SECTION 15600

HEATING & VENTILATING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Work to Be Performed - Perform the following items of work, as shown on the DRAWINGS and specified herein:

1. Furnish all labor, materials, equipment, transportation and perform all operations as required to install a complete HVAC system in accordance with these specifications and applicable DRAWINGS.
2. The specifications and accompanying DRAWINGS do not indicate every detail of pipe, valves, fittings, hangers, ductwork, equipment, etc., which are necessary for the complete installation but are provided to show the general arrangement and extent of work to be performed.
3. The Mechanical Contractor shall check the Architectural and associated plans and specifications to assure proper coordination with the other trades. In the event of work being done on existing systems, the contractor is responsible for visiting the site before bidding to gain first hand knowledge of the systems. Any discrepancies found shall be reported to the Architect/Engineer (A/E) prior to the bid.

B. Related Work Described Elsewhere

1. All cutting, patching, trenching, plastering, chases, slots, furring, grounds, masonry foundations, excavation, backfilling, pads, conduits, etc., incidental to the installation of HVAC apparatus and work shall be executed by qualified trades as shown on the DRAWINGS under the direction of the H&V trades. The Mechanical Contractor shall furnish on a timely basis the proper trade with all locations and details as required.
2. Electrical work
   The HVAC work shall include the installation of all motors, temperature controls, limit switches, etc., as herein specified. All other switches with pilot lights, all line switches, fused switches, outlets, motor starters, except as specified herein, required and all necessary wiring and fuses to properly connect and operate all electrical equipment specified will be furnished and installed as shown on the DRAWINGS.
3. PART A, "Bidding Requirements, Contract forms, and General Conditions," and DIVISION 1, "General Requirements," of PART B, "General Requirements," are hereby made a part of this Section.

1.2 MATERIALS

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

1.3 SUBSTITUTIONS

A. Any proposal for a substitution shall be made in writing by the Contractor, who shall submit full details for consideration and obtain written acceptance of the A/E.

B. Acceptance by the A/E for such substitution shall not relieve the Contractor from his responsibility regarding a satisfactory installation of such work in accordance with the intent of the plans and specifications and shall not affect his guarantee covering all parts of the work.

C. Any Material or equipment submitted for acceptance which is arranged differently or of a different physical size from that shown or specified shall be accompanied by shop drawings indicating the different arrangements of size and the method of making the various connections to the equipment. The final results shall be compatible with the system as designed.

D. Any additional cost resulting from the substitution of equipment shall be paid by the Contractor.

1.4 PRODUCT HANDLING

A. Protection
Protect all materials before, during and after installation and 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 acceptance of the A/E at no additional cost to the Owner.

1.5 PERMITS

Apply for, obtain and pay for all permits and inspections required by law and notify proper authorities in ample time for such inspections to be made.

1.6 QUALITY ASSURANCE

A. Qualifications of Workmen
Use sufficient qualified workmen and competent supervisors in the execution of this portion of the work to ensure proper and adequate installation of system throughout.

B. Codes
Work and/or mechanical equipment shall conform with all Local and State Rules and Regulations as well as the most recent versions of the National Fire Protection Association and the Building Officials and Code Administrators (BOCA) Mechanical Code, International Mechanical Code and Maine State Energy Code (ASHRAE 90.1).

1.7 SUBMITTALS

A. Shop Drawings
Before any materials are purchased or released for production, submit to the Architect/Engineer six (6) complete sets of shop drawings in accordance with the provisions of the GENERAL CONDITIONS AND SUPPLEMENTARY CONDITIONS of these specifications, showing all the HVAC materials proposed to be furnished and installed.

B. Record Drawings
During progress of the Work, maintain an accurate record of all changes made in the system installation from the layout and materials shown on the approved shop drawings. At the completion of the project, transfer all information onto a set of new blue-line prints and furnish them to the A/E for final "as-built" revisions.

C. Manual
Upon completion of this portion of the Work, and as a condition of its acceptance, deliver to the A/E for the Owner two copies of a manual describing the system. Prepare manuals in durable plastic binders approximately 8½ x 11" in size with the following:

1. Identification on, or readable through, the front cover stating general nature of the manual.

2. A copy of all reviewed submittals and shop drawings.
3. Complete instructions regarding operation and maintenance of all equipment involved.
4. Complete name and address of nearest vendor of replaceable parts.
5. Copy of all guarantees and warranties issued.
6. Where contents of manuals include manufacturer's catalog pages, clearly indicate the precise items included in this installation.

1.8 INSURANCE

The Contractor shall purchase and maintain all Workers' Compensation Insurance, Public Liability and Property Damage Insurance during the progress of the work and until completion and acceptance of the entire project by the Owner in the amounts as specified in the GENERAL CONDITIONS AND SUPPLEMENTARY CONDITIONS.

1.9 SAFETY REGULATIONS

All work shall be performed and/or installed to conform to all requirements of the Occupational Safety and Health Act of 1970 and all amendments thereto.

1.10 GUARANTEE

Guarantee all materials and workmanship furnished to be free from all defects for a period of 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. Specific equipment may require a warranty greater than one year and shall be complied with as noted within the equipment specification.

1.11 ASBESTOS

A. The owner shall be responsible for all of the following asbestos related activities as may be required including: site surveys, sampling, testing, removal specifications and removal. Following the satisfactory completion of the asbestos removal, the owner shall notify the Contractor of same.

B. The Mechanical Contractor shall not begin any work as described within this section of the specifications until receiving written notification from the owner as indicated.

1.12 DEMOLITION

The heating contractor shall be responsible for the removal or relocation of existing HVAC equipment and the associated piping, ductwork and controls. Removed equipment shall be turned over to the owner or properly disposed of by the contractor as directed by the owner.

PART 2 - PRODUCTS

2.1 TESTING AND BALANCING

A. Upon completion of the heating, ventilating and air conditioning systems of the building, the Mechanical Contractor shall employ an independent balance firm to check, adjust and balance all HVAC equipment included in the contract. Balancing Contractor must be approved by Architect/Engineer (A/E). The A/E shall be notified two days in advance of start of balancing. The balancing contractor shall be Yankee Balancing, Maine Air Balance Inc., TAB Tech or Central Air Balance.

B. All instruments used in the checking, adjusting and balancing shall be accurately calibrated and maintained. Accuracy tests on instruments shall be performed in the presence of and whenever requested by the A/E.

C. Air and water balance and checking shall not begin until systems have been completed and are in full working order. The Mechanical Contractor shall put all heating, ventilating, and air conditioning systems and equipment into full operation and shall continue the operating of same during each working day of testing and balancing. Before starting any air system, the complete system shall be checked to make sure all components are in place and operating properly and that all manual dampers are open.

D. Duct traverses shall be made to determine air flow and properly balance air quantities in main ducts for all air handling units.

