be provided with a manually adjustable balancing valve equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral EP check valve designed to minimize system fluid loss during the monitoring process. Each balancing valve shall have an indexing pointer and calibrated name plate to indicate the degree of closure of the precision machine orifice. Each balancing valve is to be constructed with internal O-ring seals to prevent leakage around the rotating element.
2. Valves shall be sized with an operating pressure differential range of 1.50 psig (minimum) to 2.00 psig (maximum). Do not use adjustable balancing valves on lines with flow rates less than 2.50 GPM, use automatic valves instead.
3. Provide a schedule clearly indicating every valve, its location, GPM, size and pressure drop.
4. Each balancing valve shall be Taco Circuit Setter with a working pressure of 175 psig and a maximum operating temperature of 250°F. Units by Bell & Gossett or Tour and Anderson will be considered.

B. Automatic (Preset) Balancing Valves

1. All cabinet unit heaters, unit heaters, hydronic duct heating coils and elsewhere as indicated, shall be provided on the return line from each unit with a balancing type valve equipped with readout taps to facilitate the connecting of a differential pressure meter. Valve body shall include a ball valve, flow control cartridge assembly, two (2) pressure/temperature plugs and inlet union. Valve bodies shall be line size.
2. Design
 - a. The GPM for the automatic flow control valves shall be factory set and shall automatically limit the rate of flow to within 5% of the specified amount.
 - b. For ½ inch to 2 inch sizes the flow cartridge shall be removable from the Y body housing without the use of special tools to provide access for regulator changeout, inspection and cleaning without breaking the main piping (Access shall be similar to that provided for removal of a Y-strainer screen).
 - c. True operating ranges of 2 - 32 psid or 5 - 60 psid are required. The design flow should be achieved at the minimum psi differential. A 50% safety factor applied to the lower operating range is not acceptable.
 - d. Each valve shall have two PIT ports.
 - e. All automatic flow control devices shall be supplied by a single source and certified flow tests, witnessed by a professional engineer, shall be available.

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- f. Provide factory product warranty of not less than five (5) years and free first year cartridge exchange.
3. Construction
 - a. Internal wear surfaces of the valve cartridge shall be electroless nickel or stainless steel.
 - b. Internal flow cartridge body shall have machined threads so the spring free height may be compensated for without the use of fixed shims. A crimped sheet metal design is not acceptable.
 - c. Internal flow cartridge shall be permanently marked with the GPM and spring range.
 - d. All valves shall be factory leak tested at 100 psi air under water.
 4. Minimum ratings
 - a. ½ inch through 2 inch pipe size: 400 PSIG at 250DF
 - b. 2½ inch through 14 inch pipe size: 600 P516 at 250°F
 5. Flow Verification
 - a. Where indicated on the plans, the differential pressure across the Automatic Flow Control Valve shall be measured for flow verification and to determine the amount of system over heading or under pumping.
 - b. Flow shall be verified by measuring the differential pressure across the coil served or the wide open temperature control valve and calculating the flow using the coil or valve Cv.
 6. Test Kit

A differential pressure test kit shall be supplied to verify flow and measure overheading. The kit shall consist of a 4½ inch diaphragm gauge equipped with ten foot hoses and P/T adapters all housed in a vinyl case. Calibration shall be 0-35 PSID for 2-32 PSI spring range or 0 - 65 PSID for 5-60 PSI range.
 7. Installation
 - a. Install automatic flow control valves on the return lines of coils as indicated on the plans. Balancing valve on supply side is not acceptable.
 - b. The standard ports and handles shall clear 1 inch thick insulation. Handle and port extensions are required for over 1 inch thick insulation.
 8. Units shall be Flow Design “AutoFlow” or approved equal.
 - a. Model ACM for ½ inch and ¾ inch sizes.
 - b. Model AC for 1 inch to 2 inch sizes.

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B. Strainers

1. All cabinet unit heaters, unit heaters, hydronic duct heating coils and elsewhere as indicated, shall be provided on the supply line to each unit with a strainer equipped with ports to facilitate the connecting of a pressure gauge or thermometer and a hose end drain. Valve body shall include a ball valve and shall be line size.
2. Construction
 - a. 20 mesh stainless steel strainer, removable without breaking the main piping.
 - b. Ball valve shall have Teflon packing, brass packing nut, blowout-proof stem, large diameter plated ball and a handle with vinyl grip.
 - c. A integral union shall be provided on the discharge end of the strainer and shall incorporate an EPDM O-ring and tailpiece. Unions shall be available in both male & female threaded and sweat configurations.
 - d. Units shall be rated for 400 psig at 250°F.
3. Strainers shall be mounted upstream of ATC control valves (see typical piping diagrams on drawings).
4. Units shall be by Flow Design or approved equal.
 - a. Model YCM for ½ inch and ¾ inch sizes.
 - b. Model YC for 1 inch to 2 inch sizes.

C. Radiator Valves

All radiation shall be provided with ball valve for 125 psig at 250°F. as specified under valves.

D. Drains

Each downfeed cabinet unit heater, unit heater and coil shall be provided with a drain valve between the shut-off valves and heating equipment at the lowest point in the piping. All low points in piping mains shall be provided with drain valves. Drain valves shall be ball valves as specified under VALVES with hose connections and metal caps.

E. Air Vents

1. Air vents shall be installed at the equipment, all high points in the piping as indicated on the plans or as may be required.
2. Automatic air vents shall be Taco 409 brass vent with ¾ inch I.D. flexible tube drain. Units by Anderson, Armstrong (No. 1-AV) or Sarco will also be considered. Pet cocks shall be installed with each unit and the drains from the vents shall be run as indicated on the plans. An air chamber shall be installed at each air vent on piping 2 inches and larger piping. Do not use on glycol systems, use manual vents only.

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3. Manual air vents shall consist of air chamber with a Dole No. 14A Coin Valve with copper tube extension. Install valve in accessible location.
4. By-pass type vents shall be installed where shown and as detailed on the drawings. By-pass valves shall be plug-type globe as specified under VALVES.

F. Expansion Tank

Furnish and install vertical pressurized replaceable bladder type water expansion tank pre-charged to pressure shown on the drawings. Tank shall be constructed of steel for 125 psi working pressure in accordance with ASME Code, and have the necessary tappings for water connections and charging valve. Tank shall be furnished with ASME stamp and certification papers. A copy of ASME certification shall be provided with equipment submittal.

1. Tank shall be installed with a manual shut-off valve between the tank and the system and a union between the tank and the valve.
2. Tank shall be Taco CBX series. Units by Bell & Gossett or Wood will be considered. Capacities shall be as shown on drawings.

G. Backflow Preventer

Backflow preventer shall be furnished under division 22, "PLUMBING".

H. Water Pressure Reducing Valve

Furnish and install a pressure reducing valve with brass body construction and built-in strainer in the cold water piping connected to hot water heating system as shown on the drawings. The valve shall be adjustable and be No. 335, as manufactured by Taco. Units by Bell & Gossett and Watts will be considered. Provide pressure relief valve with operating pressure 100% over system pressure, but not exceeding 100 psi.

I. Air Separator

Furnish and install air separator, Taco AC4F, Bell & Gossett "Rolairtrol" or approved equal. Unit shall be flanged and contain a strainer system. Unit to be constructed in accordance with A.S.M.E. boiler and pressure vessel code and stamped 125 psig design pressure.

J. Pressure Gauges

Furnish and install pressure gauges with gauge cocks on piping where shown on drawings. Tubing to pressure gauges shall be of sufficient length to extend beyond pipe insulation and still leave enough space to easily operate the gauge cock. The dial range shall be such that the normal pressure shall be approximately midway of the dial. Gauges shall be Weiss Series 4CTS with 4½ inch dial size, stainless steel or cast aluminum case, with brass "T" handle cocks. Provide steam siphons on steam pressure gauges and bronze pressure snubbers on water pressure gauges. Units by Ashcroft, Nurnburg & Terrice will be considered.

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Pressure range: Water Systems 0-60 psi

k. Thermometers

Furnish and install where indicated on the drawings and in Part 3 - EXECUTION, analog dial type thermometers with stainless steel case, 4½ or 5 inch dial size, bimetal, universal angle type. No other style will be accepted. Thermometers shall be Weiss 5VBM series. Units by Ashcroft, Nurnburg & Trerice will be considered. Provide and install thermometer wells on supply and return branch piping to duct reheat coils (when present) and two thermometers in boxes for the Owner's use.

Temperature Range: Heating System... 30°F. - 240°F.

2.09 CIRCULATING PUMPS

A. Circulating Pumps P-1 and P-2

1. Furnish and install hot water circulating pumps of the type, size and capacity shown on drawings. Pumps shall employ ECM technology, Wilo Stratos or approved equal.
2. Pumps shall be wet rotor, glandless inline circulating pumps and shall include electronic variable speed control to operate at constant/variable differential pressure control without external sensors.
3. Materials and Construction
 - a. Circulating pumps shall be constructed with Cast-Iron bodies with factory applied Cathaphoresic coating.
 - b. Shafts shall be constructed of high quality stainless steel. Motor bearings shall be metal impregnated carbon sleeve bearing type. Impellers will be constructed of a high strength, glass filled polypropylene engineered composite.
4. Pumps shall include the following features:
 - a. Integrated synchronous motors using ECM technology with permanent magnetic rotors, sensorless control electronics and single phase electronic converters.
 - b. Infra-red (IR) interface for wireless communication and an infra-red monitor.
 - c. Integrated overload motor protection.
 - d. Fault contact "FC" terminals shall be included in the terminal box and are to be potentially free, normally closed contacts that open on the event of a failure.
 - e. Interface (IF) modules shall be included and installed in the terminal box of each pump to permit external on/off, dual pump communication and pump operation status. See section 23 09 00, "AUTOMATIC TEMPERATURE CONTROL" for coordination.
 - f. Internal programming to regulate pump on/off operation based on outdoor temperature.

