

October 09, 2009 modifications on pages 24, 25 & 39

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
EC	Electrical Contractor (Division 26)
GC	General Contractor
HC	Heating (mechanical) Contractor
PC	Plumbing Contractor

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 heat pump systems in building areas indicated on drawings.
 - d. Pipe, valve and fittings
 - e. Hot water specialties
 - f. Radiation
 - g. Air handling units
 - h. Unit heaters
 - i. Insulation
 - j. Fans

- k. Sheetmetal
- l. Automatic Temperature Control (ATC)
- m. 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. Automatic Temperature Control (ATC)
- 2. Excavation and backfill
- 3. Cutting and patching
- 4. Firestopping between building construction and pipe sleeves and between building construction and ductwork, Section 07900.
- 5. Electrical conduit and wiring, except as noted below
- 6. Roofing, curbs, curb openings and framing of openings.
- 7. Setting of sleeves in masonry work (sleeves provided by Mechanical Contractor)
- 8. Door louvers
- 9. 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, 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. All wiring provided under this section shall be in accordance with the latest rules and regulations of the National Fire Underwriters, National Electric code, State of Maine Oil Burner Code, and 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.

4. Automatic Temperature Control (ATC) Systems

Electric wiring shall be furnished and installed by ATC Contractor under supervision of 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.

Low voltage control wiring must be plenum rated and adequately supported with no sags or “droops”. Low voltage wiring need not be installed in conduit unless required by local code.

5. Fans

- a. Single phase 120 volt units: Division 26r to wire to unit mounted disconnect switch with overload protection provided with unit.
- b. Fans shall operate as indicated on "FAN SCHEDULE", drawing M14 and as indicated in Section 15900, "Automatic Temperature Control".

6. 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.

7. Air Handling Units

Division 26 shall provide and wire disconnect switches at each air handling unit.

8. Duct Smoke Dampers

Duct smoke dampers shall be furnished and installed by Mechanical Contractor. All wiring for the actuators and interlock wiring to the building fire alarm system shall be furnished and installed by Division 26.

9. 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.

- 10. All motors 1/3 HP and smaller shall be wired for 120 volt, 1 phase, 60 hz; motors 1/2 hp and larger shall be wired for 208 volt, 1 or 3 phase (as indicated on Equipment Schedules), 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
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. Use sufficient qualified workpersons and competent supervisors in execution of this portion of the work to ensure proper and adequate installation of system throughout.

- B. Work performed shall conform with all Local and State Rules and Regulations, as well as those of the National Fire Protection Association (N.F.P.A.).
- C. Piping design shall conform to ANSI, ASME B31.9 and AWS D10.9 codes.

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**, see Division 1. 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 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.

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 may be provided in either the 2000 or 2004 file formats. 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 to the Architect for review. The quantity of copies shall be as outlined in Division 1. If shop drawings are not submitted within the allotted time frame 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. Contractor's name, address, telephone and fax numbers shall be provided with every shop drawing submission. 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.
- B. 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 all other trades and performing his work in a safe and satisfactory manner.

- C. 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 own expense. If the materials are not removed (or replaced) or if the project is delayed as a result the Architect reserves the right to order the withholding of payment until the situation is resolved in a manner satisfactory to the Architect.
- D. Mechanical shop drawings shall be separate from Plumbing shop drawings. Submittals not separated from plumbing shop drawings will be refused for re-submittal.
- E. 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. However, submitting shop drawings electronically in.pdf format 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.
- F. 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 and/or smoke dampers and sleeves
 - f. Turning vanes
 - g. Side takeoff fittings
 - h. Flexible duct
 - i. Manual dampers
 - j. Louvers and brick vents - provide color chips (photocopies not acceptable) – provide samples if substituting
 - k. Filters
 - 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 handling units and accessories - provide curves for fan wheels submitted and computer selection printouts.
 - c. Air conditioning units and accessories - provide computer selection printouts.
 - d. Fans and accessories - provide full fan curves and computer selection printouts.
 - e. Horizontal unit heaters
 - f. Equipment identification tags
 - g. Heat recovery units

- h. Outdoor (Compressor/condenser) units
- 3. Piping and Accessories
 - a. Pipe, valves, unions and flanges
 - b. Balancing valves with read-out gauge and pressure tappings. Provide a schedule clearly indicating every valve, its location, GPM, size and pressure drop.
 - c. Air vents (automatic and manual)
 - e. Pipe hangers and insulated pipe supports
 - f. Pressure gauges and thermometers
 - g. Pipe and valve markers
 - h. PEX tubing, fasteners, connectors and accessories
- 4. Terminal Units
 - a. Convectors
 - b. Finned radiation
 - c. Hot water heating coils - provide computer selection printouts.
- 5. Insulation
 - a. Pipe
 - b. Duct
 - c. Pipe fittings
- 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 paid by the Mechanical Contractor*. Copies of the mechanical CAD drawings may be made available to the Mechanical Contractor 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 MINOR 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, but any answers or advice is non-binding. Therefore, inquires about such items 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).

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. 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.