E. All air terminals shall be tested with three readings taken and the average recorded along with that specified.

F. Take all necessary air flow measurements to determine the output of the fans and units. Revise the RPM of the equipment as necessary to produce the CFM required at the various air outlets or inlets. The final air flow readings at the air outlets and inlets shall be within -5% to +10% of the air volumes indicated on the plans, however, relative space pressurization shall remain positive or negative as designed.

G. The various systems shall operate with a minimum of air noise and the use of the air volume control dampers at the diffusers and registers to restrict air flow to the point they are noisy will not be acceptable.

H. Balancing information shall be provided for all operating conditions on any piece of equipment designed to operate at multiple CFM or GPM settings.

I . Upon completion of the checking, adjusting and balancing, the Contractor shall submit six (6) certified copies of the Mechanical systems Test and Balance Report to the A/E for approval. The Report shall be in tabulated form with each piece of equipment or outlet properly identified by its equipment number or room number and location and shall include the following:

1. Air Systems
   - a. Fan/Air Handling Unit Designation and service Location
     - Manufacturer
     - Model Number
     - Serial Number
   - b. Capacities (specified and actual) Total CFM
     - Return CFM
     - Outside air CFM
     - Total static pressure
     - Inlet static pressure
     - Discharge static pressure
     - Fan RPM
   - c. Motor and Drive Data (specified/actual/manufacturer)
     - Horsepower
     - Phase
     - Voltage
     - Amperage
     - RPM
     - Service factor

Sheave size and number of grooves
Fan sheave size and number of grooves
Belts - quantity and model number

d. Duct Traverse Data
Equipment designation
Duct size and location
Effective area
Duct velocity (specified/actual)
CFM (specified/actual)
Pressure

e. Outlet Data
Equipment designation and type
Equipment location
Equipment size
CFM (design, initial, final)

2. Water Systems

a. Pumps
Designation and service
Location
Manufacturer
Model number
Serial number

b. Capacities (specified and actual)
GPM
TDH
Amperage
Suction pressure
Discharge pressure
Pressure differential

c. Motor (specified and actual)
Horsepower
Voltage
Amperage
Phase

d. Terminal Heaters and Branch Mains
System and location
Heater designation
Valve size
Setting, differential and GPM (specified and actual)
Pressure drops through heating and cooling coils

J. Air balance dampers shall be adjusted and the position marked.

K. Water flow fittings shall be adjusted and the position marked.

L. Check operation of fire dampers, reset and tag date of test on side of duct next to access panel.

2.2 ELECTRIC MOTOR EFFICIENCY RATINGS

All motors 1/3 hp and smaller shall be wired for 120 volt, 1 phase, 60 hz; motors ½ hp and larger shall be wired for 3 phase, 60 hz, unless specifically shown otherwise. All integral horsepower motors shall be efficiency type, and have no less than the following efficiency:

Table I
Minimum Motor Efficiency
Minimum Guaranteed Efficiency (%)

Hp	Open Motor Efficiency	Enclosed Motor Efficiency
1	82.5	82.5
1.5 - 2	84	84
3	86.5	87.5
5	87.5	87.5
7.5	88.5	89.5
10	89.5	89.5
15 - 20	91	91
25	91.7	92.4
30	92.4	92.4
40 - 50	93	93
60	93.6	93.6
75	94.1	94.1
100	94.1	94.5
125	94.5	94.5

2.3 WATER PIPING (GLYCOL)

A. General

1. Provide and erect in accordance with the best practice of the trade all water supply, return, and vent piping shown on the plans and as required to complete the intended installation. The Contractor shall make such offsets as are shown or required to place all piping in proper position to avoid other work and to allow the application of insulation and finish painting.
2. The size and general arrangements, as well as the methods of connecting all piping, valves, equipment, etc., shall be as indicated.
3. All piping shall be erected so as to provide for the easy and noiseless passage of water under all working conditions. Inverted eccentric reducing fittings shall be used whenever hot water pipes reduce in size.
4. All water mains shall be run level or pitch slightly upward away from boiler so that no air pockets are formed in the piping. The mains shall be set at elevations such that the runouts feeding equipment shall have no pockets where air can collect or vents provided. Provide drains at all low points in the piping system.
5. In the erection of water piping, make proper allowances for expansion and contraction; piping shall be anchored as necessary to control the expansion. Runouts shall be the size indicated on the plans and shall come off the main with a minimum of two 90^{o} elbows provided on runout from main.
6. Install a sufficient number of flanged fittings or unions to facilitate assembly and

disassembly of piping and removal of equipment.

7. All steel pipe mains 2½" and larger and concealed piping in chases and walls regardless of size shall have welded connections, using standard factory-fabricated tees, elbows, reducers, caps, etc. Branch outlets in welded sizes shall be made with tees for full size or one size reduction and with either "Weldolets" and "Threadolets" or factory shaped nipples for all other sizes. All welds shall be made by qualified welders. All welds shall conform with the rules set forth in the Standard Manual on Pipe Welding of the Heating, Piping, and Air Conditioning Contractors National Association.
8. Steel piping 2" and smaller, (except concealed piping in chases and walls), shall have screwed connections. All threads on piping must be full length and clean-cut with inside edges reamed smooth to the full inside bore. Close nipples shall not be used without specific approval of the Architect/Engineer.
9. The contractor may use Victaulic grooved piping products in lieu of welded, flanged or threaded joints for all steel piping 2-1/2" and larger. All materials, gasketing, fittings, valves and etc. associated with the grooved piping system, shall be suitable for the operating temperatures and pressures of the water piping system. The grooved piping system shall be installed as per the manufacturers recommendations.
10. Combination balancing/shut-off valves shall be used to balance all terminal heating equipment and shall be installed with a minimum of 20 pipe diameters of unobstructed straight run upstream and 10 downstream of the valve.

B. Pipe Materials
1. Water, Drains, Vents - Schedule 40 standard weight black steel ASTM A-120 and A-53 or Type "L" copper hard temper, ASTM B88.
2. Cold Water - Type "L" hard drawn copper tubing.

C. Pipe Fittings
1. Screwed - 125# cast or malleable iron screwed pattern ANSI B16.1
2. Unions - 250# malleable iron with brass to iron ground seats.
3. Flanges - 150# forged steel slip-on ANSI B16.5.
4. Sweat - Cast bronze or wrought copper and bronze ANSI B16.18 and B16.22.
5. Connections to Equipment - 2" smaller screwed unions, 2½" and larger flanged.
6. Welded - Standard weight butt well carbon steel ASTM A-234 from A106 Grd. B. seamless tube.
7. Dielectric Unions - Provide dielectric unions at connections between dissimilar metals.

D. Jointing
1. Screwed - Use suitable pipe joint compound or tape.
2. Flanges
3. Solder (Heating) - Solid string or wire, 95% tin, 5% antimony, acid core, past types or solderflux combinations not permitted.