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- g. Internal programming to regulate pump speed in response to changes in system pressure.
 - h. Internal programming to provide lead/lag operation.
5. Pumps shall have a terminal box with NPT electrical connections and a secure, gasketed cover, Class 2 protection level. Include on the face of the terminal box cover a single adjustment button, front readable graphical pump display, field adjustable for horizontal or vertical positioning of the terminal box. The display shall indicate:
- a. Operation status
 - b. Control mode
 - c. Differential pressure or speed/setpoint
 - d. Fault and warning signals
6. Pumps shall have a coded terminal strip indicating common/neutral/ground within the terminal box for field connections for single phase 230 volt, 60 Hz power.
7. Electrical
- a. Motor shall be a minimum of class H winding insulation as defined by UL 778.
 - b. Voltage variances shall be less than +/- 10% from rated voltage with pump under load conditions. Maximum amperage not to be exceeded is indicated on the pump nameplate. Electrical power to the pump is confirmed when the face of the graphic display is lit.
8. Startup and adjustment
- Manufacturer shall provide a factory authorized mechanic to provide startup services for the pumps. Startup shall include (but not be limited to):
- a. Setup of lead / lag control between pumps.
 - b. Adjustment of required pressure settings.
 - c. Verification that the ATC system is able to communicate with the pumps for start/stop and alarming features as required by the ATC system.

2.10 BOILERS

- A. Furnish and install where shown on the drawings, low mass cast iron, direct vent natural gas fired boiler units. Units shall be condensing type with stainless steel burners. Units shall be wired for 120 volts, 1 phase, 60 hertz power, see "Boiler Schedule", sheet M15.
- B. Compliances
 - 1. ASME Compliance: Boilers shall bear ASME "H" stamp and be National-Board listed.
 - 2. FM Compliance: Control devices and control sequences according to requirements of FM.

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3. IRI Compliance: Control devices and control sequences according to requirements of IRI.
4. Comply with NFPA 70 for electrical components and installation.
5. CSD-1
6. SCAQMD Rule 1146.2 for low NO_x equipment
7. BACT Compliant (Best Available Control Technology)

C. Submittals

1. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated.
2. Detail equipment assemblies and indicate dimensions, required clearances, and method of field assembly, components, and location and size of each field connection.
3. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
4. Source Quality Control Tests and Inspection Reports: Indicate and interpret test results for compliance with performance requirements before shipping.
5. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
6. Maintenance Data: Include in the maintenance manuals specified in Division 1. Include parts list, maintenance guide, and wiring diagrams for each boiler.

D. Warranties

1. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents. Installing contractor shall provide one year of warranty parts and labor.
2. Special Warranty: Submit a written warranty, executed by the contractor for the heat exchanger.
3. Warranty Period: Manufacturer's standard, but not less than 10 years from date of Substantial Completion on the heat exchanger. Warranty shall be non-prorated and not limited to thermal shock. Additional 21 year thermal shock warranty on heat exchanger.

E. Design

Boilers shall be CSA design certified as a condensing boiler. Boilers shall be designed for a minimum of 4:1 continuous turn down with constant CO₂ over the turndown range. Boilers shall operate with natural gas and have a CSA certified input rating as noted on the drawings, and a thermal efficiency rating of 88% at rated input and 99% at minimum input. Boilers shall be symmetrically air-fuel coupled such that changes in combustion air flow or flue flows affect the BTUH input without affecting combustion quality. Boilers will automatically adjust input for altitude and temperature induced changes in air density. Boilers shall use a proven pilot interrupted spark ignition system and shall use a UL approved flame safeguard ignition control system using UV detection flame sensing. The UV detector shall be air cooled to prevent condensate formation and so designed as to prevent misalignment. The design shall provide for silent burner ignition and operation. The boiler shall be down fired counter flow such that formed condensate always moves

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toward a cooler zone to prevent re-evaporation. An aluminum corrosion resistant condensate drain designed to prevent pooling and accessible condensate trap shall be provided. Boiler shall be able to vent a horizontal distance of 80 equivalent feet.

F. Service Access

Boilers shall be provided with access covers for easily accessing all serviceable components. The boilers shall not be manufactured with large enclosures, which are difficult to remove and reinstall. All accesses must seal completely as not to disrupt the sealed combustion process. All components must be accessible and able to adjust with the removal of a single cover or cabinet component.

G. Indicating Lights

Each boiler shall include a diagnostic control panel with a full text display indicating the condition of all interlocks and the BTUH input percentage. Access to the controls shall be through a completely removable cover leaving diagnostic panel intact and not disrupted.

H. Components

1. Combustion Chamber shall be constructed of cast-iron.
2. Heat Exchanger: Boilers shall be a cast iron sectional unit designed for pressure firing and shall be constructed and tested for 100 P.S.I water working pressure, in accordance with the A.S.M.E. Section IV Rules for the Construction of Heating Boilers. Individual sections will have been subjected to a hydrostatic pressure test of 250 PSIG at the factory before shipment and they shall be marked, stamped or cast with the A.S.M.E. Code symbol. Boilers with less than 250-psi pressure test will not be acceptable for this project. The sections shall be of a down fired counter flow single-pass design. Water ports will be sealed with graphite port connectors. The sections will be fully machined for metal to metal sealing of the gas side surfaces. The design will provide for equal temperature rise through all sections. The heat exchanger shall be designed to prevent fluid boiling. The iron shall have a minimum thickness of 3/8". The heat exchanger design should have no limitations on temperature rise or restrictions to inlet water temperature and a Cv of 100.
3. Stainless steel jackets.
4. Gas burners shall be constructed of stainless steel. The burner flame shall burn horizontally and be of the pre-mix type with a forced draft fan. Burner shall fire to provide equal distribution of heat throughout the entire heat exchanger. The burner shall be easily removed for maintenance without the disruption of any other major component of the boiler. A window view port shall be provided for visual inspection of the boiler during firing. The gas distribution components and burner shall be enclosed with a cast-aluminum housing.
5. The ignition hardware shall consist of insulated ignition electrodes and UV sensing tube permanently arranged to ensure proper ignition electrode and UV alignment.
6. Boilers shall be capable of operating at rated capacity with pressures as low as 2" W.C. at the inlet to the burner pressure regulator.
7. The burner shall be capable of 99% efficiency without exceeding a Nox reading above 12 ppm.

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I. Burner and gas train

1. Burner Firing: Full modulation with 4:1 turndown @ Continuous CO₂
2. Burner Ignition: Intermittent spark
3. Safety Controls: Energize ignition (14,000 Volts), limit time for establishing flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, and allow gas valve to open.
4. Flue-Gas Collector: Enclosed combustion chamber with integral combustion-air blower and single venting connection.
5. Gas Train: Manual gas valves (2), main gas valve (solenoid), 'B' valve, pilot gas pressure regulator, and automatic pilot gas valve. All components to be factory mounted.
6. Safety Devices: Low gas pressure switches, air-flow switch, and blocked flue detection switch. All safeties to be factory mounted.

J. Boiler Trim

1. Safety-Relief Valve: 50 psi, ASME rated, factory set to protect boiler and piping as per schedule/drawings.
2. Combination water pressure and temperature shipped factory installed. LCD inlet/outlet temperature gauges to be an integral part of the front boiler control panel to allow for consistent easy monitoring of temperatures factory mounted and wired.
3. Low water cut off (with manual reset) shall be factory mounted and wired. Provision for installation of a low water cut off shall be provided.
4. Boilers shall be provided with a Honeywell RM7897C series digital flame safe guard display module standard. The flame safe guard shall be capable of both pre and post purge cycles.
5. Operating Temperature Control: Shall be a digital controller adjustable from 120 to 240 degrees F. Control shall be factory mounted and sense the inlet and outlet temperature of the boiler through resistance sensors.
6. High Limit: Temperature control with manual-reset limits boiler water temperature in series with the operating control. High Limit shall be factory mounted and sense the outlet temperature of the boiler through a dry well.
7. Aluminum condensate receiver pan.
8. Low air pressure switch.
9. Blocked Flue Detection Switch
10. Manual Reset Low Water Cut Off (CSD-1 Factory Mounted and wired)
11. Modulation Control
12. Temperature/Pressure Gauge
13. Manual Reset High Limit
14. Air Inlet Filter (Washable)
15. Inlet/Outlet Temperature Display
15. Full Digital Text Display for all Boiler Series of Operation and Failures
17. Variable Frequency Drive and Combustion Air Fan
18. Condensate Drain
19. FM and CSD-1 Compliant Gas Train
20. Diagnostic Keyboard Display for RM7800 series control.

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K. Motors

Open drip-proof motors where satisfactorily housed or remotely located during operation. Blower motor shall be externally mounted for ease of service. There shall be no requirement to remove covers or gas train components to remove the blower motor. Blower motor shall not exceed ½ HP and not require more than 5 amps.

L. Controls

1. Each boiler shall maintain set temperature as determined by its own internal controls. Temperature shall be reset according to outdoor temperature. Provide outdoor and boiler temperature sensors with each boiler.
2. Controls shall include a “true run time” lead-lag controller to designate one boiler as the lead unit while the other boiler serves as stand-by. The lead boiler shall provide heat as required by the heating system. Should the lead boiler not be able to meet load demands the stand-by boiler shall become active to supplement the lead boiler.
4. Circulating pumps P-1 and P-2 shall operate according to internal programming. A flow switch mounted in each boiler shall verify flow before permitting boiler(s) to fire.
5. Boiler manufacturer shall provide qualified personnel to install any controls and wiring requiring field installation. Installer shall work closely with the ATC Contractor to be sure interlocks between boiler controls and building controls are installed and functioning properly.
6. Each boiler shall be provided with Modbus communication compatibility as standard. See section 23 09 00, “AUTOMATIC TEMPERATURE CONTROL” for coordination.
7. Provide complete wiring schematics and control instructions for boilers with submittals.

M. Units shall be Hydrotherm Model KN Series, shipped in one piece on skids. Other units meeting these specified requirements will be considered.

N. Testing

Testing all pressure parts of the boilers shall be subjected to hydro-static tests according to ASME Code for low pressure boilers. Field tests shall be limited to maximum working pressure for which each boiler is intended. Contractor shall furnish all equipment, piping, water and labor necessary to perform such tests as may be required by the Boiler Inspector or as directed by Architect. Tests shall be of duration necessary to satisfy Boiler Inspector and Architect.

O. Startup and Commissioning

1. Engage a factory-authorized service representative to assist the Contractor with startup service. Start up to be performed only after complete mechanical room operation is field verified to offer a substantial load, and complete system circulation. One-year warranty shall be provided by the manufacturer. One year's service shall be provided by the Contractor. Manufacturer shall also include pricing to provide a factory authorized technician for up to 4 service calls over that one year period.