1.21 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, chilled water supply and return, low pressure steam, condensate return, pump discharge, 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:

- | | | |
|----|----------------------------------------|--------------------------------------------------------------------------------------------|
| 1. | Hot water mains | Schedule 40 standard weight black steel, ASTM 120 <<OR>> Type "L" hard drawn copper tubing |
| 2. | Heating water branches 200°F. maximum. | PEX crosslinked flexible tubing, ASTM F876 and F877. |
| 3. | Cold water & refrigerant | Type "L" hard drawn copper tubing |

C. Pipe Fittings:

- | | | |
|----|--------------------------|---------------------------------------------------------------------------------------------|
| 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 | Cast bronze or wrought copper made up with 95-5 solder |
| 6. | Connections to equipment | 2 inches and smaller - screwed unions
2½ inches and larger – flanged |
| 9. | Refrigerant | Cast bronze or wrought copper, long radius elbows, made up with Sil-Fos silver solder. |

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.

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	

6. Ball valves 1¼ inches in size and smaller shall have bronze bodies, Type 316 stainless steel stems and 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-350S	BA-300S
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, Type 316 stainless steel stems and 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-SS	B-6001-SS
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 INTERIOR HANGERS AND SUPPORTS

A. General

1. All interior 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 cold water piping 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 ¾ 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>
½" to 2"	3/8"
2½" to 3½"	1/2"

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 PAINTING

Painting shall be provided for all equipment supports, exposed flanges and back plates of finned radiation. Temperature control devices *shall not* be field painted.

Painting shall consist of no less than two (2) coats of rust inhibiting paint, Rust'O'leum or approved equal. Paint shall be capable of withstanding temperatures of up to 250°F.

Color shall be fat back.

2.07 POLYETHYLENE HEATING HOT WATER PIPING (PEX)

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.

2.08 REFRIGERANT SPECIALTIES

- A. Sight glass and moisture indicator shall be provided in the liquid line at the evaporator coil and at each compressor-condenser unit.
- B. Externally equalized expansion valve shall be installed on each liquid connection to the evaporator coil(s) if not provided by the evaporator manufacturer. Valve size shall be as verified with unit manufacturer based on actual length of piping, quantity of fittings and difference of elevation. Valve shall be manufactured by ALCO or Sporlan and installed in accordance with manufacturer's instructions.
- C. A complete charge of refrigerant as required by the system manufacturer shall be provided for the system.
- D. Liquid lines shall be provided with removable core type filter-dryer and refrigerant valves as shown on the drawings. Units to be provided with ¼ inch male pipe plug in flange plate for installation of charging valve. Units to be Sporlan or approved equal.
- E. 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.

2.09 HOT WATER SPECIALTIES

- A. Balancing Valves
 - 1. All new coils, piping mains and elsewhere as indicated, shall be provided with a balancing valve equipped with readout valves to facilitate the connecting of a differential pressure meter. Coils shall have the balancing valves on the return lines. 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).
 - 3. Provide a schedule clearly indicating every valve, its location, GPM, size and pressure drop.
 - 4. Each balancing valve shall be Taco Accu-Flo 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 Balancing Valves

1. All new finned radiation, convectors, cabinet unit heaters, unit heaters 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 handle ball valve, Y-strainer, flow control cartridge assembly, two (2) pressure/temperature plugs, inlet union and outlet 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.
 - 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. For ½ inch through 2 inch pipe sizes: An assembly shall consist of a brass Y-type body, integral brass body ball valve and 'O' ring type union. Flow Design "AutoFlow" Model AC or approved equal.
 - e. 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

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.
- c. Install, on the supply side of coils, a Y strainer with a brass blowdown valve with ¾ inch hose end connection with cap and chain.

C. Radiator Valves

All radiation shall be provided with ball valve for 125 psig at 250°F. as specified under valves. Provide a gate valve when installed within radiation covers.

D. Drains

Each downfeed radiator, convactor, cabinet unit heater, unit heater, coil and unit ventilator 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.

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. Thermometers

Furnish and install where indicated on the drawings and in Part 3 - EXECUTION, dial type thermometers with stainless steel case, 4½ or 5 inch dial size, bimetal, universal angle type. 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.
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2.10 FINNED RADIATION

- A. Finned pipe radiation shall consist of ¾ inch steel pipe with aluminum fins. See equipment schedules for specific information on fin sizes and quantities. Each radiator shall have the finned length, number of tiers (or rows) and heating surface indicated on the drawings. All covers shall be for the number of rows of element unless indicated otherwise. All covers shall have baked enamel finish in color to be selected by Architect. Provide not less than two (2) color chip cards with submittals (photocopies not acceptable).
- B. Covers for types "A" and "B" shall be 16 gauge steel, flat top with architectural bar grille, supported by a full back plate (factory painted) and securely fastened at the bottom to the radiator brackets. Elements shall be supported by approved slide cradle hangers and universal brackets spaced a maximum of 48 inches on center. Provide return line hangers where shown on drawings.
- C. Covers for type "C" shall be 16 gauge steel, flat top with architectural bar grille, supported by pedestals a full back plate (factory painted) and securely fastened at the bottom to the radiator brackets. Elements shall be supported by approved slide cradle hangers mounted to adjustable pedestal bracket support assemblies spaced a maximum of 48 inches on center.
- D. Covers for types "D" and "E" shall be 14 gauge steel, sloping top with pencil proof louvered outlet, supported by a full back plate (factory painted) and securely fastened at the bottom to the radiator brackets. Elements shall be supported by approved slide cradle hangers and universal brackets spaced a maximum of 48 inches on center. Provide return line hangers where shown on drawings.
- E. Unless shown differently on the drawings, the covers shall be a minimum of 1'-6" longer than the finned length. End covers or wall sleeve and wall sleeve supports shall be provided for each end of the cover. Provide access doors where shown. Cover supports shall be at a maximum spacing of 4'-0".