2.4 STEAM/CONDENSATE RETURN PIPING

A. General
1. Provide and erect in accordance with the best practice of the trade all steam supply and condensate return piping shown on the plans and as required to complete the intended installation. The Contractor shall make such offsets as are shown or required to place all piping in proper position to avoid other work and to allow the application of insulation and finish painting.
2. The size and general arrangements, as well as the methods of connecting all piping, valves, equipment, etc., shall be as indicated.
3. All piping shall be erected so as to provide for the easy and noiseless passage of steam

under all working conditions. Eccentric reducing fittings shall be used whenever steam pipes reduce in size, keeping the bottom of the pipe and reducer flush.

4. All steam mains shall pitch 1/16" per foot downward in direction of steam flow.
5. In the erection of piping, make proper allowances for expansion and contraction; piping shall be anchored as necessary to control the expansion.
6. Install a sufficient number of flanged fittings or unions to facilitate assembly and disassembly of piping and removal of equipment.
7. Steel piping 2" and smaller, shall have screwed connections. All threads on piping must be full length and clean-cut with inside edges reamed smooth to the full inside bore. Close nipples shall not be used without specific approval of the Architect/Engineer.
8. Steam pipe shall be Schedule 40 standard weight black steel ASTM-120 and condensate return shall be Schedule 80.
9. Pipe Fittings
   a. Screwed - 125# cast or malleable iron screwed pattern ANSI B16.1
   b. Unions - 250# malleable iron with brass to iron ground seats.
   c. Flanges - 150# forged steel slip-on ANSI B16.5.
   d. Connections to Equipment - 2" smaller screwed unions, 2½" and larger flanged.
10. Jointing
   a. Screwed - Use suitable pipe joint compound or tape.

2.5 NATURAL GAS PIPING SYSTEM

A. Refer to Plumbing Section 15400 for natural gas piping to combination oil / gas burners on the boilers.

2.6 VALVES

A. General
1. Valves shall be provided as shown and as required to make the installation and its apparatus complete in operation. Location to permit easy operation, replacement and repair. Valves shall be the product of one manufacturer and be equal to Nibco or Hammond.
2. All valves must be so constructed that they may be repacked under pressure while open.
3. In general, all gate valves shall be OS & Y or rising stem. Non-rising stem valves are acceptable only where clearance for valve stem is not available.
4. Combination balancing-meter valves shall be installed in all lines where regulation is required.
5. Check valves shall be installed in all lines where flow may reverse from intended direction.
6. Except for above, or as otherwise noted on drawings, gate valves shall be installed in all supply and return lines and on all drain lines.

B. Quality
1. The following list is based on Nibco as a means of identifying the quality and type required. Equals as specified above are acceptable.
   a. Gate Valves, 2½" and larger - 125# iron body bronze mounted, solid wedge, OS & Y flanged ends, F-617-0.
   b. 2" and smaller - 125# bronze, solid wedge, rising stem, screwed bonnet, screwed ends, T-121, T111.
   c. Ball Valves - Acceptable in lieu of gate and globe valves, in sizes ½" to 2". 400 lb. WOG bronze body, screwed or solder ends, bronze ball, Buna stem seals, Buna-N or equal resilient seats, lever handle. Equal to Nibco T-580.
   d. Globe Valve, 2" and smaller - 150# bronze, renewable composition disc for service intended, screwed ends, T235Y.

e. Check Valves - 200# bronze horizontal swing type, regrindable disc, screwed ends, T-453B.

f. Valves 6" and larger shall be resilient seated butterfly design. Seat to be rigid type and made of E.P.D.M. Body will be cast iron with neck extended to provide for 2" of insulation over flange O.D. Stem to be 410 series S.S., disc will be aluminum bronze. Valves 6" and smaller shall have lever type handle with 10^{o} notched throttling plate. 8" and larger valves to have enclosed heavy duty handwheel worm gear operator. All valves must be suitable for installing between any type of 125 or 150 lb. A.S.A. flange. Butterfly valves shall be NIBCO Fig. WL-082 wafer type. Refer to drawings for locations of butterfly valves.

2.7 HANGERS AND SUPPORTS

A. General

1. All hangers and supports shall be specifically manufactured for that purpose and shall be the pattern, design and capacity required for the location of use.
2. Piping specified herein shall not be supported from piping or equipment of other trades.
3. Hangers shall be heavy duty steel adjustable clevis type; plain for steel and cast iron pipe and copper plated for copper tubing.
4. Exposed vertical risers 3/4" and smaller shall be supported at the mid-point between each floor with split ring type hangers; copper plated for copper tubing.
5. All hangers on chilled water piping are to be installed on the exterior of the insulation with appropriate saddles.

B. Hanger Rods

1. Hanger rods shall be all thread rod in concealed area, and rods threaded on ends of rod only in finished areas and the Boiler Room. Rod size and spacing shall be as follows:

Nominal Pipe Size (in)	Maximum Span (ft)	Minimum Rod Diameter (in)
1	7	3/8
1 1/2	9	3/8
2	10	3/8
3	12	1/2
3 1/2	13	1/2
4	14	5/8
5	16	5/8
6	17	3/4
8	19	7/8
10	22	7/8
12	23	7/8

2. Provide lag points with rod couplings for fastening to wood, toggle bolts in concrete blocks or concrete structural slabs and compound anchor shields and bolts in poured concrete.

C. Supports

1. Provide and install angle iron supports for pipe hangers as required. Angle iron supports

shall be adequate size for span and piping load.

D. Vibration Isolators
1. Provide rubber in shear or spring type vibration isolators of adequate capacity to support equipment where shown.

E. Safety
1. Any support for piping, ductwork or equipment which is installed below seven (7) feet above finished floor shall have sharp edges blunted or rounded-off and shall be padded with 1" foam insulation to prevent possible personnel injury.

2.8 PIPE SLEEVES AND ESCUTCHEONS

A. Sleeves
1. Contractor shall set sleeves for all piping penetrating walls, partitions and floors. Sleeves through masonry shall be steel pipe sleeves two sizes larger than the pipe. Piping passing through non-rated walls or partitions other than masonry shall be provided with PVC or #24 gauge galvanized steel tubes with wired or hemmed edges.
2. Sleeves set in partitions shall finish flush with the underside but extend a minimum of 1" above the finish floor.
3. Spaces between sleeves and pipes shall be caulked with oakum packing and elastic cement (coal tar or asphalt compound on exterior walls) to make smoke and water tight.
4. For metal pipes or ducts passing through smoke or fire rated walls or floors caulk with 3M or CP35WB.
5. For plastic pipes passing through smoke or fire rated walls or floors use 3M FS-195 wrap/strip with putty smoke sealants and intumescence. Device shall be UL classified for 2 hour rating.

B. Escutcheons
1. Where piping passes through finished walls, floors, ceilings and partitions, provide and set two piece nickel plated steel floor and ceiling plates.