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2. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections. Do not proceed with boiler startup until wiring installation is acceptable to equipment Installer.
3. Complete manufacturer's installation and startup checklist and verify the following:
 - a. Boiler is level on concrete base.
 - b. Flue and chimney are installed without visible damage.
 - c. No damage is visible to boiler jacket, refractory, or combustion chamber.
 - d. Pressure-reducing valves are checked for correct operation and specified relief pressure. Adjust as required.
 - e. Clearances have been provided and piping is flanged for easy removal and servicing.
 - f. Heating circuit pipes have been connected to correct ports.
 - g. Labels are clearly visible.
 - h. Boiler, burner, and flue are clean and free of construction debris.
 - i. Pressure and temperature gages are installed.
 - j. Control installations are completed.
4. Ensure pumps are operate properly.
5. Check operation of pressure-reducing valve on gas train, including venting.
6. Check that fluid-level, flow-switch, and high-temperature interlocks are in place.
7. Start pumps and boilers, and adjust burners to maximum operating efficiency.
 - a. Fill out startup checklist and attach copy with Contractor Startup Report.
 - b. Check and record performance of factory-provided boiler protection devices and firing sequences.
 - c. Check and record performance of boiler fluid-level, flow-switch, and high-temperature interlocks.
 - d. Run-in boilers as recommended or required by manufacturer.
8. Perform the following tests for each firing rate for high/low burners and for 100, 66, and 33 percent load for modulating burners. Adjust boiler combustion efficiency at each firing rate. Measure and record the following:
 - a. Gas pressure on manifold.
 - b. Combustion-air temperature at inlet to burner.
 - c. Flue-gas temperature at boiler discharge.
 - d. Flue-gas carbon-dioxide and oxygen concentration.
 - e. Natural flue draft (if applicable).
9. Measure and record temperature rise through each boiler.

P. One Year Service

Each boiler-burner unit shall be provided with free service period of one (1) year after acceptance by Owner. This service will include parts replacement and repair, excluding normal maintenance and adjustment. This service shall be a factory authorized service.

2.11 SMOKE PIPE

- A. Furnish and install as indicated on drawings, a single wall, vent system complete with all

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required supports, braces, stiffeners, hangers and weather caps. Smoke pipe shall be single wall complete with all required supports, braces, stiffeners and hangers. Sizes indicated on drawings are minimum diameters required by the specified boiler manufacturer. Material shall be AL29-4C stainless steel, no less than 0.015 inches thick. System shall be UL-1738 listed and comply with ANSI Z21.47, NFPA 54 and the National Fuel Gas Code. Shop drawings shall carry documentation of such.

2.12 DUCT HEATING COILS

A. General

Furnish and install where indicated a duct mounted water heating coil, size and capacity as indicated on drawings. All coils 9 inches in height shall be headerless and entire unit shall be same height as the duct. Other coils may be header type. All coils shall be 1 or 2 row, ¼ serpentine with same end piping connections.

B. Headers

Water headers shall be seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Vent connections shall be provided at the highest point.

C. Tube and Fins

Tubes shall be round, seamless copper tubing brazed into intruder header tube holes using copper brazing alloys, tested at 315 lbs and guaranteed for 250 psig working pressure. Tubes shall be staggered in the direction of air flow. Fins shall be rippled aluminum with full drawn collars to provide a continuous surface cover over the entire tube. The use of internal restrictive devices to obtain turbulent flow will not be allowed since they prevent complete drainage of the coil.

D. Casing

Casing shall be constructed of continuous galvanized steel with 3/8 inch diameter bolt holes for flange mounting at 6 inch centers. Coil side plates shall also be of continuous galvanized steel of reinforced flange type construction for greater strength.

E. Coils shall be by Trane (type ST for units 9 inches in height and less). Units by Carrier, McQuay, USA Coil or York will be considered.

2.13 CABINET UNIT HEATERS

A. Cabinet unit heaters and fan coil units shall be provided and installed where shown and fastened securely. The units shall be mounted as indicated on the drawings and shall include multi-blade centrifugal fans with quiet operating three (3) speed high efficiency direct drive motor, insulated casing, coils of copper tubes with aluminum fins, tamper proof access door to motor control switch. Capacities indicated on drawings to be based on 130°F. inlet water.

B. All units shall be provided with 3 speed fan switch and unit mounted disconnect switch with thermal overload protection, all factory installed and wired.

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- C. Cabinets shall be 18-gauge steel with exposed corners and edges rounded, easily removed access panels. Finish shall be factory applied baked enamel in color as selected by Architect on visible surfaces of enclosure or cabinet. Provide two (2) color chip cards with submittals (photocopies not acceptable).
- D. Cabinet insulation shall be 2 inch thick dual density bonded glass fiber. Exposed side shall be high density erosion proof material suitable for use in airstreams up to 4500 FPM.
- E. Coils shall be evenly spaced aluminum fins mechanically bonded to copper tubes, designed for 200 psi and 220 degrees F.
- F. Provide two (2) sets of 1 inch *pleated media* throwaway type filters for each unit as specified under paragraph 2.19, "FILTERS". One set to be provided WITH each unit from the manufacturer to be used during construction and the other set installed when project is completed.
- G. The following units are based on Trane Models in order to establish a standard. Approved equals by American Air Filter or McQuay will be considered.
 - 1. Vertical surface units shall be Trane Cabinet Unit Heater Type FFBB or approved equal with [heavy duty line voltage electric return air thermostat provided and wired by unit manufacturer] [remote heavy duty line voltage electric thermostat and strap-on aquastat provided by Temperature Control Contractor as indicated].
- H. Shut-off valve, balancing valve, drain valve with metal cap and air vent shall be provided on each unit.

2.14 HORIZONTAL UNIT HEATERS

- A. Furnish and install hot water type horizontal propeller unit heaters as shown. Motors shall be totally enclosed and provided with overload protection and factory wired service disconnect switch.
- B. Units shall have coils with copper tubes and aluminum fins. Supply connections shall be in at the rear bottom and return out the rear top.
- C. Provide double directional louvers on each horizontal unit and controls indicated in "AUTOMATIC TEMPERATURE CONTROL".
- D. Shut-off valve, balancing valve and drain with metal cap shall be provided with each unit.
- E. Units shall be manufactured by McQuay. Units by American Air Filter or Trane Co. will be considered.

2.15 HEAT PUMP SYSTEM

A. General

Provide and install a variable capacity, split system, heat pump, heat recovery air conditioning and heating system as indicated on drawing. Systems shall be a variable refrigerant flow zoning system providing simultaneous heating and cooling.

The systems and equipment described herein are based on a Mitsubishi City-Multi VRFZ system, R2-Series (simultaneous cooling and heating) split system heat pump consisting of PURY outdoor (Compressor/Condenser) units, BCC (Branch Circuit Controllers) units, multiple indoor heat pump units and M-NET DDC (Direct Digital Controls). The PURY outdoor Compressor/Condenser units shall be a vertical discharge, 460 volt, three phase units. Sanyo or LG equipment meeting the features and performance requirements of this equipment will be considered. If a substitution of Sanyo or LG is made by the contractor it should be noted as add or deduct to the Mitsubishi quotation. Mitsubishi is a two-pipe system, LG and Sanyo are three-pipe systems and it will be the responsibility of the contractor to submit revised refrigerant piping plans for review. It will also be the responsibility of the contractor to include any additional control or power wiring that is required in addition to the specified Mitsubishi equipment.

Units shall be listed by Electrical Laboratories (ETL) and bear the ETL label. All wiring shall be in accordance with the National Electrical Code (N.E.C.). Units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

A full charge of R-410A for the condensing units only shall be provided in the condensing units.

Provide a full diagrammatic drawing of the heat pump systems shown all components (including equipment tags), refrigerant piping (including lengths and sizes) and control wiring with the shop drawings.

OU-15 will be the S-Series Heat Pump.

B. Warranty

All units shall be covered by the manufacturer's limited warranty for a period of one (1) year from date of installation. In addition the compressors shall have a manufacturer's limited warranty for a period of six (6) years from date of installation.

If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty shall not include labor.

C. Outdoor (Compressor/Condenser) Units

1. The outdoor units shall be intended specifically for use with other system components. The PURY outdoor units shall be equipped with multiple circuit boards that interface to the M-NET controls system and shall perform all

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functions necessary for operation. The outdoor units shall have a powder coated finish. The outdoor units shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.

- a. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of outdoor rated capacity.
- b. Outdoor units shall have a sound rating no higher than 63 dB(A).
- c. Both refrigerant lines from the outdoor units to the BC (Branch Circuit) Controller (Single or Main) shall be insulated.
- d. Outdoor units shall have an accumulator with refrigerant level sensors and controls.
- e. Outdoor units shall have a high pressure safety switch, over-current protection and DC bus protection.
- f. Outdoor units shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 984 to 1,312 feet. The greatest length is not to exceed 492 feet between outdoor unit and the indoor units without the need for line size changes or traps.
- g. Outdoor units shall be capable of operating in heating down to -4°F ambient temperature without additional low ambient controls.
- h. Outdoor units shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.

2. Unit Cabinets

Casings shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel.

3. Fans

- a. Outdoor units #4 and #5 shall be furnished with one direct drive, variable speed propeller type fan.
- b. Outdoor units #1, 2 and 3 shall be furnished with two direct drive, variable speed propeller type fans.
- c. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
- d. All fan motors shall be mounted for quiet operation.
- e. All fans shall be provided with a raised guard to prevent contact with moving parts.
- f. The outdoor unit shall have vertical discharge airflow.

4. Refrigerant

R410A refrigerant shall be required for PURY outdoor unit systems.

5. Coils

- a. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
- b. The coil fins shall have a factory applied corrosion resistant blue-fin finish.

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- c. The coil shall be protected with an integral metal guard.
- d. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
- e. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

6. Compressors:

- a. Outdoor units shall be equipped with one inverter driven scroll hermetic compressor and one scroll hermetic compressor.
- b. Crankcase heaters shall be factory mounted on the compressors.
- c. Outdoor unit compressors shall have an inverter to modulate capacity. The capacity shall be completely variable down to 16% of rated capacity.
- d. Compressors shall be equipped with an internal thermal overload.
- e. Compressor shall be mounted to avoid the transmission of vibration.

7. Electrical

- a. The outdoor unit electrical power shall be 460 volts, 3-phase, 60 hertz.
- b. The outdoor unit shall be capable of satisfactory operation within voltage limits of 413-506 volts.
- c. The outdoor units shall be controlled by integral microprocessors.
- d. The control circuit between the heat pump (indoor units), BC Controllers and the outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

D. Branch Circuit (B.C.) Controllers

- 1. Branch Circuit Controllers shall be specifically used with R410A R2-Series systems. These units shall be equipped with a circuit board that interfaces to the M-NET controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controllers shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.

2. BC Unit Cabinet:

- a. The casing shall be fabricated of galvanized steel.
- b. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
- c. The unit shall house two tube-in-tube heat exchangers.