- F. All ratings shown on the drawings are based on 170°F. average water temperature with a 20°F. temperature drop. The following types are based on Sterling to establish a standard:
1. Type "A" to be single tier element, 14 inch high enclosure; Classic, JVA-AR-14.
 2. Type "B" to be single tier element, 14 inch high enclosure; Classic, JVB-AR-14.
 3. Type "C" to be pedestal type, double wide (10.5/16 inches), 10¾ inches to top; Classic, JVB-AR-2PM.
 4. Type "D" to be single tier element, low profile, 11 inch high enclosure; JVA-S11.
 5. Type "E" to be two tier element, low profile, 20 inch high enclosure; JVB-S.
- G. Provide matching blank covers without inlet or outlet of 16 gauge steel where shown.
- H. New covers for existing radiation shall be as follows:
1. EFP-1 shall be Classic, JVB-AR-14; 14½ inches high & 5¼ inches deep.
 2. EFP-2 shall be Classic, JVB-AR-2PM pedestal; 6¾ inches high & 10¼ inches wide.
- I. Units by Dun-Ham Bush, Rittling, Trane Co. and Vulcan will be considered.

2.11 DUCT REHEAT COILS

A. General

Furnish and install, where indicated, duct mounted water heating coils, sizes and capacities as indicated on drawings. Coils shall be header type, 1 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. Coil shall be Trane Type 5W. Units by Carrier, McQuay, USA Coil or York will be considered.

2.12 HORIZONTAL UNIT HEATER

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 Section 15900, "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 Trane Co. Units by American Air Filter or McQuay will be considered.

2.12.1 CABINET UNIT HEATER

A. New cabinet unit heaters 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 180°F. inlet water with a 20°F. drop.

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.

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 2.18, "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. Horizontal units flush with ceilings shall be Trane Cabinet Unit Heater Type FFEB or approved equal with bottom supply and return grilles integral with the cabinet (not attached separately). Supply grilles shall be double deflection. Unit shall have fully removable bottom access panel. Units to be controlled by remote heavy duty line voltage electric thermostat and strap-on aquastat provided by Temperature Control Contractor.
- H. Shut-off valve, balancing valve, drain valve with metal cap and air vent shall be provided on each unit.

2.13 HEAT RECOVERY UNITS

- 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 ½ inch thick neoprene insulation. 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 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.

Fans shall be driven using belts and sheaves. Motors shall be standard NEMA frame with open drip-proof enclosures. V-belt drives shall be designed for a minimum 1.2 service factor.

- G. The rotor media (energy wheel) shall be made of aluminum, coated to prohibit corrosion. All surfaces shall be coated with a non-migrating adsorbent specifically developed for the selective transfer of water vapor. The desiccant shall utilize a 3A molecular sieve certified by the manufacturer to have an internal pore diameter distribution which limits adsorption to materials not larger than the critical diameter of a water molecule (2.8 angstroms). Verification in writing shall be presented from the desiccant manufacturer confirming that the internal pore diameter distribution inherent in the desiccant being provided limits adsorption to materials not larger than the critical diameter of a water molecule (2.8 angstroms). In addition, the face of the media shall be coated with an acid resistant coating to provide maximum protection against face oxidation. Equal sensible and latent recovery efficiencies shall be clearly documented through a certification program conducted in accordance with ASHRAE 84 and ARI 1060 standards. The media shall be cleanable with low temperature steam, hot water or light detergent, without degrading the latent recovery. Dry particles up to 600 microns shall freely pass through the media. 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.

Manufacturers using wheels with a rotor based on non-aluminum materials (i.e., paper, plastic or Mylar) that require periodic replacement shall provide the owner with a spare wheel for each unit or equivalent wheel segments for future use and storage.

- H. The cross-contamination characteristics of the selected desiccant shall also be certified by an independent third party. If said certification is not available, the outside air requirement for each specified unit shall be multiplied by a factor given in the table below for each desiccant. It shall be the contractor's responsibility to resize the duct work / air conditioning equipment and take responsibility for proper system operation at the higher OA CFM if a desiccant other than 3A is used.
- I. The rotor cassette shall be a sheet metal framework, which limits the deflection of the rotor due to air pressure. The cassette shall be made of galvanized steel to prevent corrosion. The rotor cassette shall be easily removable from the Energy Recovery Unit to facilitate rigging (if necessary) and ease of service. The wheel cassette design shall use pillow block bearings for long life. A non-adjustable purge sector shall be included in the cassette.
- J. Filters shall be 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.
- K. Unit shall include an integral airflow monitoring station with the ability to read both ventilation and exhaust airflow expressed in CFM. Monitor gauge to be flush mounted on unit exterior and watertight. Monitor shall be SEMCO Model AQ Flow or Ruskin Model IAQ50 Integral Monitor/Damper, or approved equal.