2.9 ANCHORS

A. Anchors shall be provided and installed where shown on the DRAWINGS or as required to control expansion.

2.10 INSULATION

A. General
1. Insulation shall be provided for the following:
a. Hot water supply and return piping.
b. Steam and condensate return piping.
c. Heat exchangers.
d. Last seven (7) feet of exhaust ducts up to wall cap, louver, brickvent or roof fan.
e. Outside intake ducts.
f. Supply and return air ducts from all ducted units except exposed ductwork in the gymnasium and track area.
g. Boiler breeching.
h. Duct liner shall be provided for the last 7' of exposed exhaust duct up to the fan in the gymnasium.
2. Insulation systems shall have a flame spread rating of 25 or less and a smoke developed

and fuel contributed rating of 50 or less.

B. Piping

1. All water supply and return piping; exposed, above ceilings, within walls, pipe chases or pipe enclosures; shall be insulated with heavy density fiberglass pipe insulation with all service jacket. Longitudinal jacket flaps to be secured with flare type stainless steel staples to eliminate fishmouths. Cut insulation to include pipe hangers. All insulation in exposed locations (except boiler room) shall have all seams and laps sealed with adhesive, in addition to staples. Thickness shall be as indicated in Table 1, Minimum Pipe Insulation.
2. All fittings shall be wrapped with fiberglass insulation and covered with a one piece PVC fitting cover secured with flare type staples. Cover joints with 4" insulation straps over.
3. Piping runouts to HV units, unit heaters, unit ventilators and cabinet unit heaters shall be insulated up to the unit enclosures.
4. 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.
5. Valves, flanges and unions shall not be insulated.

C. Boiler Breeching and Emergency Generator Flue Gas Pipe

The breeching from the boiler shall be insulated with 2" thick asbestos free calcium silicate blocks securely fastened with #14 annealed iron wire. Over this apply Ami Glass high temperature textile model #RGL1450-60 or equal.

D. Interior Ducts

Interior ducts shall be insulated with 1½" thick fiberglass duct wrap with a factory applied vapor barrier facing. 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" or wider, mechanical fasteners shall be provided approximately 12" O.C.

G. Exhaust Duct Lining

Provide Permacote linacoustic standard duct liner, 1" thick, UL listed, ISO 9000 certified, maximum air velocity, 5000 FPM, R value, 2.2 hr-sq ft-F/BTU. Liner shall be adhered to sheet with approved adhesive conforming to ASTM C 916 with all exposed edges and joints coated with Johns Manville SuporSeal. Liner shall also be mechanically secured as necessary per NAIMA “Duct Liner Installation Standard”.

E. Installation

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

TABLE 1
MINIMUM PIPE INSULATION*

Piping System Type	Fluid Temp. Range, °F	Insulation thickness in inches for pipe sizes <1"	1" to < 1-1/2"	1-1/2" to <4"	4" to < 8"	8" and Larger	
Domestic Water Systems							
Cold Water	--	½	½	1	1	1	
Hot Water	105+	½	½	1	1	1	
Process or Safe Systems	--	--	1/2	1	1	1	
Heating Systems - Steam, Steam Condensate & Hot water							
High Pressure/temp.	350 +	2½	3	3	4	4	
Med. Pressure/temp.	251 - 350	1½	2½	3	3	3	
Low Pressure/temp.	201 - 250	1½	1½	2	2	2	
Low temperature	141 - 200	1	1	1	1½	1½	
	105 - 140	½	½	1	1	1	
Cooling Systems							
Chilled Water, Refrigerant or Brine	40 - 60	½	½	1	1	1	
	Below 40	½	1	1	1	1½	

* Based on minimum thermal resistance (R) of 4.0 per inch of thickness on a flat surface at a mean temperature of 75°F.

2.11 PACKAGED BOILER-BURNER UNIT (B-1, B-2)

A. General Description:

Furnish and install as herein specified, shown or scheduled on the Contract Drawings, one new Boiler/Burner unit for low pressure steam heating service and arranged for completely automatic operation firing #2 oil and natural gas. Boiler shall have a top flue arrangement.

Boiler shall be furnished complete with an insulated metal jacket; Forced draft burner; Cast iron smokehood with integral 14 guage aluminized steel damper; Pressure tight front and rear flame observation ports with covers; Steel angle floor rails; Cast iron burner mounting plate with insulation and additional controls and devices as hereafter specified.

Boiler/Burner unit shall have been rated in accordance with the Hydronics Institute Testing and Rating Standard for Heating Boilers, and shall be performance tested and listed by IBR +0.10 ins. Water draft as scheduled.

B. Boiler Construction/Installation:

Boiler shall be a Cast Iron sectional unit of the wet base type designed for pressure firing and it shall be constructed and tested for 15 PSI Maximum steam working pressure in accordance with the A.S.M.E Section IV Rules for the Construction of Heating Boilers. Individual sections will have been subjected to a hydrostatic pressure test of 125 PSIG at the factory before shipment and they shall be marked, stamped or cast with A.S.M.E. Code symbol.

Boiler sections shall be of one piece design incorporating the furnace space and flue gas collector space with perimeter joints between the sections arranged for permanent pressure sealing with high temperature ceramic fibre rope. Upper and lower ports for connecting the water space of adjacent sections shall be sealed by means of special composition “Hy-Temp” Hydronic port seals. Sections shall be assembled with short draw rods, tightened to final torque after the section assembly is complete.

All boiler discharges shall be piped to floor drains as shown on the Contract Drawings and as indicated by the Consulting Engineer. Blowdown valves shall be Brass, ball type and not less than one inch IPS and they shall discharge to a floor drain or away from the boiler as directed by the Consulting Engineer. Pipe ends shall be cut at a 45 Degree to prevent a cap or plug from being installed. All such discharge piping shall be supported by hangars or stand-offs to prevent the valve body from undue stress or strain.

Boiler drain valves shall be connected to the lowest water space available and shall be installed with pipe and fittings to connect the bottom blowoff full size to drain. All individual sections shall have legs to provide support on both sides. Two 3"X3" base angles shall be furnished to be set under field assembled boilers to provide level level support for the sections when shimmed and grouted to a concrete floor. The base angles shall be tapped to receive the supporting frame for the insulated metal jacket.

Insulating metal jacket shall consist of 20 gauge steel panels fitted with 1 ½ Lb./Cu. Ft. density fibre glass insulation glued to the inside of the panels. Jacket panels shall be finished with blue hammertone paint baked on and shall be arranged with slots and knockouts to accommodate the boiler piping and to allow jacket installation after the piping is in place. Left hand side panels shall be furnished with chrome plated knobs for easy removal and to provide easier access to the boiler cleanout covers. Cleanout covers shall be sized and located to allow full access to the extended pin type heating surface areas for cleaning with a wire brush. Cleanout covers shall have grooves to contain high temperature ceramic fibre rope seals for gas right fir to the sections.

Stop valves shall be provided in the supply and return pipe connections to the boiler. Provisions

shall be made for the expansion and contraction of the heating mains connected to the boiler by providing substantial anchorage at suitable points and assisted by the use of swing joints to allow the piping to expand and contract without imposing excessive forces on the boiler piping.

Steam boilers shall be provided with the appropriate number of intermediate sections with 4" tappings located to discharge steam from the unique “obround” upper port gallery.