3. Refrigerant

R410A refrigerant shall be required for BC Controllers in conjunction with PURY outdoor unit systems.

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4. Refrigerant valves:
 - a. The unit shall be furnished with multiple two position refrigerant valves.
 - b. Each circuit shall have one (54,000 Btu/h or smaller indoor unit section) two-position liquid line valve and a two-position suction line valve.
 - c. When connecting a 54,000 Btu/h or larger indoor unit section, two branch circuits shall be joined together at the branch controller to deliver an appropriate amount of refrigerant. The two refrigerant valves shall operate simultaneously.
 - d. Linear electronic expansion valves shall be used to control the variable refrigerant flow.
5. An integral condensate pan and drain shall be provided.
6. Electrical
 - a. Unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
 - b. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz).
 - c. The BC Controller shall be controlled by integral microprocessors.
 - d. The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

E. Ducted Heat Pump (Air Handling) Units

1. Units shall be model PDFY-P__NMU-E, high-performance ceiling concealed ducted indoor fan coil for mounting above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The PDFY shall be used with the R2-Series outdoor unit and BC Controller or S-Series outdoor unit. The PDFY shall support individual control using M-NET DDC controllers and shall feature external static pressure settings up 0.40 in. WG, 208/230 Volts, single phase.

Where indicated on the plans the low profile PEFY-P_NMSU-E shall be used.

2. Units shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. Units shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
3. Cabinet
 - a. Cabinets shall be ceiling-concealed, ducted.
 - b. Cabinet panels shall have provisions for a field installed filters on the intake.
4. Fan

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- a. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
- b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
- c. The indoor unit shall have a ducted air outlet system and ducted return air system.

5. Filter:

Return air shall be filtered by a field-supplied filter. Provide two (2) sets of 1 inch *pleated media* throwaway type filters for each unit as specified under paragraph 2.19, "FILTERS". One set to be provided WITH each unit from the manufacturer to be used during construction and the other set installed when project is completed.

6. Coil

- a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
- b. The tubing shall have inner grooves for high efficiency heat exchange.
- c. All tube joints shall be brazed with phos-copper or silver alloy.
- d. The coils shall be pressure tested at the factory.
- e. A condensate pan and drain shall be provided under the coil.
- f. The unit shall include a condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan.
- g. Both refrigerant lines to the PDFY indoor units shall be insulated.

7. Electrical

- a. Unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
- b. System shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz).

8. Controls

Units shall use controls provided by the manufacturer to perform functions necessary to operate the system. See section 23 09 00, "AUTOMATIC TEMPERATURE CONTROLS".

F. System Controls

See section 23 09 00, "AUTOMATIC TEMPERATURE CONTROLS".

Provide to controls contractor all controls that are to be provided by the Variable Refrigerant Flow manufacturer.

2.16 HEAT RECOVERY UNITS

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- A. Provide and install rooftop, curb mounted air to air heat recovery units as shown on drawings. Capacities shall be as scheduled on drawings.
- B. Units shall be listed per ANSI/UL 1995, Heating and Cooling Equipment. Energy transfer ratings of the energy recovery wheel shall be ARI Certified. Unit shall bear the AMCA Certified Rating Seals for Air Performance. Performance shall be as scheduled on plans. Exhaust discharge and outside air intake shall not be located on the same side of unit casing.
- C. Standard casing panels shall be 20 gauge galvanized steel, lined with not less than 1 inch thick fiberglass insulation with Foil-Scrim-Kraft facing. Housings shall be supported by a formed structural base forming a pan to ensure weather tight construction. Lifting holes shall be provided at the unit base. Units shall have a weatherproof sheet metal roof. The outdoor air intake opening shall be protected by a galvanized steel sheet metal weather hood, moisture eliminators, and include an automatic shutoff damper with electric operator and time delay relay to give the damper an opportunity to open prior to the fan starting. The exhaust air discharge shall be covered with a gravity back draft damper and weather hood. The exterior of the unit shall be coated with an epoxy primer and a polyurethane enamel painting system for added protection. Painting system shall be rated to meet a 1500-hour salt spray test.
- D. Access to components shall be provided through a large, tightly sealed and easily removable access panel. Access panels shall be constructed of the same materials as the unit casing. The wheel cassette shall be easily removable from the unit. The roof of the unit shall also be removable for access.
- E. The supply air and exhaust air from the building shall be oriented for a vertical inlet and discharge.
- F. Fans shall be double width double inlet design with forward curve type wheels. The blades shall be designed for maximum efficiency and quiet operation. Impellers shall be statically and dynamically balanced.

For belt driven fans V-belt drives shall be sized for a minimum 150% of driven horsepower. Sheaves shall be adjustable on fans with motors less than 10 HP to allow independent balancing of exhaust and supply airflows. Pulleys shall be of the fully machined cast type, keyed and securely attached to the fan wheel and motor shafts. Optional speed controllers on direct-drive fans shall allow independent balancing of exhaust and supply airflows.

Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds.

Motors shall be standard NEMA frame, energy efficient, complying with EPACT standards, for single speed ODP enclosures. Motors shall be permanently lubricated, heavy-duty type, matched to the fan load and furnished at the specified voltage and phase with thermal overload protection. Where 3-phase is indicated motors shall be VFD rated.

Fans and motors shall be mounted to a unit base with neoprene isolators as standard. Belt drive motors shall be factory mounted to an adjustable motor plate having two heavy-

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duty adjusting bolts for alignment and belt tension.

- G. The rotor (energy wheel) shall be made of either a light weight polymer media in a stainless steel rotor or an aluminum media, coated to prohibit corrosion in a galvanized steel rotor. All surfaces shall be permanently bonded with a desiccant for both sensible and latent recovery and be designed to insure a laminar flow. Wheels with sprayed on desiccant coatings are not acceptable. The energy recovery wheel shall transfer moisture entirely in the vapor phase. Efficiencies shall match performance as scheduled, transfer ratings must be ARI certified to standard 1060 and bear the ARI certification symbol for ARI Air-to-Air Energy Recovery Equipment Certification Program based on ARI 1060. Ratings "in accordance with 1060" without certification are not acceptable. The media shall be cleanable with low temperature steam, hot water or light detergent, without degrading the latent recovery. Wheel media shall be independently tested and shown to conform to the requirements of NFPA-90A, documenting a flame spread of less than 25 and a smoke generation rating of less than 50.
- H. The rotor cassette shall be easily removable from the unit to facilitate rigging (if necessary) and ease of service. The wheel cassette design shall use pillow block bearings for long life. For rotors thicker than 3" an adjustable purge sector shall be included in the cassette.
- I. Filters shall be not less than 1 inch thick permanent aluminum washable type mounted in the outside air hood and in the return air plenum. The filters shall be listed by Underwriters' Laboratories as Class 2.
- J. Units shall be equipped with a rotation sensor and controller such that should the energy recovery wheel not rotate during a signaled run period, the controller shall send a 24 volt AC signal suitable for operating a relay to be used as an alarm contact. In addition, this controller shall be equipped with an outdoor air temperature and discharge temperature sensors such that the energy recovery wheel can be modulated via a (VFD) during moderate temperature periods if desired.
- K. Units shall require a single point 60-cycle power connection. See equipment schedule on sheet M15 for voltage and phase requirements. The electrical panel shall consist of individual motor contactors, short circuit and overload protection, disconnect switch (for pre-heaters) and control power transformer. The NEMA 3R electrical panel shall be mounted on the unit exterior for ease of access or be a factory integral panel to the unit. A factory installed and wired 120 volt convenience outlet shall be provided inside the panel. Units shall be ETL listed and labeled.
- L. Manufacturer shall warrant to Owner that for a period of not less than eighteen (18) months from the date of shipment the goods to be delivered to Owner will in all material respects be free from defects in material and workmanship when used in a proper and normal manner. Should any failure to conform to the above appear within eighteen months after the date of shipment, manufacturer agrees upon prompt notification thereof during the Warranty Period and confirmation to manufacturer's satisfaction that the goods have been stored, installed, operated and maintained properly and in accordance with standard industry practice, to correct the non-conformity at manufacturer's option either by repairing any defective part or parts or by making available at manufacturer's plant a repaired or replacement part.

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Manufacturer shall warrant to the Owner for a period of not less than 60 months that the wheel contained in the energy recovery unit in all material respects to be free from defects in material and workmanship when used in a proper and normal manner. For warranty purposes the wheel includes, media, desiccant coating, wheel hub, wheel rim and spokes.

- M. Provide a remote control panel mounted to each unit. Panels shall be located in Electrical 501A. Panels shall contain:
1. A contactor to permit start/stop operation with a signal from the building ATC system
 2. Rotation detection
 3. On-Off-Auto switch
 4. Wheel Frost Protection
- N. Provide factory authorized start-up and Owner training by a factory authorized representative.
- O. Submittals must include performance data which incorporates total unit energy consumption (fan power, wheel operation, energy recovery, etc.) vs. energy savings.
- P. Units shall be provided with factory insulated curbs not less than 16 inches high. Contractor shall fill the curbs with fiberglass batt insulation for added thermal and sound protection.
- Q. Units shall be Semco FV series for horizontal ducting. Equivalent units meeting the requirements of this specification by Greenheck will be considered.

2.17 FANS

- A. General
1. Fans with capacity and types shown on the drawings shall be provided and installed. In order to establish a standard, fan model numbers indicated below are based on Cook (unless noted otherwise) Equivalent units by Acme, Greenheck and Ilg ONLY will be considered.
 2. Fan selection shall be based on sloping portion of curve with spare capacity of 20% of total CFM and static pressure without increasing motor size. **Provide full fan curves with submittals that shown the entire operating range of the fan - not just the operating point. Fans that are submitted without this data will not be accepted.**
 3. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance and shall be listed by the Canadian Standards Association Testing Laboratory (CSA). Sones indicated on drawings are AMCA ratings and are the maximum allowable. HVI sound ratings are not acceptable.
 4. All fans shown with vibration isolators on drawings shall be provided with spring type unless otherwise indicated.
 5. Motor operated dampers (where indicated) shall be furnished by ATC

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Contractor. See Section 23 09 00.

B. Types

1. EF-1, 2, 3 and 4 shall be either in-line or ceiling mounted, direct driven, centrifugal exhaust fan, GC Series.

Fans shall be manufactured at an ISO 9001 certified facility and shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (cUL 705). Fans shall bear the AMCA certified ratings seal for sound and air performance.