- L. Unit 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. The controller shall not initiate an alarm during a stop/jog function. In addition, this controller shall be equipped with an outdoor air temperature sensor such that the energy recovery wheel can be stopped during moderate temperature periods if desired. The controller shall perform a stop/jog function for the wheel long enough to promote the self-cleaning features of the wheel but not long enough to induce energy recovery. This same temperature controller shall allow the energy recovery wheel to be operated in stop/jog mode during very low temperature periods to prevent freezing of the wheel while still delivering outdoor air through the unit
- M. Units shall be equipped with an electric preheat coil located in the fresh air inlet. Coils shall be of the resistance type with elements enclosed in a steel sheath with fins and painted with a baked on aluminum paint. Coils shall include thermal cutout protection with automatic primary protection and a secondary manual reset linear thermal cutout. Coils shall have magnetic safety and backup contactors, main disconnect, fusing, control transformer, air flow interlock switch and SCR controller. Coils shall be UL Listed and constructed in accordance with NEC requirements. A temperature controller shall be located in the outdoor air section of the unit and shall supply the signal to the SCR controller.
- N. Units shall require a single point 60-cycle power connection. See schedule 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. A factory installed and wired 120 volt convenience outlet shall be provided inside the panel. Manufacturer shall also provide variable frequency drives (VFD's) pre-wired into each unit for each fan. Drives shall be for balancing purposes only. Units shall be ETL listed and labeled.
- O. 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.

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.

- P. Provide a remote control panel for unit. Panel shall be located in Electrical/Data Closet 111. Panel 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 Stop/Jog Frost Protection
- Q. Provide factory authorized start-up and Owner training by a factory authorized representative.
- R. Submittals must include performance data which incorporates total unit energy consumption (fan power, wheel operation, energy recovery, etc.) vs. energy savings.
- S. Units shall be Semco FV series for vertical ducting. Units shall be provided with factory insulated curbs not less than 14 inches high. Contractor shall fill the curbs with fiberglass batt insulation for added thermal and sound protection. Equivalent units meeting the requirements of this specification by Greenheck will be considered.

2.14 HEAT PUMP SYSTEM

A. General

Provide and install a variable capacity, split system, heat pump heat recovery air conditioning system. System 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, 208/230 volt, three phase units. Equivalent equipment meeting the features and performance requirements of this equipment will be considered.

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.

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 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.
- 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 208/230 volts, 3-phase, 60 hertz.
- b. The outdoor unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz).
- 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.
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, Y-Series outdoor unit, 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.
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 filtered outside air intake.

4. Fan

- 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 2.18, "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 15900, "AUTOMATIC TEMPERATURE CONTROLS".

F. System Controls

See section 15900, "AUTOMATIC TEMPERTURE CONTROLS".

2.15 AIR CONDITIONING UNITS

A. General

Provide and install split system, direct expansion, air conditioning systems for the Server Room. Systems shall include vertical floor-mounted indoor compressor/evaporator units complete with internal precision temperature and humidity control. Capacities shall be as indicated on drawings.

The systems shall be labeled in accordance to UL 1995 Standard, and MEA NYC approved (MEA-163-88-E) (CSA if applicable) listings.

The units shall be designed for corner installation, requiring front only access through a hinged and removable front access panel. The electric box shall hinge outward allowing for front only access to all components. No allowance for side service access shall be required, however removable side access panels shall be provided for additional access. The refrigeration system shall be split with a matching outdoor air-cooled condenser.

The evaporator section shall be specifically designed for high sensible heat ratio. The heat exchanger shall be propeller fan for outdoor installation.

B. Submittals shall be provided with the proposal and shall include:

1. Computer selection and verification of required capacities.
2. Single-line Diagram
3. Dimensional, electrical, and capacity data
4. Piping and electrical connection drawings.

C. Cabinet and Frame Construction

Cabinet and access panels shall be fabricated from 16 gauge galvanized steel and painted with a 2-ply epoxy finish to match and provide corrosion protection. The panels shall be lined with 1/2 inch, 2 lb, high-density sound and thermal insulation and sealed with self-extinguishing gasketing conforming to NFPA 90A and 90B.

D. Electrical

1. The systems shall incorporate modular motor controllers utilizing motor start protectors and circuit breakers to eliminate the need for fuses. All wiring shall be in accordance with the National Electric Code (NEC) and shall include:
 - a. Motor branch circuit short circuit protection
 - b. Motor load switching controllers (contactors)
 - c. Motor overload protection.

2. The control circuit shall be a 24 VAC Class II low voltage circuit, including primary and secondary circuit protection. Low voltage, high voltage, and common wires shall be color-coded and shall be individually numbered at each end for ease of service tracing. All wiring shall be in accordance with the National Electric Code (NEC).
3. Included in the system's electrical control circuit shall be a 2-pin terminal connection for remote stop/start of the air conditioner by remote source.
4. A unit mounted, prewired main power disconnect switch shall be factory provided. The disconnect switch shall be dust-proof, non-fused type with a lockable handle.