C. Steam Trim:
A.S.M.E. schedule side outlet safety valve set for 15 PSI;4 ½ inch diameter steam pressure gauge, bottom connection, 0 to 30 PSI range with Inspector’s Gauge cock and siphon; Gauge glass with gaurds and tri-cock; L404C mercury switch type High limit pressure control with manual reset and siphon; PA404 Micro switch type Operating pressure control with siphon. M&M#157 Low Water Cutoff/Pump Control for pump returns and M&M#63 Auxiliary Low Water Cutoff.

Boiler shall be furnished as a knocked down unit for field assembly, erection and connection on site and it shall be furnished with all castings, fittings appurtenances necessary for the assembly, connection and operation of the boiler as specified. Boiler installation shall be accomplished within acceptable A.S.M.E. piping practices and requirements and in strict accordance with the boiler manufacturers recommendations and instructions.

D. Combustion System:
The unit shall include a high pressure atomizing flame retention type, forced draft combination gas /oil burner listed by Underwriters Laboratories and complying with the rules and regulations of the local authorities having jurisdiction. The burner shall be equipped for full modulation. Full modulation shall employ a bypass nozzle arrangement with bypass pressure regulator and fuel oil pump to control oil firing rate and a three-way oil valve and spring loaded oil pressure actuated damper cylinder to control combustion air.

Burner shall be equipped with a 300 PSI fuel unit driven off the same motor shaft as the blower. The fuel unit shall have two stage pumping gears, self-contained pressure regulating valve and shall be suitable for 3450 RPM service with suction vacuum up to 15" of mercury. Ignition shall be accomplished by direct spark.

The burner shall be provided with a control cabinet constructed of 16 gauge steel with hinged removable door. Burner accessories, interlocks, and controls not mounted elsewhere shall be on, or in, the control cabinet and shall be factory wired through terminal strips. The control cabinet shall contain such items as the flame safegaurd control, motor relays, or starters, indicating lights, service switch and power switch. Control circuit shall be wired for 115 volts, 60 cycle alternating current supply. Provide control circuit transformer from 480V / 3ph to 120 V 1ph.

E. Flame Safegaurd:
Burner shall be furnished with an electronic flame safegaurd control flame detector. Basic control is a Honeywell R8184/CAD Cell. Each is equipped with a U.V. detector.

F. Panel and Burner Options:
Indicator lights: Power-On, Burner Motor, Ignition, Low Fire, High Fire, Flame Failure. Alarm bell or Alarm Horn for flame failure. Alarm Reset System.

G. Burner Lightoff and Warranty Service:
The manufacturer shall provide factory certified lightoff for the burners and one year of warranty service on burner controls starting on the lightoff date. The warranty service shall include labor materials to replace any parts or controls which fail in service as the result of a defect in material of manufacture.

The owner shall be responsible for the cost of normal maintenance, such as replacement of filter medium, cleaning, oiling, etc. Service control system malfunction, etc., shall be paid for by the owners. The owner's operating personnel shall be instructed in the operation and maintenance of the burner and controls at the time of lightoff. The owner shall arrange to have the people who require training to be present at the lightoff.

H. Boilers shall be mounted on 4" concrete pads.

I. Oil Burner Wiring

1. One (1) 480 volt 3 phase circuit shall be provided for boiler burner and controls as a part of the electrical system. Transformer shall be provided with unit for controls.
2. Fusible element safety switch and emergency shut-off switch shall be wired as a part of the electrical system.
3. The fusible element switch at each burner shall be mounted directly above the burner and level with the top of the boiler jacket; approximately 48" above burner.
4. This Contractor shall provide and wire all other control devices in accordance with Division 16, Electrical. Devices shall include: Operating and hi-limit aquastats, low level cut-offs and other devices required by codes and boiler manufacturer.
5. All wiring shall comply in full with the electrical portion of these Specifications relative to the wiring methods and types of equipment used and be in accordance with the rules and regulations of the National Fire Protection Association, local codes, and the State Oil Burner Code.

J. Boiler Breeching

1. Furnish and install as indicated on the DRAWINGS steel boiler breeching with gauges as listed below complete with all required supports, braces, stiffeners, hangers, cleanouts, etc., on the outside. All joints shall be welded or gasketed to make gas tight. Provide cleanout access door in breeching and full size barometric relief damper.

BREECHING CONSTRUCTION TABLE

Black, Hot Rolled Steel Gauges (Min.)	Reinforcing for Rectangular Sides
Under 12" 18 Ga.	None
13" to 24" 16 Ga.	None
25" to 29" 14 Ga	None
30" to 36" 14 Ga.	1-1/2" x 1-1/2" x 3/16" @ 5 ft. spacing
37" to 60" 12 Ga.	2" x 2" x 1/4" @ 5 ft. spacing
Over 60" 10 Ga.	3" x 3" x 1/4" @ 5 ft. spacing

2.12 PACKAGED BOILER-BURNER UNIT (B-3)

A. Provide and install water boiler-burner units. Units shall consist of an assembled cast iron boiler, insulated metal jacket, wet base combustion chamber, forced draft flame retention combination oil/gas burner, electronic programming combustion control, high limit control, operating control, ASME rated relief valve set at 40 psi low water cut-off and piping, blow off valve as per ASME code, pressure altitude gauge, return yoke with flexible seals and all necessary accessories. Unit shall have a top flue discharge.

B. Boiler-burner units shall have a minimum net IBR water rating as scheduled. The units shall be H.B. Smith, Weil McLain or Burnham. The boilers shall be erected in strict accordance with manufacturer's instructions and recommendations. Start up and one (1) year's service shall be provided.

C. The oil burner shall be provided with the boiler and be forced draft flame retention type for No. 2 fuel oil and natural gas. Burner shall be wired for power supply as scheduled on plans.

D. The electronic combustion controls shall consist of Carlin CCT 60-200 with 4 second lockout and pre-purge or equal, C554A CAD cell assembly or UV scanner if over 19 GPH, motor starter relays for burner motor, mounted in a control cabinet and factory wired to a terminal strip. All controls shall be furnished in a pre-wired and mounted control panel. Controls shall be in accordance with NFPA recommendations, and be U.L. approved, and be in accordance with state and local codes.

E. The boiler controls shall consist of a separate operating aquastat and well, and a separate high limit aquastat and well.

F. Boiler shall be provided with Hydrolevel 550 or equal low water cut-off furnished with contacts for alarm and test and check function.

G. Boilers shall be mounted on 4" concrete pads.

H. Oil Burner Wiring

1. One (1) 120 volt 1 phase circuit shall be provided for boiler burner and controls as a part of the electrical system.
2. Fusible element safety switch and emergency shut-off switch shall be wired as a part of the electrical system.
3. The fusible element switch at each burner shall be mounted directly above the burner and level with the top of the boiler jacket; approximately 48" above burner.
4. This Contractor shall provide and wire all other control devices in accordance with Division 16, Electrical. Devices shall include: Operating and hi-limit aquastats, low level cut-offs and other devices required by codes and boiler manufacturer.
5. All wiring shall comply in full with the electrical portion of these Specifications relative to the wiring methods and types of equipment used and be in accordance with the rules and regulations of the National Fire Protection Association, local codes, and the State Oil Burner Code.