Wheel housing and integral outlet duct shall be injection molded from a specially engineered resin exceeding UL requirements for smoke and heat generation. The outlet duct shall have provision for an aluminum backdraft damper with continuous aluminum hinge rod. The inlet box shall be minimum 22 gauge galvanized steel. Motor shall be isolation mounted to a one piece galvanized stamped steel integral motor mount/inlet. A field wiring compartment with receptacle shall be standard. To accommodate different ceiling thickness, an adjustable pre-punched mounting bracket shall be provided. Units shall include a backdraft shutter in the outlet duct connection and be designed with provision for field conversion from ceiling to in-line. A white, aluminum grille provided for ceiling mounted units. Units shall be shipped in ISTA certified transit tested packaging.

Wheel shall be centrifugal forward curved type, injection molded of polypropylene resin. Wheel shall be balanced in accordance with AMCA Standard 204-96, *Balance Quality and Vibration Levels for Fans*.

All units shall have an internal, factory wired fan speed controller for balancing purposes. EF-3 shall also include a pre-wired time delay shut-off switch.

Motor shall be open drip proof type with permanently lubricated sealed bearings and include impedance or thermal overload protection and disconnect plug. Motor shall be furnished at the specified voltage and phase.

2. SF-1 shall be in-line mounted, direct driven, centrifugal exhaust fan, GN Series.

Fan shall be manufactured at an ISO 9001 certified facility and shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (cUL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.

Wheel housing and integral outlet duct shall be injection molded from a specially engineered resin exceeding UL requirements for smoke and heat generation. The outlet duct shall have provision for an aluminum backdraft damper with continuous aluminum hinge rod. The inlet box shall be minimum 22 gauge galvanized steel. Motor shall be isolation mounted to a one piece galvanized stamped steel integral motor mount/inlet. A field wiring compartment with receptacle shall be standard. Unit shall include a backdraft shutter in the outlet duct connection. Unit shall be shipped in ISTA certified transit tested packaging.

Wheel shall be centrifugal forward curved type, injection molded of

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polypropylene resin. Wheel shall be balanced in accordance with AMCA Standard 204-96, *Balance Quality and Vibration Levels for Fans*.

Unit shall have an internal, factory wired fan speed controller for balancing purposes. Motor shall be open drip proof type with permanently lubricated sealed bearings and include impedance or thermal overload protection and disconnect plug. Motor shall be furnished at the specified voltage and phase.

2.18 SHEETMETAL

A. General

The work under this section includes all the required sheetmetal and duct work, extensions for grilles, manual dampers, automatic counterbalanced (backdraft) dampers, deflectors, setting of control dampers, grilles, registers, diffusers, flexible connections, fire dampers, and louvers, as shown on the drawings or required to make the installation complete in accordance with the intent of the drawings and specifications.

B. Ducts

1. The size of ducts marked on the drawings will be adhered to as closely as possible. The right is reserved to vary duct sizes to accommodate structural conditions during the progress of the work without additional cost to the Owners. The duct layout is schematic to indicate size and general arrangement only. All ducts shall be arranged to adjust to "field conditions". The Sheet Metal Contractor shall coordinate his work with Division 26 and other trades.
2. Medium and low pressure ducts shall be constructed of galvanized steel in accordance with the following table of duct sizes OR the latest SMACNA HVAC Duct Construction Standards for Metal and Flexible Duct unless otherwise shown on drawings.

Low pressure ducts:

<u>Dimensions of Longest Side</u> (inches)	<u>Minimum Sheet</u> <u>Metal Gauge</u>
Up thru 12	26
13 --> 30	24
31 --> 42	22
43 --> 60	20
61 --> inf.	18

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Medium pressure ducts with air velocities greater than 1,200 FPM:

<u>Dimensions of Longest Side</u> (inches)	<u>Minimum Sheet</u> <u>Metal Gauge</u>
Up thru 10	26
11 --> 12	24
13 --> 18	22
19 --> 22	20
23 --> 30	18
30 -> Inf.	16

3. Methods of fabrication and installation shall be in strict accordance with guidelines set forth in the latest SMACNA Guide and Data Book for Low and Medium Pressure Duct Construction unless otherwise shown on drawings. Cross break all ducts with largest dimension being 18 inches and larger. Beaded ducts are not acceptable except for ductwork less than 18 inches in either direction.
4. All dampers and deflectors shall be a minimum of #22 gauge and stiffened as required. Splitter dampers shall not be acceptable.
5. All joints in ducts shall be made air tight, and all branches and turns shall be made with long radius elbows and fittings. Long radius elbows are defined as having a centerline radius of 12 times the width of the duct. If long radius elbows are not used, elbows 18 inches wide and larger shall be provided with fixed double wall airfoil turning vanes designed to reduce the resistance of the elbow to the equivalent of a long radius elbow with a throat radius of not less than duct width. Square elbows less than 18 inches wide shall be provided with single wall turning vanes. Square elbows with outside corners cut at 45° or rounded are not acceptable.
6. All ducts shall be installed with necessary offsets, changes in cross sections, risers, and drops which may be required. They shall be constructed with approved joints and be supported in an approved manner.
7. Round ductwork shall be constructed in accordance with the latest SMACNA HVAC Duct Construction Standards for round and oval duct construction. Ductwork larger than 8 inches in diameter shall employ spiral seams. All turns shall be made with smooth (not segmented), long radius elbows and fittings. All seams shall be type RL-5, grooved seam pipe lock or better. *Lap seams are not permissible.* Gauge thicknesses shall be as outlined in SMACNA for galvanized steel round duct gauge selections for maximum 2 inches w.g. static pressure. Ductwork shall be supported with full wrap-around band and single hanger strap as indicated in Figure 4-4 of the 1985 edition of the SMACNA HVAC Duct Construction Standards handbook.
8. Furnish and install flexible connections on exhaust fans (where indicated), horizontal unit ventilators, horizontal cabinet unit heaters and all Mechanical units. Connections shall be made from Ventglas neoprene coated glass fabric as furnished by Ventfabrics, Inc., or approved equal.

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9. Every precaution shall be taken to keep interior of duct system free from dirt and rubbish and to protect all ducts and equipment during construction. At completion, this Mechanical Contractor shall thoroughly clean all equipment to the satisfaction of the Architect.
10. Spaces between ducts and wall or floor construction shall be caulked to make smoke and water tight with 3M brand fire barrier caulk CP25 or putty 303, Ciba-Geigy CS240 Firestop Sealant or approved equal.
11. Testing, Balancing and Leak Testing... See Part 3, EXECUTION
12. Requirements set forth in applicable codes (see part one) shall supercede SMACNA standards.

C. Diffusers, Grilles and Registers

1. Grilles and/or registers shall be installed at all air supply, return and exhaust openings as shown. All units to be aluminum, except as noted, and provided with baked enamel finish to match color of grille or register and countersunk screw holes. Mounting screws shall be oval head type with head painted to match finish. Unless stated otherwise, the following list is based on model numbers of Anemostat to establish a standard of quality (if substituting, certified sound criteria shall be included with submittals indicating CFM and NC levels of each register and grille). Krueger and Price only will also be considered for review.
 - a. Supply Registers: Double deflection; X2HO with opposed blade damper and $\frac{3}{4}$ inch front blade spacing; front blades set horizontal.
 - b. Supply Grilles: Double deflection; X2H, $\frac{3}{4}$ inch blade spacing; front blades set horizontal.
 - c. Exhaust and Return Registers: X3HOD with opposed blade damper and $\frac{3}{4}$ inch, 45° front blade spacing, front blades set horizontal.
 - d. Exhaust, Return and Transfer Grilles: X3HD with $\frac{3}{4}$ inch, 45° front blade spacing, front blades set horizontal.
 - e. Exhaust and Return Registers (lay-in): AC3LOD with opposed blade damper and $\frac{3}{4}$ inch front blade spacing, front blades set horizontal.
 - f. Exhaust, Return and Transfer Grilles (lay-in): AC3LD with $\frac{3}{4}$ inch, 45° front blade spacing, front blades set horizontal.
 - g. Filtered Return Grilles (lay-in): 3HD-81L filter grilles with hinged core, $\frac{3}{4}$ inch front blade spacing, front blades set horizontal. Provide filters with grilles as outlined in paragraph 2.__, "FILTERS".
 - h. Filtered Return Grilles: Anemostat 3HD-81 filter grilles with hinged core, $\frac{3}{4}$ inch front blade spacing, front blades set horizontal. Provide filters with grilles as outlined in paragraph 2.__, "FILTERS".

All lay-in registers and grilles shall be supported directly to building structure with no less than two (2) safety chains located at opposing corners.

2. Diffusers shall be installed at all air supply openings as shown. All units to be aluminum, except as noted, and provided with white baked enamel finish. The following list is based on model numbers of Anemostat to establish a standard of

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quality (if substituting, certified sound criteria shall be included with submittals indicating CFM and NC levels of each diffuser). Krueger and Price only will also be considered for review.

- a. Round face, steel construction, circular discharge, circular duct connection, fully adjustable core assembly, white finish. Model C-27 for 24 inch x24 inch lay-in application for units up to and including 8 inches in size. Units larger than 8 inches shall be model C-27 without panel. Provide all units in lay-in ceilings and exposed units with type ED neck straightening grid. Units in gypsum ceilings shall have combination butterfly damper and straightening grid. Straightening grids to be factory mounted.
- b. Linear slot shall be type extruded aluminum construction with steel clips, adjustable pattern, baked enamel white finish throughout, model SLAD-DM for units mounted in exposed, round ductwork and model SLAD for units mounted in suspended lay-in T-bar ceilings. Lay-in units shall include model PLEN factory insulated boot or approved equal for units in suspended lay-in T-bar ceiling systems with. Boot duct inlet collar bottom shall be located not less than 6 inches above the diffuser face to avoid adjacent lighting. Support diffusers to structure. Note: Boot to be fully insulated, including end caps. If this is not available from the manufacturer it must be insulated in the field.

All lay-in diffusers shall be supported to building structure with no less than two (2) safety chains located at opposing corners.

D. Louvers

1. All exterior louvers shall be extruded aluminum construction with interior bird screens and anodized finish in color to be selected by Architect. Provide not less than 2 color chip cards with submittals for review (photocopies not acceptable). Frames and blades shall have not less than 50% minimum free area and no less than 0.081 inches thick. All louvers shall comply with Section 08400 of this specification. The following list is based on model numbers of Ruskin to establish a standard of quality; approved equal units by American Air Warming and Arrow are acceptable.
2. All louvers shall be stationary blade type. Units to be 6 inches deep with certified rating of zero water penetration at free area velocity of 900 FPM based on tests in accordance with AMCA Standard 500. Units 48 inches and less in width shall be Model ELF6375X. Units greater than 48 inches in width shall have drainable blades, Model ELF6375DX.
3. Frames of all louvers to be box type for mounting in masonry. Provide factory mounting flanges on head and side jambs with extended sill for units mounted in frame walls.
4. Louvers in doors shall be provided as a part of the door by the General Contractor.