E. Direct Expansion System

1. The system shall be configured for a draw-thru air pattern across the evaporator to provide uniform air distribution over the coil face. The coils shall be an A-Frame design to provide maximum coil surface area and minimum depth to provide a high sensible cooling capacity. The coils shall be seamless drawn copper tubes, mechanically bonded to tempered aluminum fins with a raised lanced fin design for maximum heat transfer. Coil end plates shall be hot dipped galvanized steel. The evaporator coil shall be mounted in an insulated UL-94-V-O polymeric.
2. The evaporator coil shall be constructed of copper tubes and aluminum fins. Refrigerant flow shall be controlled by an externally equalized thermostatic expansion valve.
3. All refrigerant piping shall be refrigerant grade tubing. Each refrigeration circuit shall include, as a minimum a refrigerant drier/strainer sight glass with moisture detector, a thermal expansion valve with rapid bleed port feature and external equalizer, an evaporator coil, a compressor, a high pressure switch with manual reset, and a low pressure switch with automatic reset.
4. Systems shall have a liquid line solenoid for refrigerant isolation to prevent liquid slugging. All high-pressure joints shall be brazed, and the entire system shall be pressure tested at the factory with dry nitrogen, evacuated to at least 50 microns and fully charged with refrigerant.
5. Compressors shall be high efficiency, high reliability and low noise scroll type. Compressors shall be complete with charging and service shraeder ports, internal vibration isolation, internal thermal overloads, an internal pressure relief valve, an internal discharge gas vibration eliminator, and external vibration mounting isolation.

- F. Evaporator blowers shall be belt driven with a double-width, double-inlet housing and forward-curved blades and permanently lubricated ball bearings sized for an average 100,000 hours of service life. The blowers shall be dynamically and statically balanced to minimize vibration and operate in the Class 1 range. The blowers shall be corrosion protected with a painted housing and impeller wheel. The blowers shall have an

adjustable base for belt tensioning and a locking system to prevent the motors from moving. The motor's drive sheave shall have an adjustable pitch to change the speed of the blowers. The motors shall be 1725 rpm and shall have overload protection and a minimum NEMA service factor of 1.15.

G. Controls

1. Units shall include Microprocessor Controller, Electrode Canister Humidifier and Dehumidification Mode with Electric Reheat/ Heat providing precision temperature and humidity control.
2. A display key pad shall feature an easy to read, 4 Row x 20 Character liquid-crystal alpha-numerical display. The attractive remote mounted (standard) keypad/display, allows the operator to visually monitor and customize unit functions and settings. The self-explanatory, keypad nomenclature shall aid in the ease of location of system programming features.
3. The performing of simple functions such as adjusting the Temperature or Humidity set point shall be made obvious:

Press TEMP SETPT or HUMID SETPT, ARROW UP or DOWN to adjust & press ENTER to accept.
4. The controller shall be field program configurable and capable of matching the unique needs of any data center, telecommunication or other critical area. The keypad/display shall be unit mounted as the standard.
5. The temperature and humidity sensor shall be return air, unit mounted as a standard.
6. The system shall be completely factory preprogrammed, and therefore, most applications will require no field setup. The "default" set points and their ranges shall be easily adjusted from the keypad/display.
7. The system shall be supplied with the following factory preprogrammed and field adjustable default settings:
 - a. Temp/Humid Control
 - b. Alarms
 - c. Compressor Short Cycle
 - d. Unit Status Display
 - e. Current Unit Status
 - f. Run Times
 - g. Alarm Conditions
 - h. Summary Alarm Contact
 - i. Alarm History
 - j. Control Inputs/Outputs
 - k. Digital (On/Off) Outputs
 - l. Analog (0-10 VDC) Outputs
 - m. Temperature Anticipation

- n. Power Loss Restart
- o. Sequential Load Activation
- p. Recovery Delay
- q. Compressor Operations
- r. Short Cycle Protection
- s. Cold Start Time Delay
- t. Pump-Down Cycle
- u. Security
- v. Keypad Lockout
- w. Diagnostic & Service Mode
- x. Control Board
- y. Input Diagnostics
- z. Output Diagnostics (Service Mode)
- aa. Time Clock & Night Set-back
- bb. Time Clock Feature
- cc. Night Set-Back Feature
- dd. Override Feature
- ee. Cyber Networking Options
- ff. Multi-Unit sequencing to automatically initiate the unit operation of a designated standby/backup unit, as well as, locally and remotely alert the alarm condition. To allow for equal unit runtime and/or to ensure unit operation, the control shall be configured for automatic timed and/or manual lead-lag of standby unit operation. The sequencing control logic shall automatically initiate the current standby unit upon a user selectable system failure alarm condition.
- gg. The controller shall be programmed to automatically change from current primary unit operation to secondary standby unit operation.
- hh. In addition to switchover via manual, automatic timed or failure, controller shall initiate switchover to standby unit operation to assist in the temperature and/or humidity control of the space.