I. Boiler Breeching

1. Furnish and install as indicated on the DRAWINGS steel boiler breeching with gauges as listed below complete with all required supports, braces, stiffeners, hangers, cleanouts, etc., on the outside. All joints shall be welded or gasketed to make gas tight. Provide cleanout access door in breeching and full size barometric relief damper.

BREECHING CONSTRUCTION TABLE

Black, Hot Rolled Steel Gauges (Min.)	Reinforcing for Rectangular Sides
Under 12" 18 Ga.	None
13" to 24" 16 Ga.	None

25" to 29" 14 Ga	None
30" to 36" 14 Ga.	1-1/2" x 1-1/2" x 3/16" @ 5 ft. spacing
37" to 60" 12 Ga.	2" x 2" x 1/4" @ 5 ft. spacing
Over 60" 10 Ga.	3" x 3" x 1/4" @ 5 ft. spacing

2.13 HOT WATER HEATING SYSTEM SPECIALTIES

A. Shut-off and Balancing Valves

1. All terminal units such as unit heaters, heating coils, cabinet unit heaters, unit ventilators, etc. shall be provided with a tight closing gate valve on the supply side and a tight closing combination balancing and meter valve on the return side.
2. Balancing valves on the units, coils, pumps, and piping mains where shown shall be Bell & Gossett circuit-setter, Taco, or equal. The valves shall be of the plug type with bronze or cast iron body, bronze disc screwed pattern up to 2" size and flanged 2½" and larger. Valves shall have provisions for connecting portable differential pressure gauge. Meter connections shall have built-in check valves.

B. Drain Valves

Each downfeed terminal 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. The valves shall be 1" gate valves or sized as shown on the DRAWINGS and provided with hose nipples and caps.

C. Air Vents

1. Air vents shall be installed in the piping and at the equipment as indicated on the plans and at high points as required.
2. Automatic air vents shall be B & G air vents No. 107 or equal with 3/4" NPT vent connection and 1" tapping at the top. Run line from tapping to nearest suitable drain or to 12" AFF in mechanical rooms. Provide manual shut off in feed to automatic air vent.
3. Manual air vents shall consist of air chamber with a 3/8" pipe off the top and a 3/8" gate valve. The valve shall be installed in an accessible location.

D. Air Separator

Air separator shall be either tangential flow or straight through flow type with accessories and capacities as indicated on the plans. Separator to be stamped for 125 PSI ASME construction.

E. Expansion Tanks

Tank shall be suitable for 125 PSI working pressure with ASME stamp. It shall have sealed-in elastomer diaphragm suitable for an operating temperature up to 240^{o}F. Tank shall include system connection tappings mounting base for vertical installation and precharged to 18 PSI or the initial fill pressure of the system, whichever is higher. Tank shall be equal to Taco CBX Series.

F. Thermometers

1. Furnish brass immersion thermowells where indicated and two immersion thermometers suitable for all thermowells for use in balancing and by operating personnel.
2. Furnish and install where shown on the DRAWINGS adjustable angle thermometers with 9" case, stainless steel frame front double strength glass window, brass separable socket, 30 to 240^{o}F. range, No. Bx93403 1/2 as manufactured by H.O. Trerice Co., or A9VS3 ½ by Weiss or 903AJ by Moeller.

G. Pressure Gauges:

1. Furnish pressure gauge connections where indicated consisting of 1/4" take-off with globe valve.

2. Furnish 0-100 PSI, 3-1/2 inch pressure gauge where indicated. Equal to Trerice Model 600, or Weiss PG-A or Moeller X07X05.

H. Relief Valves

Provide a diaphragm operated ASME relief valve with setting and capacity as indicated. Valves shall be equal to Bell & Gossett, Taco or Watts Regulator Co.

I. Strainers

1. "Y" Pattern: Bronze or cast iron body flange ends, 150 PSI body, model or stainless steel screen.
2. Basket Type: Bronze or cast iron body, clamped cover, 125 PSI working pressure, perforated brass basket, equal to Mueller #135.

J. Water Pressure Reducing Valves

Furnish and install a pressure reducing valve with brass body construction and built-in strainer in the cold water piping connected to the hot water heating or chilled water system as shown on the drawings. The valve shall be adjustable and be equal to N256 in as manufactured by Watts Regulator Co., Taco or Bell and Gosset. Valve shall have fast-fill capability.

K. Vibration Isolator

1. Provide flexible joints on the inlet and outlet of the base mounted pumps. Joints shall have integral flanges with split metal back up rings and be rated for 150 PSI at 250^{o}F. The unit shall be constructed of carbon steel w/ stainless steel hose and stainless steel braid and have a minimum length of 9" face to face. The joints shall be equal to FFCS as manufactured by Minnnesota Flexible Corp.

2.14 STEAM HEATING SYSTEM SPECIALTIES

A. General

All steam specialties shall be suitable for low pressure up to 15 psig application.

B. Shut-off

1. All terminal heaters shall be provided with a tight closing gate valve on the supply side.
2. Radiator valves shall be the packless type having a heavy metal diaphragm through which steam motion is transmitted to the valve mechanism. No packing or bellows will be accepted. Valve shall open fully on less than one turn of the handle. Valve bodies shall be cast brass with brass couplings.

C. Steam Traps

1. Low pressure thermostatic traps shall have cast brass bodies with forged brass covers and grass tail pipes and collars. Thermostatic member, integral with trap cover, shall be of the multi-corrugated brass bellows type having not less than ten corrugations and shall be non-adjustable.
2. Float and thermostatic traps shall have heavy cast iron bodies and covers arranged for easy dismantling without breaking piping connections . Float valve mechanism shall be brass and shall have variable lever ratio to insure quick and wide opening for discharge condensation. Thermostatic bellows member for venting air shall have not less than ten corrugations and shall be protected against damage from water hammer by brass shield cup. Float traps shall have side inlet and outlet tappings, plus an optional bottom outlet tapping.

D. Strainers

Strainers shall be of the "Y" type having heavy cast iron bodies with blow-off tappings on screen covers. Sizes ½" through 1½" shall have screen of 20 mesh model. Sizes 2" and over shall be perforated stainless steel, 233 holes per square inch, with .045" diameter, .016" thick. Screen shall be removable without disturbing piping.

E. Pressure Gauges

1. Furnish pressure gauge connections where indicated consisting of 1/4" take-off with #735-2 needle valve.
2. Furnish 0-15 psi, 3½" pressure gauge where indicated. Equal to Trerice Model 800, or Weiss or Moeller.