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E. Duct Sleeves

Provide aluminum duct sleeves through outside wall at all locations as shown on drawings.

F. Sealing of Ducts

All ductwork shall be sealed with low VOC water based duct mastic, either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", Polymer Adhesive "Airseal #11", or United Duct Seal (United McGill Corp.) water base, latex or acrylic type sealant. All transverse joints to be continuously sealed. Note that, except as noted, oil or solvent based sealants are specifically prohibited. Duct tape, in any form or material, is also prohibited.

All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. All sealants shall be UL rated at no more than flame spread of 5 and smoke developed of 0. At contractor's option Hardcast 1602 sealant tape may be used in lap joints and flat seams.

G. Duct Access Doors

Hinged insulated access doors with seals shall be provided in ducts where indicated on drawings, or as required. Units shall be provided at each manual damper, motor operated damper, duct coil, duct mounted temperature control device and fire damper unless accessible through grilles and as shown on drawings. Units to be Ruskin Model ADH-22 for rectangular duct and Model ADR for round duct or approved equal by Elmdor.

H. Motor Operated Dampers

Motor operated control dampers mounted in ductwork shall be provided by ATC Contractor, but installed by this Contractor. Contractor shall seal dampers to ductwork to provide a completely waterproof and airtight seal between damper frames and ductwork.

I. Manual Dampers

1. See Part 3, EXECUTION for installation notes.
2. Manual dampers with smallest dimension 5 inches or less shall be shop fabricated, single 22 gauge blade, 3/8 inch rod, provided with position indicator and locking quadrant.
3. Manual dampers with smallest dimension larger than 5 inches but smaller than 11 inches shall be single blade steel, 16 gauge construction, provided with position indicator and locking quadrant. Unit shall be Ruskin Type MD35 or approved equal.
4. Manual dampers with smallest dimension larger than 11 inches shall be opposed blade steel, 16 gauge construction, linkage concealed in frame, provided with position indicator and locking quadrant. Unit shall be Ruskin Type MD35 or approved equal.

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5. Dampers to be installed in aluminum ductwork shall be fabricated of aluminum or isolated from ductwork with rubber grommets between the damper and the duct to prevent oxidation between dissimilar metals.
6. Provide hand quadrants for all manual dampers, Ventline Model 560 or approved equal.

J. Backdraft Dampers

Provide and install automatic counterbalanced backdraft dampers in air relief ducts, kitchen hood exhausts (in the fan curb) and where indicated on the drawings. Unit frames shall be channel type, constructed of 0.090 inch extruded aluminum. Blades shall be 0.025 inch formed aluminum with extruded vinyl edge seals. Unit shall employ aluminum blade linkage concealed in the frame and adjustable zinc plated counterbalance bar on blades (except on top blade). Units shall be capable of being mounted in any position, Ruskin Model CBD2 or approved equal. Contractor shall seal dampers to ductwork to provide a completely waterproof and airtight seal between damper frames and ductwork.

K. Fire Dampers

1. Fire dampers shall be installed to comply with NFPA Code No. 90A and shall bear a U.L. label.
2. All fire dampers to be provided by damper manufacturer with integral sleeves with access doors and mounting angles. Sleeves provided "in-field" are not acceptable. Models indicated are Ruskin to establish a standard:
 - a. Wall and floor types, 12 inches in height and less; Model IBD2-D, style "B".
 - b. Wall and floor types, greater than 12 inches in height; Model IBD2-D, style "A".
 - c. Wall type behind grilles; Model IBDT, Style G
3. Provide factory mounted fusible links designed to melt at 165°F. and close the damper.
4. Installation shall be in accordance with damper manufacturer's instructions.

L. Flexible Duct

Provide and install insulated flexible duct where shown on drawings. Ducts 20 inches in diameter and smaller shall be a double lamination of polyester encapsulating a steel wire helix forming an air-tight inner core. The core shall be wrapped in a blanket of fiberglass insulation (R 4.2) and sheathed in a rugged and durable reinforced metallized polyester jacket. Duct shall be class 1, U.L. 181 compliant and rated for not less than 2 inches w.g. positive working pressure. Duct internal diameter shall be same size as diffuser served. Atco UPC 030 or approved equal.

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M. Side Takeoff Fittings (for flexible duct)

Provide and install, at all flexible duct branches to diffusers, a bellmouth side takeoff fitting with damper. Fittings shall be pre-manufactured with bell end shall have a 1½ inch radius and employ a self-adhesive gasket seal and be pre-drilled for attachment screws. Units with manual dampers shall be heavy duty with bearings and hand quadrants. Fittings shall be anchored to ductwork with *not less than* three (3) screws. Final diameter shall be same size as diffuser served. Units shall be no thinner than 22 gauge, G-90 galvanized steel. Buckley Bellmouth HD-BM, HD-BMD or approved equal by Flexmaster or United Enertech.

N. Turning Vanes

1. Provide and install at all square duct elbows 18 inches and larger, and where shown on drawings, fixed double wall airfoil type turning vanes. Turning vanes shall be constructed as outlined in the latest SMACNA HVAC Duct Construction Standards guidebook, Figure 2-3.
2. Provide and install at all square duct elbows less than 18 inches in width, and where shown on drawings, fixed single wall turning vanes. Turning vanes shall be constructed as outlined in the latest SMACNA HVAC Duct Construction Standards guidebook, Figure 2-3.

O. Wall Caps

Wall caps shall be provided where indicated and shall include weather hoods extending to the bottom of the outlet. Units shall be 26 gauge (min) steel, primed for field painting and include a 0.020 inch damper with magnetic closure strips. Turn wall caps over to the General Contractor for finish painting prior to installation. All units shall be identical in appearance and shall be provided by Aldes Ventilation Corp. (<http://www.americanaldes.com>) 2000 Series or Artis Metals Company (<http://www.artiscaps.com/exhaust.html>). Wall caps provided with fans are not permissible unless they meet these design and construction standards.

2.19 FILTERS

All air handling units and cabinet unit heaters shall be provided with a minimum of three (3) sets of filters with pleated media. One set to be used during construction (and replaced by the Mechanical Contractor during construction if required as determined by the Clerk of the Works and/or the Mechanical Engineer). Second set to be installed a minimum of one (1) day and a maximum of three (3) days prior to testing and balancing and/or final inspection. The third set shall be turned over to the Owner in their original unopened shipping boxes for their future use.

Filters shall be Farr 30/30, Air Guard DP-40 or approved equal; 1 inch thick.

2.20 EQUIPMENT IDENTIFICATION

Tag each boiler, heat recovery unit, fan, circulating pump, air handling unit, outdoor unit, unit heater, cabinet unit heater and switch with rectangular engraved nameplates with white letters on black, Brady Corp., Seton Name Plate Corp. or approved equals. Nameplates shall be mechanically fastened to equipment (adhesives are not acceptable). Embossed labels are not acceptable.

All indoor unit nameplates shall be 4 inches by 1½ inches, Setonply Style No. M1774. All outdoor unit nameplates shall be 2½ inches by ¾ inch, Setonply Style No. M1771.

Identify all heating hot water supply and return, refrigerant suction and liquid, and drain piping with "Set Mark" full snap-around pipe markers by Seton Name Plate Corporation or approved equal by Brady Corp. Markers shall include both identification and direction of flow. Use yellow background with black letters for hot water supply and return, green background with black letters for refrigerant and green background with white letters for drain piping. Markers shall be no less than 10 feet apart except in boiler rooms and mechanical rooms where they shall be not less than 20 feet apart. Identification shall read "Heating Water Supply", "Heating Water Return", "Drain", "Refrigerant Suction" and "Refrigerant Liquid" as applicable. Domestic hot and cold water piping shall be labeled differently from heating water piping.

Tag all valves (if not tagged by valve manufacturer) with 1½ inch round brass tags and #6 bead chains, Seton #M4506. Tag shall be consecutively numbered. Provide valve charts identifying valve number, valve identification and service. Mount charts in Boiler Room and Mechanical Room in 8½ inch x 10 inch and 8½ inch x 11 inch self-closing aluminum frame with plastic windows. Identify ducts and fire dampers with ventmark HVAC markers.

2.21 INSULATION AND CONDENSATE PROTECTION

A. General

1. Insulation shall be provided for all hot water supply and return piping, refrigerant piping, outside air intakes, supply ducts concealed above ceilings and other insulation where shown on drawings.
2. All insulation products shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less per ASTM E 84, UL 723 and NFPA 255.

B. Hot Water Supply & Return Piping

1. All metallic hot water supply and return piping shall be insulated with heavy density fiberglass pipe insulation with 850°F. temperature rating and factory applied self sealing ASJ jacket. Cut insulation to include pipe hangers. Maximum "k" factor of 0.23 at 75°F. mean temperature difference per ASTM C 518. Owens Corning SSL II, Johns Manville Micro-Lok HP or approved equal.

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Insulation thickness for metallic hot water shall be as follows:

<u>Pipe Size</u>	<u>Insulation Thickness</u>
½" – 1½ "	1"
2" - 8"	2"

Insulation thickness for metallic hot water run-outs in partitions shall be as follows:

<u>Pipe Size</u>	<u>Insulation Thickness</u>
½" - 1"	½"

2. All fittings shall be wrapped with fiberglass insulation and covered with a one piece PVC insulated fitting cover secured with flare type stainless steel staples.
3. The ends of insulation on exposed pipes at valves, flanges, unions, etc., shall be finished neat with covering to match jacket and secured with mastic.
4. All valves 2½ inches and larger shall be wrapped with fiberglass insulation, covered and finished neat with covering material to match ASJ jacket on pipe insulation and secured with mastic.
5. Valves less than 2½ inches in size, flanges and unions shall not be insulated. Exception: All valves for cold water application shall be insulated.