8. Sequence of Operation

- a. To establish a single point of control reference, the controller's temperature and humidity set point shall be determined by the master unit's setpoints whereas the current on-line unit operates and controls space temperature and/or humidity based on the master unit's TEMP and HUMID SETPT in respect to their individual deadband, and/or PI Control settings.
- b. The current standby unit is enabled when the actual space temperature or humidity rises or falls to a condition equal to the Master Unit's (U1's) setpoint plus dead-band plus Inter-stage differential (if appl.) plus Capacity Assist Differential.
- c. Each unit of a group, incorporating Capacity Assist Mode, shall include its own standard unit mounted return air T/H sensor. If the Capacity Assist Sensor or its communications cable were to fail, Multi-Unit & Capacity Assist Mode operations will be automatically disabled, and the N+1 Units will perform as stand-alone systems.

H. Humidity Control

1. The humidifier shall be an electrode steam canister type and shall have an adjustable humidity output setting from 25 to 100% of the full rated humidifier capacity. The humidifier shall have an automatic flush cycle that senses the current consumption of the humidifier and controls mineral concentration of the water. A "Change Cylinder" light shall notify service personnel when the humidification output is below rated requirements and when maintenance is due.
2. The floor A/C shall provide refrigeration-based dehumidification mode. Moisture is condensed on the cooling coil and discharged through the condensate drain. Reheat (electric, hot gas, steam, or hot water) shall be provided to offset sensible cooling during the dehumidification cycle.

I. Finned Tubular Electric Reheat

A factory mounted and wired low-watt density, plated fin-tubular design electric resistance heater shall be included to provide automatic sensible re-heating as required during the dehumidification cycle and automatic heating mode. Electric heaters shall be provided with miniature thermal/magnetic circuit breakers, which shall protect each ungrounded conductor. Also included will be one automatic reset and one manual reset over-temperature safety device (pilot duty).

J. Air Pattern shall be top discharge through three-way grille plenum box with front "free" return.

K. Filters

1. Units shall have slide out, 2" deep, class 2 (per U.L. Standard 900) filters. The filters shall be easily accessed through a front access door. The filters shall have an efficiency rating of at least, 30% dust-spot as measured by ASHRAE Standard 52-76 test method.
2. The filter chamber shall be an integral part of the unit, located within the cabinet and serviceable from the front of the unit for both up-and down-flow configuration.

L. Remote Outdoor Propeller Condenser

The system shall be a remote outdoor air cooled condenser with direct-driven propeller fan(s). The condenser cabinet shall be of aluminum construction and contain copper tubes and aluminum fins. The condenser cabinet shall house the condenser coil, direct-drive propeller fan(s) and TEFC fan motor(s), and NEMA 3R condenser motor control/enabling box. The compressor(s) shall be located with the evaporator section. The condenser shall be sized to provide the total heat rejection of the system at 95°F ambient temperature for the corresponding evaporator unit. The head pressure control feature shall be low ambient head pressure control down to a minimum ambient temperature of -20°F via variable fan speed head pressure control.

M. A factory piped and wired hot gas reheat valve shall be provided to divert the hot compressor discharge gas from the condenser to the hot gas reheat coil during the dehumidification cycle. This energy saving feature shall require no additional energy and is able to offset all of the sensible cooling capacity of the system.

- N. A condensate pump shall have be provided in each unit with a lift of not less than 10 feet of head. The condensate pump shall be specifically designed to operate with the higher condensate temperatures caused by the flush and drain cycle of the electrode canister humidifiers.
- O. An ionized smoke detector shall be factory installed and wired in the evaporator section of the suction side of the evaporator blower. The air conditioner will shut down upon sensing smoke in the return air stream.
- P. Units shall be SATS CyberONE Series "COS" Vertical Floor Mounted Precision Control Air Conditioners by Stultz Air Technology Systems or approved equal.

2.16 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.

B. Types

- 1. EF-1 shall be ceiling mounted, direct driven, centrifugal exhaust fan, Model GC 120-180.

Fan shall be manufactured at an ISO 9001 certified facility. Fan 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 include 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 prepunched mounting bracket shall be provided. A white steel grille and radiation damper

shall be provided. Radiation damper shall meet NFPA 90, BOCA, SBCCA and UBC requirements. Unit 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*.

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. PF-1, 2, 3, 4, 5, 6 & 7 shall be paddle wheel type, 56 inch diameter. Each unit to include downrod support, steel yoke, heavy duty capacitors, thermal overload protection, sealed bearings, balanced blades and rotor and solid state speed controller. Fans shall be reversible and include remote dial type speed controllers with on/off switch and direction switch. Fans shall be interlocked with the ATC system to operate from temperature or manually. See Section 1590, "AUTOMATIC TEMPERATURE CONTROLS". Fans shall operate without wobble or vibration or they shall be replaced at no additional expense to the owner. Units shall be Model 56301RDP by Leading Edge, Inc. or approved equal.
3. PF-8 & 9 shall be paddle wheel type, 36 inch diameter. Each unit to include downrod support, steel yoke, heavy duty capacitors, thermal overload protection, sealed bearings, balanced blades and rotor and solid state speed controller. Fans shall include remote dial type speed controllers with on/off switch and direction switch. Fans shall be interlocked with the ATC system to operate from temperature or manually. Locate temperature sensors in stairwells directly below each fan. See Section 1590, "AUTOMATIC TEMPERATURE CONTROLS". Fans shall operate without wobble or vibration or they shall be replaced at no additional expense to the owner. Units shall be Model 3620-1 by Leading Edge, Inc. or approved equal.