2.15 STEAM/HOT WATER CONVERTOR

A. Capacity as scheduled on plans.

B. Type

Shell and tube, U-bend removable tube bundle, steam in shell, water in tubes. Equipped with mounting legs.

C. Materials

1. Shell - steel
2. Tubes - 3/4" OD copper
3. Heads - cast iron
4. Tube sheets - steel
5. Tube supports - steel

D. Construction

A manufacturers' data report for pressure vessels, form No. U-1 as required by the provisions of the ASME Code Rules, is to be furnished to the engineer for the owner upon request. This form must be signed by an authorized inspector, holding a National Board commission, certifying that construction conforms to the latest ASME Code for pressure vessels for:

Shell 150 - psig design pressure at 300^{o}F.
Head - 150 psig design pressure at 300^{o}F.

as detailed in Form No. U-1. The ASME "U" symbol should also be stamped on the Heat Exchanger.

E. Installation

1. The steam supply line shall be adequately sized and equipped with a steam control valve. The steam control valve shall be actuated by a thermal control element in the hot water line from the Exchanger adjusted and set to maintain a reset (ambient) temperature in the water leaving the Exchanger.
2. Exchanger shall have adequate condensate return line equipped with proper trap for steam system.
3. Exchanger shall be equipped with proper vacuum breaker and/or vent as required.

F. Manufacturers

Exchangers shall be as manufactured by ITT Bell & Gossett, Taco, or equal.

2.16 HEATING SYSTEM CIRCULATING PUMPS (In-Line)

A. Manufacturers
   1. Bell & Gossett
   2. Taco
   3. Aurora

B. Size, capacity, and performance as shown on the DRAWINGS.

C. The pump shall be of the horizontal, oil lubricated type suitable for 125# working pressure. The pumps shall have a ground and polished steel shaft with integral thrust collar. The shaft shall be supported by two horizontal sleeve bearings designed to circulate oil. The pumps are to be equipped with a water tight seal with mechanical seal faces to be carbon on ceramic. The motor shall be non-overloading at any point on the pump curve and shall be ODP with TOP. The pump shall be an in-line type pump driven through a self-aligning flexible coupling by an oil-lubricated motor.

D. Each pump shall be provided with shut-off valves, strainer, unions or flanges; check valve, balancing valve and pressure gauge ports.

2.17 HEATING SYSTEM CIRCULATING PUMP (Base-Mounted)

A. Size, capacity, and performance as shown on the DRAWINGS.
B. Single stage vertical split case design, cast iron, bronze fitted construction, internals serviceable without disturbing piping. Enclosed impeller, keyed to shaft and secured with locknut. Mechanical seal with carbon seal ring and remite or equal seat. Oil lubricated bronze journal bearings and hardened alloy steel shaft. Pump shall have flexible coupling between motor and shaft. Motor shall be NEMA design, open drip proof construction. Pump motor horsepower shall be non-overloading. Unit to be base mounted type.
C. Pumps shall be manufactured by Bell and Gossett, Taco, or Aurora.
D. Each pump shall be provided with shut-off valves, strainer, unions or flanges; check valve, balancing valve and pressure gauge ports.

2.18 PROPELLER UNIT HEATERS (UH)

A. Furnish and install horizontal or vertical unit heaters as shown. Units shall nave capacities not less than shown on the DRAWINGS. Units shall have direct connected aluminum fans and motors. Motors shall have integral overload protection.
B. Units shall have coil with copper tubes, aluminum fins and adjustable directional louvers. Supply connection shall be in at the bottom and return out the top.
C. Shut-off valve, combination balancing and shut-off valve, vent and drain valve shall be provided on each unit.
D. Units shall be as manufactured by Trane Company, American Air Filter, McQuay or equal.

2.19 CABINET UNIT HEATERS (CUH)

A. Furnish and install cabinet unit heaters of the size, capacity and arrangement as shown.
B. Wall mounted models shall have exposed surfaces constructed of steel, not less than 16 gauge with ceiling models not less than 18 gauge. All units to be supplied with a baked enamel finish color selection by the Architect/Engineer. Provide 3 sets of throw-away filters with the units.
C. Shut-off valve, combination balancing and shut-off valve, vent and drain valve shall be provided on each unit.
D. Unit shall have direct driven forward curve double inlet centrifugal fan. Hot water coil shall be copper tubes with mechanically bonded aluminum fins.
E. Additional requirements for cabinet accessories, outdoor air intakes, etc., shall be as noted on the DRAWINGS.
F. Provide on-off multi-speed switch mounted in units.

G. Provide 3 sets of filters.
H. All high ESP motors shall be capable of .3" wc at CFM indicated unless noted otherwise.
I. Unit shall be as manufactured by Trane, McQuay, Vulcan or AAF.

2.20 HEATING AND VENTILATING AIR HANDLING UNITS (AHU)

A. General

The unit must be rigged and lifted in strict accordance with the Installation Operation and Maintenance manual (TSC-IM-1). The unit is to be installed in strict accordance with the specifications. Unit shall be UL and CUL Listed. Unit shall ship fully assembled. Units shipped in one piece will have a minimum of six points of lift. These lift points will be permanently attached to the unit base and be designed to accept standard rigging devices.

B. Unit Construction

Unit panels shall be solid double-wall construction. Fiberglass insulation with a perforated liner can be added to sections as specified on the schedule. All exterior wall panels shall be made of galvanized steel. The casing shall be able to withstand up to 1.5 times design static pressure, or 8" WC, whichever is less, with no more than 0.005 inch deflection per inch of panel span. The unit base design will allow unit to rest on top of roofcurb when field installed. Entire length and width under base will be sealed for additional water management protection.

C. Insulation

Unit shall be factory insulated. Panels and unit roof shall be of double-wall construction with interior and exterior panels and insulation. Panel insulation system shall provide a minimum R value of 12. Insulation shall conform to NFPA 90 requirements.

D. Unit Paint

External surface of unit casing shall be prepared and coated with a minimum 1.5 mil enamel finish or equal. Units supplied with casing exterior factory painted shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours. Unit casing exterior will be provided with manufacturer’s standard color, or alternative color when required.

E. Unit Roof

Unit roof will be constructed of two pieces. Inner roof will be installed in such a manner as to prevent air bypass between internal components. Outer roof will be sloped a minimum .25" per foot either from one side of unit to other, or from center to sides of the unit. Roof assembly will overhang all walls of units by 2" minimum.

F. External Pipe Cabinet

Piping cabinet shall be supplied by the manufacturer (factory assembled) and shall be of the same construction as the main unit casing. Piping cabinet shall be mounted external to the unit and shipped separate to be field installed. Piping cabinet shall have removable panels or optional access door of the same construction as the unit door.

G. Drain Pans

Coils and moisture eliminators shall be provided with a stainless steel, two-way sloping IAQ drain pan to allow for proper condensate removal. Access or blank sections may be provided with an IAQ drain pan when specified.