C. PEX Tubing and Refrigerant Piping

1. PEX Tubing and refrigerant piping (not pre-insulated by equipment manufacturer) shall be insulated with ½ inch flexible, closed cell elastomeric thermal insulation. Material shall be 25/50 rated (flame spread rating of 25 or less and smoke developed rating of 50 or less) when tested in accordance with ASTM E84, latest revision.
2. Cover exterior insulation with ultraviolet resistant vinyl sheet outdoor PVC jacket.
3. Material shall be flexible elastomeric in tubular foam. AC/Accoflex, AP/Armaflex, A/P Armaflex SS or approved equal. Product shall meet the requirements as defined in ASTM C 534, Grade 1, Type I, "Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form"
4. Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft²-°F at a 75°F mean temperature when tested in accordance with ASTM C177 or ASTM C 518, latest revisions.
5. Materials shall have a maximum water vapor transmission of 0.08 perm inches when tested in accordance with ASTM E 96, Procedure A, latest revision.

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6. Adhesive shall be the insulation manufacturer's recommended contact adhesive: Armaflex 520, Armaflex 520 BLV.
7. Insulation finish shall be the insulation manufacturer's recommended finish: WB Armaflex Finish.
8. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings as specified above.

D. Duct and Equipment Insulation

1. Interior duct insulation shall be a $\frac{3}{4}$ pound density, all-service fiberglass duct wrap with factory applied foil faced FRK vapor barrier facing meeting the requirements of ASTM C 1136, Type II. Insulation material shall meet the requirements of NFPA 90A, NFPA 90B, ASTM C 1290 and ASTM C 553. Operating temperature range shall be from 40°F. to 250°F. Maximum "k" factor of 0.30 at 75°F. mean temperature difference. Owens Corning Type 75, Johns Manville Microlite XG or approved equal.
2. Insulate the following ducts with 1½ inches installed thickness fiberglass duct wrap:
 - a. All air handling unit supply air ducts concealed above ceilings.
3. Insulate the following ducts with 3 inches installed thickness fiberglass duct wrap:
 - a. All heat recovery unit supply air ducts between roof deck and duct heating coils.
 - b. All heat recovery unit exhaust air ducts between roof deck and motorized dampers.
 - c. All ductwork between EF-1 and outside wall.
 - d. All ductwork between SF-1 and outside wall.
 - e. All exhaust ductwork between walls and motorized dampers.
 - f. Boiler combustion air intake ductwork.
4. Material to carry U. L. label. All laps to be sealed and held in place with adhesive and flare staples. All lap joints to be folded under before stapling so no raw insulation will be showing. On the bottom of ducts 24 inches or wider, mechanical fasteners shall be provided approximately 12 inches O.C.

E. Air Separator

Air Separator shall be insulated with 2 inch thick heavy density fiberglass insulation with ASJ jacket. Insulation to be securely fastened. Finish cover insulation with 14 ounce re-wettable canvas. Note: Manufacturer's identification plates shall remain exposed with insulation material tapered down to plate and finished as specified above.

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F. Smoke Pipe

Boiler smoke pipes shall be insulated with 2 inch thick mineral fiber (800°F. minimum rating) with a 0.032 inch aluminum jacket. Horizontal seams shall be located on top of the smoke pipe for appearance purposes".

G. Condensate Protection

Solder or weld bottom and sides of ducts connected to outdoors to prevent water leaks from rain and snow. Seal duct wrap and liner to minimize condensation.

H. Installation

All insulation work shall be executed by skilled insulation workmen regularly employed in the trade.

2.22 AUTOMATIC TEMPERATURE CONTROL (ATC)

See section 23 09 00

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Inspection

1. Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all work is complete to the point where this installation may properly commence.
2. Verify that Mechanical systems may be installed in strict accordance with all pertinent codes and regulations and the approved shop drawings.

B. Discrepancies

1. In the event of discrepancy, immediately notify Architect.
2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 INSTALLATION OF PIPING AND EQUIPMENT

A. General

1. All piping shall be installed within building insulation.
2. Size and general arrangements as well as methods of connecting all piping, valves, and equipment shall be as indicated, or to meet requirements for complete installation.
3. All pumps shall be supported independently of the piping system.
4. All piping shall be erected to provide for easy and noiseless passage of refrigerant and hot water under all working conditions. Inverted eccentric reducing fittings shall be used whenever water pipes reduce in size in the direction of flow. Tee fittings with reduction in the main direction of flow (run) are not acceptable.
5. All hot water mains shall be run level or pitch slightly upward so that no air pockets are formed in piping. Mains shall be set at elevations so run-outs feeding heating equipment shall have no pockets where air can collect or automatic vents shall be provided.
6. Where preset balancing valves (ABV) are used, it is critical that there not be two valves installed in series anywhere throughout the piping system.
7. Provide drains with hose threads and metal caps at all low points in the water piping system.

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8. In erection of hot water piping, care must be taken to make allowance for expansion and contraction; piping shall be anchored as necessary to control expansion.
9. Runouts to terminal heating units shall be size indicated on plans and shall come off the main downward (downfeed units) or off the side (upfeed units).
10. Install dielectric fittings at all points of dissimilar piping connections.
11. Install a sufficient number of unions or flanges to facilitate assembly and disassembly of piping and removal of equipment.
12. Install all piping promptly, capping or plugging all open ends and making pipe generally level and plumb, free from traps, and in a manner to conserve space for other work.
13. Inspect each piece of pipe, tubing, fittings, and equipment for defects and obstructions; promptly remove all defective materials from the job site.
14. Install pipes to clear all beams and obstructions; do not cut into or reduce the size of load carrying members without the approval of the Architect.
15. All risers and offsets shall be substantially supported.
16. Make all changes in pipe size with reducing fittings.
17. All low points in water piping shall be provided with an accessible plug tee or drain valve.
18. All high points in water piping shall be provided with an accessible automatic vent.
19. Maximum spacing of hangers for steel piping shall be as follows:

<u>Pipe Size</u>	<u>Spacing</u>
1/2", 3/4" & 1"	6'-0"
1 1/4" & 1 1/2"	8'-0"
2" & 3"	10'-0"
4" and larger	14'-0"

20. Maximum spacing of hangers for copper piping shall be as follows:

<u>Pipe Size</u>	<u>Spacing</u>
1/2", 3/4" & 1"	6'-0"
1 1/4" & 1 1/2"	6'-0"
2" & 3"	10'-0"

21. Maximum horizontal spacing for pipe supports for PEX shall be 18 inches.

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22. Whenever possible valves shall be installed with the operating stems in the upright position, however when conditions dictate it is acceptable to position valves 90° to either side of vertical. Valves shall not be installed with the stems in the downward position.
23. Do not substitute one style of valve indicated on drawings for another unless authorized by the Architect. Example: If a gate valve is shown use ONLY a gate valve or if a ball valve is shown use ONLY a ball valve.
24. Mount in-line air separators which include integral strainers independent of the piping system. Do not obstruct removal area of strainer with pipe hangers, equipment or other piping.

B. Joints and Connections

1. Smoothly ream all cut pipe; cut all threads straight and true; apply best quality Teflon tape to all male pipe threads but not to inside of fittings; use graphite on all plugs.
2. Make all joints in copper tube (water and drains) with 95-5 tin-antimony solder applied in strict accordance with the manufacturer's recommendations.
3. All joints in refrigerant tubing shall be brazed.

C. Fire Safety

Fire extinguishing equipment shall be kept within 25 feet of welding areas at all times. Contractor shall take additional measures when welding close to wood structures to protect the wood from igniting.

D. Thermometers

1. Install thermometers where indicated on drawings and:
2. Install thermometer wells on supply and return branch piping at all duct hot water heating coils and two (2) thermometers with storage cases for the Owner's use.

E. PEX tubing

1. Install PEX tubing where indicated on drawings.
2. Tubing shall be supported from building structure only, not from other piping or equipment.
3. Do not support other piping or equipment from PEX tubing.
4. PEX tubing may be threaded through structure with the structure acting as support so long as support is not provided in lengths greater than 32 inches on center. Use protective sleeves or bushings where tubing passes through metal studs. Tubing shall not have sags or low points that would prevent thorough drainage of the system.

5. Support devices shall be a product of the PEX manufacturer. Support devices shall be screwed, not nailed, into wood. Do not attach to the underside of floor decks. It is acceptable to support PEX tubing to the side of steel bar joists with “zip” strip draw bands at 16 inch centers (maximum). Leave adequate provision for pipe insulation (where used).

3.03 PIPING TEST AND ADJUST

- A. During the installation, all hot water supply and return piping shall be tested with water to a pressure of not more than 125 psi and held for a period of not less than four (4) hours. Isolate boilers and any other piping or devices not designed for this pressure. Do not use compressed air on PEX tubing systems. Any leaks shall be repaired and another test applied to the piping. All piping shall be tested before it is insulated or otherwise concealed. Contractor shall be required to certify in writing that piping has been tested and conforms to these requirements.
- B. Before operating the water system, all of the new piping shall be flushed out to remove oil and foreign materials. This shall be accomplished by circulating a solution of heavy duty detergent by use of Mechanical Contractor supplied pump.
- C. After the installation is complete and ready for operation, the system shall be tested under normal operating conditions in the presence of the Architect and demonstrated that the system functions as designed.
- D. It shall be demonstrated that all parts of heating system have a free and noiseless circulation of water and that all parts are tight. It shall also be demonstrated that all units are functioning properly and that control system operates correctly.
- EG. Should any defects in operation develop during the test periods, the Mechanical Contractor will proceed to correct defects immediately. Additional tests will be conducted after correction.

3.04 INSTALLATION OF DUCTWORK AND EQUIPMENT

- A. General
 1. Size and general arrangements as well as methods of connecting all diffusers, registers, grilles, duct coils and equipment shall be as indicated, or to meet requirements for complete installation.
 2. Construction standards and sheet metal gauges shall be as outlined in the latest edition of the SMACNA HVAC Duct Construction Standards handbook for metal and flexible ducts unless specifically indicated otherwise.
 3. Manual Dampers
 - a. Manual dampers may be shop-fabricated on units 5 inches in height and less. All dampers larger than 5 inches MUST be pre-fabricated as previously outlined in this specification.
 - b. All manual dampers located within 10 feet of a fan outlet shall have the

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- blades oriented perpendicular to the fan shaft.
- c. Provide duct access door as large as possible up to 12 inches x 12 inches at each manual damper larger than 5 inches.

B. Protection and Cleaning

1. All open ends of ductwork which is to be unattended for 4 hours or more shall be temporarily protected with plastic sheeting and duct tape (or similar method) to reduce the collection of construction dust and debris.
2. Prior to testing and balancing and at the end of the construction, clean the interiors of all supply and return air ductwork before changing filters in air handling equipment. Careful coordination must be maintained between the time of testing and balancing and final delivery to avoid re-accumulation of dust and debris within the duct systems which will require additional cleaning by the Mechanical Contractor.