2.17 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, duct lining, setting of control dampers, grilles, registers, diffusers, flexible connections, fire dampers, smoke 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

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 discharge of each air handler. Connections shall be made from Ventglas neoprene coated glass fabric as furnished by Ventfabrics, Inc., or approved equal.
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, relief, 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, Price and Titus 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 Registers (floors): Double deflection; Airline Series AL, Model AL-20-0-9-A-0-R with border #7, mounting style "A", reinforced for floor application

- c. Supply Grilles: Double deflection; X2H, ¾ inch blade spacing; front blades set horizontal.
- d. Exhaust and Return Registers: X3HOD with opposed blade damper and ¾ inch, 45° front blade spacing, front blades set horizontal.
- f. Exhaust, Return and Transfer Grilles: X3HD with ¾ inch, 45° front blade spacing, front blades set horizontal.
- g. Return Registers (filtered): X3HD-81 (X3HD-81-L for lay-in application) with opposed blade damper, ¾ inch, 45° front blade spacing, front blades set horizontal. Removable core for filter access, 1 inch pleated filter. Provide filters with grilles as outlined in paragraph 2.18, "FILTERS".
- h. Return Grilles (filtered): X3HD-81 (X3HD-81-L for lay-in application) with ¾ inch, 45° front blade spacing, front blades set horizontal. Removable core for filter access, 1 inch pleated filter. Provide filters with grilles as outlined in paragraph 2.18, "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 quality (if substituting, certified sound criteria shall be included with submittals indicating CFM and NC levels of each diffuser) [or approved equal units by Krueger and Price and Titus only] [Krueger, Price and Titus will also be considered for review but a sample of each item must be submitted as well].
 - 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 type, extruded aluminum construction with steel clips, adjustable pattern, exterior baked enamel white finish and flat black interior. Series LBD-PL for lay-in T-bar ceiling systems with factory insulated boot or approved equal. 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. Duct Sleeves

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

E. Sealing of Ducts

All new 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 for use on this project. Duct tape, in any form or material, is also prohibited.

For exterior applications, "Uni-Weather" (United McGill Corp.) neoprene based sealant shall be used. No other sealants may be used.

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.

F. 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 (both sides), 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.

G. 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.

H. 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.

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.

I. 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.

J. Fire Dampers

1. Fire dampers shall be installed to comply with NFPA Code No. 90A and shall bear a U.L. label. Provide fire rated access door at each fire damper not accessible through grille. All dampers shall comply with UL555 for dynamic testing and positive closure under air flow.
2. All fire dampers to be provided by damper manufacturer with integral sleeves 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 IBD20, style "B".
 - b. Wall and floor types, greater than 12 inches in height; Model IBD20, 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.

K. Fire/Smoke Dampers

1. Fire/Smoke dampers shall be installed to comply with NFPA 90A and 92A and U.L. standard UL555S, Sept. 1983 version. Provide a fire rated access door at each damper not accessible through grille.

2. All dampers to be provided by damper manufacturer with integral sleeves and mounting angles. Sleeves provided "in-field" are not acceptable. Models indicated are Ruskin to establish a standard:
 - a. Wall type; Model FSD36, Leakage Class II for vertical mounting.
3. Provide factory mounted electric, normally closed, 120 VAC actuator with each unit. Actuators shall be rated for 350°F. temperatures. Also 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.

M. Side Takeoff Fittings (for flexible duct)

Provide and install, at all flexible duct branches to diffusers, a bellmouth side takeoff fitting with manual damper. Fittings shall be pre-manufactured with bell end shall have a 1.1/2 inch radius and employ a self-adhesive gasket seal and be pre-drilled for attachment screws. 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.

2.18 FILTERS

All air handling units and filtered return grilles and registers 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.

2.19 EQUIPMENT IDENTIFICATION

Tag each new fan, air handling unit, branch circuit controller (BCC), outdoor (Compressor/Condenser) unit, 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.

On air handling units, branch circuit controller (BCC) and outdoor (Compressor/Condenser) units, nameplates shall be 4 inches by 1½ inches, Setonply Style No. M1774. On all other units nameplates shall be 2½ inches by ¾ inch, Setonply Style No. M1771.

Identify all new heating hot water supply & return and refrigerant 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 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", "Refrigerant Suction" and "Refrigerant Liquid" as applicable. Domestic hot and cold water piping shall be labeled differently from heating water piping.

Tag all new valves (if not tagged by valve manufacturer) with 1½ inch round brass tags and #6 bead chains, Seton #M4506. Tag shall be consecutively numbered. DO NOT DUPLICATE EXISTING VALVE IDENTIFICATION NUMBERS. 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.

2.20 INSULATION AND CONDENSATE PROTECTION

A. General

1. Insulation shall be provided for all new hot water supply and return piping, refrigerant piping, outside air intakes, supply ducts, exhaust and relief ducts and other insulation where shown on drawings.
2. Insulation systems shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

B. Hot Water Supply & Return Piping

- 1. All new hot water supply and return piping shall be insulated with heavy density fiberglass pipe insulation with 450°F. temperature rating and factory applied ASJ jacket. Longitudinal jacket flaps to be secured with flare type stainless steel staples. Cut insulation to include pipe hangers. Any existing pipe insulation which has been removed or damaged as a result of construction shall be re-insulated to conform to this specification.

Insulation thickness for hot water mains shall be as follows:

<u>Pipe Size</u>	<u>Insulation Thickness</u>
½" - 2"	1"
2½" - 8"	1½"

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 chilled water application shall be insulated.
- 6. Wherever insulation is exposed to occupied areas it shall be covered with a white PVC plastic covering material. Covering shall be applied in no less than 4 foot lengths with shingle joints. Longitudinal joints shall be on the top or back sides so as to be out of sight and sealed with adhesive materials provided with the jacketing. Material shall be butted to finish walls or Insulation Contractor shall be required to provide escutcheon plates as specified in paragraph 2.4, B. Jacketing material shall be Ceel-Tite 130 series as manufactured by Ceel-Co. or approved equal. Provide samples if substituting. In areas where ceilings are higher than 10 feet or there are no ceilings, terminate covering material at 10 feet above finish floor.

C. Refrigerant Piping

Refrigerant suction piping shall be insulated with 1 inch Self-Seal Armaflex SS or approved equal. Cover exterior insulation with ultraviolet resistant vinyl sheet outdoor PVC jacket. Material shall be 25/50 rated (flame spread rating of 25 or less and smoke developed rating of 50 or less) flexible, closed cell elastomeric thermal insulation.

D. Duct and Equipment Insulation

1. Insulate the following ducts with 1½ inches thick fiberglass duct wrap with factory applied vapor barrier facing:
 - a. Air handling unit supply air ducts
 - b. Heat recovery unit supply air ducts.
2. Insulate the following ducts with 3 inches thick fiberglass duct wrap with factory applied vapor barrier facing:
 - a. Rooftop heat recovery unit supply air ducts starting at the point of entry into the building (at the roof deck) to the duct heating coil.
 - b. Rooftop heat recovery unit return air ducts starting at the point of entry into the building (at the roof deck) for a linear distance of ten (10) feet.
3. 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.
4. Interior ductwork which is to be insulated and exposed to occupied spaces shall be covered with a semi-rigid board designed for use with ductwork. Material shall be unfaced fiberglass, 1½ inches thick, k factor of 0.23 at 75°F. mean temperature difference, Owens Corning 703 or approved equal. Material to be impaled over welded pins mechanically fastened to the duct exterior at not less than 12 inch centers. Material shall be covered with 14 ounce re-wettable canvas or reinforced insulating cement to a smooth and finished appearance ready for painting. Note: This does not apply to ductwork in boiler room or mechanical rooms unless specifically noted otherwise.

E. 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.

F. Installation

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

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 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 new 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 runouts feeding heating equipment shall have no pockets where air can collect or automatic vents shall be provided.
6. Where preset balancing valves 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.
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 hot water radiation and terminal units shall be size indicated on plans and shall come off the main downward (downfeed units) or off the side (upfeed units) with no less than three (3) 90 degree elbows provided on runout from main to drop or rise to radiation to absorb movement.
10. Install brass 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 approved 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>
½", ¾" & 1"	6'-0"
1¼" & 1½"	8'-0"
2" & 3"	10'-0"

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

<u>Pipe Size</u>	<u>Spacing</u>
½", ¾" & 1"	6'-0"
1¼" & 1½"	6'-0"
2" & 3"	10'-0"

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

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 thermometers on piping at all hot water heating coils.

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 new 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 refrigerant and water and that all parts are tight. It shall also be demonstrated that all units are functioning properly and that control system operates correctly.
- E. 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 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. All duct openings on air handling equipment shall be covered with plastic sheeting or heavy cardboard and tightly sealed with duct tape (or similar method) to reduce the collection of construction dust and debris.
3. 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 15 equipment and entire ATC system for specified operation and control sequences.
3. The mechanical contractor shall startup all Division 15 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. ATC systems are installed complete and operable.
 - c. Proper thermal overload protection is in place for new 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, smoke and volume dampers are in place and open.
 - h. Air coil fins are cleaned and combed.
 - i. Duct 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.
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.

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 in Section 15900, "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 new 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.

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".

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 adjustable balancing valves so that each is furnished with design fluid flow within 5% of the specified quantities. Mark all set points.
9. Take flow readings at each preset balancing valve and record the results.
10. Adjust air discharge patterns of all supply air diffusers, registers and grilles for optimal air diffusion.
11. 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.
12. 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) Static pressures; suction, discharge and total
 - 3) Total system flow rate
 - 4) Individual terminal flow rates (Terminal readings must show location, make, model and size of register, grille or diffuser).
 - 5) Filter status report

b. Water

Calibrated balancing device readings shall indicate location, size, setting, differential pressure (for adjustable valves), rated gpm 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 convectors, finned radiators (spackle droppings), unit ventilators, air handling units, VAV units, fans 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 twenty-four (24) hours. (Temperature control 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 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