3.05 TESTING, ADJUSTING AND BALANCING (TAB)

A. General

1. TAB contractor shall be a subcontractor to the Mechanical Contractor.
2. TAB contractor shall perform functional performance test of all Division 23 equipment and entire ATC system for specified operation and control sequences.
3. The mechanical contractor shall startup all Division 23 equipment as required by the equipment specifications. Mechanical contractor shall verify that systems are complete and operable before TAB commencing work. Ensure the following conditions:
 - a. Systems are started and operating in a safe and normal condition.
 - b. Temperature control systems are installed complete and operable.
 - c. Proper thermal overload protection is in place for electrical equipment.
 - d. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - e. Duct systems are clean of debris.
 - f. Fans are rotating correctly.
 - g. Fire and volume dampers are in place and open.
 - h. Air coil fins are cleaned and combed.
 - i. Access doors are closed and duct end caps are in place.
 - j. Air outlets are installed and connected.
 - k. Duct system leakage is minimized.
 - l. Hydronic systems are flushed, filled, and vented.
 - m. Pumps are rotating correctly.
 - n. Proper strainer baskets are clean and in place. Service and balance valves are open.
4. TAB Contractor shall submit field reports to General Contractor. Report defects and deficiencies noted during performance of services which prevent system testing and balance.

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5. TAB contractor shall submit all verification and functional performance checklists/results, signed by indicated personnel, organized by system and sub-system.
6. TAB contractor shall submit other reports described below.

B. Work Included

1. Test, adjust and balance all air and water systems, including components to conform to air and water flow rates shown on drawings.
2. Test complete automatic temperature control sequences for specified operations described under AUTOMATIC TEMPERATURE CONTROLS.
3. Complete and submit balance report. Report shall be submitted with information noted on one side of sheet only (i.e., backside of sheet shall be blank.).
4. Testing of air and water systems will be done by the same agency.
5. Mechanical Contractor SHALL PROVIDE copies of shop drawings indicating coil gpm's, air handling unit air volumes, etc. to the Testing and Balancing contractor at no cost to the contractor.
6. Careful coordination must be maintained between the time of testing and balancing and final delivery to avoid re-accumulation of dust and debris within the duct systems which will require additional cleaning by the Mechanical Contractor. See Part ____, paragraph __ above.

C. Quality of Compliance

1. Qualification: TAB Contractor must be independent test and balancing agency.
2. AABC Compliance: Comply with AABC Manual MN-1 "AABC National Standards" as applicable to mechanical and hydronic distribution systems and/or Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
3. Industry Standards: Comply with ASHRAE recommendations for measurements, instruments and testing and balancing.
4. Coordination: Work together with Automatic Temperature Control Contractor to adjust set points of various devices to balance system(s) and test ATC sequences of operation. Temperature Control Contractor shall be responsible for balancing return air, exhaust (relief) air and outdoor air dampers on Air Handling Units in order to achieve proper mixed air temperatures.
5. ASHRAE Guideline 1-1996, "The HVAC Commissioning Process".

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D. Execution of TAB Work

1. TAB Contractor shall visit job site and determine that control devices, test devices and valves are correctly installed and ready for balancing.
2. Examine each air and hydronic distribution system to see that it is free from obstructions. Determine that all dampers, registers and valves are in a set or full open position; that moving equipment is lubricated, and that required filters are clean and functioning. Request that Installing Contractor perform any adjustments necessary for proper functioning of the system.
3. TAB Contractor shall use test instruments that have been calibrated within a time period recommended by the manufacturer, and have been checked for accuracy prior to start of testing, adjusting and balancing activity.
4. Verify that all equipment performs as specified. Adjust variable type drives, volume dampers, control dampers, balancing valves and control valves as required by TAB work.
5. Test pressure profile of systems by traverse as required.
6. Adjust each register, diffuser terminal unit and damper to handle and properly distribute design airflow within 5% of specified quantities. Mark all setpoints.
7. Adjust front and rear discharge louvers on each supply register to distribute air in an even pattern or as indicated on plans.
8. Adjust all balancing valves so that each heating/cooling coil is furnished with design fluid flow within 5% of the specified quantities. Mark all set points.
9. Adjust air discharge patterns of all supply air diffusers, registers and grilles for optimal air diffusion.
10. Document results of all testing on approved TAB report formats and submit 3 copies for approval and record within 15 days of completion of TAB work. Include a warranty period of 90 days, during which time the Architect/Engineer may request a re-check or re-adjustment of any part of the work.
11. Reports shall be compiled on a spreadsheet such as Excel, Quattro-Pro, Lotus, etc. and shall clearly indicate the following *minimum* information:
 - a. Air (Rated and Actual)
 - 1) System/unit name
 - 2) HP, BHP, voltage, amperage and fan rpm
 - 3) Static pressures; suction, discharge and total
 - 4) Total system flow rate
 - 5) Individual terminal flow rates (Terminal readings must show location, make, model and size of register, grille or diffuser).

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- 6) Provide a static pressure profile of all AHU's components in the two extreme operating modes; minimum outdoor air and economizer cycle.
 - 7) Filter status report
- b. Water
- 1) Pump full flow and no-flow suction and discharge pressures.
 - 2) Rated and actual amperage, voltage and total discharge head (TDH).
 - 3) calibrated balancing device readings will indicate location, size, setting, differential pressure and rated and actual gpm.

Reports to have a minimum of color or must be compatible with monochrome printers. Reports must be submitted to the Architect electronically in addition to hard copies.

E. Drawings

Drawings in CAD format may be made available to the TAB Contractor after the contract for this work is awarded. Contact the Engineer via telephone or at mechsyst@maine.rr.com and request the drawings, indicating CAD format required and a return e-mail address. See par. 1.10, "ELECTRONIC DRAWINGS AND FILE SHARING" for additional information.

F. Acceptable TAB Contractors (listed alphabetically)

1. Central Air Balance
2. Maine Air Balance
3. Tab-Tech International
4. Tekon-Technical Consultants
5. Yankee Balancing

3.06 CLOSING IN UNINSPECTED WORK

A. General

Do not cover up or enclose work until it has been properly and completely inspected and approved.

B. Noncompliance

Should any work be covered up or enclosed prior to all required inspections and approvals, uncover the work as required. After it has been inspected completely and approved, make all repairs and replacements with materials necessary for approval by the Architect and at no additional cost to the Owner.

3.07 TEMPORARY HEATING

- A. Mechanical Contractor shall install the new heating system and related equipment as soon as those portions of the building are ready and the work can be performed.
- B. Mechanical Contractor will be required to permanently connect as many units as possible for temporary heat.
- C. At the conclusion of the temporary heating period, the complete system shall be thoroughly cleaned.
- D. General Contractor will be required to assume full responsibility for the care and operation of the new equipment during its temporary use and to return the equipment to the Mechanical Contractor in perfect order, normal wear and tear excepted.
- E. Water, fuel and electric power required to operate the heating system for temporary heat shall be provided by the General Contractor.

3.08 CLEANING

Prior to acceptance of the buildings, thoroughly clean all exposed portions of the Heating, Ventilating and Air Conditioning installation, including the removal all labels and all traces of foreign substance. Prior to testing and balancing vacuum and clean inside of all air handling units and cabinet unit heaters. Clean the interiors of ductwork as outlined in 3.04, "INSTALLATION OF DUCTWORK AND EQUIPMENT"; paragraph "B", "Protection and Cleaning".

309 INSTRUCTIONS

On completion of the job, the Mechanical Contractor shall provide a competent technician to thoroughly instruct the Owner's Representative in the care and operation of the system. The total period of instruction shall not exceed four (4) hours. (ATC system instruction shall be in addition to this instruction period). The time of instruction shall be arranged with the Owner.

3.10 REFRIGERANT PIPING

Refrigerant piping shall be installed and tested in accordance to the conditions set forth herein and as required by the manufacturer of the refrigeration equipment by personnel with not less than 5 years experience in the installation of refrigerant piping.

The installation shall be inspected and certified by the manufacturer of the refrigeration equipment prior to charging with refrigerant.

Refrigerant piping shall be run in a approved manner, providing traps where necessary to maintain gas velocities to return oil to the compressor and to keep systems free of oil slugs at the compressor. Fittings shall be long radius and soldered with Sil-Fos or silver solder. The inside of all refrigerant piping shall be thoroughly cleaned using Virginia Solvent #10 or approved equal; followed by a wiping of compressor oil and then wiped dry with a clean, dry cloth. All refrigerant piping shall then be tested with nitrogen and all joints tapped with a rubber mallet to make sure they are tight. A soap solution shall then be applied to each joint. High side test shall be a minimum of 250 psi while the low side test shall be tested to a minimum of 100 psi. Any equipment that may be damaged by these pressures shall be removed. After pressure test, a freon

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test shall be applied using Halide torch. The interior of the piping system shall be thoroughly cleaned of all oil, dirt and foreign matter then evacuated and dehydrated. All copper tubing shall be supported by copper coated clevis type hangers, see Paragraph 2.03; "HANGERS AND SUPPORTS". The hangers on the suction piping shall be sized to include the insulation and metal shields 12 inches long shall be placed between hangers and insulation.

3.11 REMOVAL OF EXISTING PIPING AND EQUIPMENT

- A. All piping and equipment indicated on the drawings for removal shall be done so by the Mechanical Contractor.
- B. All materials removed shall remain the property of the Owner until such time the Owner has reviewed the removed materials and either taken or designated items which he may wish to retain. The remainder shall become the property of this Mechanical Contractor and be removed from the premises immediately.
- C. Any damages done to removed materials prior to release by the Owner shall be corrected by the Mechanical Contractor at no additional expense to the Owner. Any materials removed prior to release by the Owner shall be replaced by the Mechanical Contractor at no additional expense to the Owner.

3.12 RECYCLING

Discarded materials, both new and removed, shall be recycled whenever practical through metal salvage dealers (ductwork, piping, etc.), paper salvage (cardboard shipping containers, etc.), wood & plastic products, etc. The Mechanical Contractor shall retain the salvage value of discarded materials and may use this value to offset his project bid price if so desired. Toxic materials such as adhesives, coolants, refrigerants, etc. SHALL be disposed of in a manner acceptable to the State of Maine Department of Environmental Protection.

3.13 HAZARDOUS MATERIALS

Mercury, asbestos or any other material deemed hazardous by the Federal Environmental Protection Agency or the State of Maine Department of Environmental Protection, shall not be used in any components of the mechanical systems.

END OF SECTION 23 00 00