H. Access Doors

Access doors shall be constructed with a double-wall of solid G90 galvanized steel interior panel. Automotive style gasketing around the full perimeter of the access door shall be used to prevent air leakage. Door gasketing shall be mounted to the perimeter of the door and shall seal against a

raised door frame. Door frame shall channel water away from gasket. Door shall have a protective flange to shield gasket from exposure. Preferred door handle shall not penetrate door casing. Door shall have a single handle latch.

I. Fans

The vibration levels of the complete fan assembly shall be checked and excessive vibration (including that caused by fan imbalance) shall be eliminated in the factory. Fan shaft shall be properly sized and protectively coated with lubricating oil. Fan wheels shall be keyed to fan shaft to prevent slipping. Fan shafts shall be solid and designed so that fan shaft does not pass through its first critical speed as the unit comes up to its rated rpm. Fan shafts shall not exceed 75 percent of their first critical speed at any cataloged rpm. Fan shall be provided with an access door on the drive side of the fan.

FC Fans - Fan shall be double-width, double-inlet, multiblade type as produced by the unit manufacturer. Fan shall be forward curved (FC) as required for stable operation and optimum energy efficiency. Fan shall be equipped with self-aligning, antifriction bearings with an L-50 life of 200,000 hours. Fan performance shall be certified as complying with ARI Standard 430-89.

BI Fans - Fan shall be double-width, double-inlet, multiblade type as produced by the unit manufacturer. Fan shall be backward inclined (BI) as required for stable operation and optimum energy efficiency. Fan shall be equipped with self-aligning, antifriction bearings with an L-50 life of 200,000 hours. Fan performance shall be certified as complying with ARI Standard 430-89.

J. Fan Isolation

Fan connection shall be isolated from unit casing by a flexible canvas duct.

One-Inch Spring Isolators — Fan and motor assembly (sizes 3-8) shall be internally isolated from the unit casing with 1-inch deflection spring isolators, furnished and installed by the unit manufacturer.

Two-inch Spring Isolators - Fan and motor assembly (sizes 10-100) shall be internally isolated from the unit casing with two-inch deflection spring isolators, furnished and installed by the unit manufacturer.

K. Drives

Variable Pitch - Drives shall be variable pitch, suitable for adjustment within ±5 percent of specified rpm.
1.5 Service Factor - Drives shall be selected at 1.5 service factor.

L. Motors

Motor shall be mounted integral to an isolated fan assembly furnished by the unit manufacturer. Motor shall be mounted inside the unit casing on a slide base to permit adjustment of drive belt tension. Motors shall comply with NEMA MG-1.

High Efficiency E+ Open Drip-Proof - Motor shall be a T-frame, squirrel cage, open drip-proof with size, type and electrical characteristics as shown on equipment schedule.

M. Motor Options

480 Volt/3 Ph/60 Hz

N. Fan Options

Grease Lines — Grease lines of both bearings shall be extended to the fan support bracket on the drive side.

O. Coils

Coils shall be manufactured by the supplier of the air handling unit. Coils shall be installed such that headers and return bends are enclosed by unit casings. Coils shall be removable by unbolting the wall panels in the coil section. Coil connections shall be clearly labeled on outside of units. Coils shall have aluminum plate fins and seamless copper tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by mechanical expansion of the tubes. Soldering or tinning shall not be used in the bonding process. Fin surfaces shall be cleaned prior to installation in the unit to remove any oil or dirt that may have accumulated on the fin surfaces during manufacturing of the coil. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 410. Coil casing shall be a minimum 16-gauge G90 galvanized or 304 stainless steel with formed end supports and top and bottom channels. If two or more coils are stacked in the unit, intermediate drain channels shall be installed between coils to drain condensate to the main drain pans without flooding the lower coils or passing condensate through the airstream of the lower coil.

1. Water Coils

Coils shall be burst tested to 300 psig and proof tested under water to 200 psig. 1/2" Unit Coils UW Headers are to be constructed of round copper pipe with steel pipe connections. The steel pipe shall be attached to the copper pipe in such a manner as to inhibit galvanic corrosion of header system. Fin surface shall be Delta-FIo ™ .005 aluminum fins.

Tubes shall be 1/2 inch OD, .016 inch copper.

Fin surface shall be Delta Flo ® .005 aluminum.

P. Filters

Filter section shall have filter racks, an access door for filter removal and block-offs as required to prevent air bypass around filters. Unit shall be supplied with pleated two-inch angle filters. Provide three complete sets.

Pleated Media — Filters shall be two-inch thick non-woven fabric, treated with adhesive and continuously laminated to a supported steel wire grid. Filters shall have a rated average dust spot efficiency of not less than 25 to 35 percent when tested in accordance with ASHRAE 52-76 atmospheric dust spot method.

Q. Filter Box

A section shall be provided that supports angled filter racks and outside and return air dampers.

R. Inlet Hood

For units with outside air requirements, manufacturer shall provide inlet hood for each outside air damper with high performance moisture eliminator to prevent water carryover into unit casing from outside air. Hoods shall be sized for 100% of nominal damper capacities. Outlet hood shall be provided on exhaust air openings.

S. Dampers

Dampers shall modulate the volume of return air. Dampers shall be Ruskin CD60 type double-skin ultra low-leak airfoil design or equivalent with metal compressible jamb seals and extruded blade edge seals on all blades. The dampers shall be rated for a maximum leakage rate of less than 1

percent of nominal airflow at 1 inch wg. Blades shall rotate on stainless steel sleeve bearings. Dampers shall be arranged in parallel or opposed blade configuration.

T. Face and Bypass Dampers
Ultra low-leakage face and bypass dampers shall be provided as scheduled on drawings. Dampers shall be Ruskin CD60 type double-skin airfoil design or equivalent. Damper blades shall be of minimum 14-gauge galvanized steel and damper frames of minimum 16-gauge galvanized steel. Blades shall be of opposed blade action, with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings. Face damper and bypass damper shall be mechanically linked together and provide end driven control shafts. Leakage rate shall not exceed 5 cfm/foot2 at 1 inch wg and 9 cfm/foot2 at 4 inch wg. Damper section shall be supplied with an access door.

U. Airflow Monitoring Station
A factory-mounted damper shall be provided in the outdoor air opening to measure airflow. Damper blades shall be galvanized steel, housed in a galvanized steel frame and mechanically fastened to a rotating axle rod. The dampers shall be rated for a maximum leakage rate of less than 1% of nominal airflow at 1" WG. The airflow measurement station shall measure from 15 to 100 percent of total outside air and/or return air. The airflow monitoring device shall adjust for temperature variations. The airflow monitoring output shall be a 2-10 VDC signal proportional to velocity. The accuracy of the airflow measurement station shall be + 5 percent.

V. Manufacturer
Unit shall be by Trane T-Series or equal.

2.21 UNIT VENTILATORS (UV)

A. Furnish and install hot water and steam coil unit ventilators where shown on the DRAWINGS. The units shall have the heating capacity, minimum outdoor air settings, arrangement, standard CFM ratings listed, and provided with the Temperature Control manufacturer's controls field mounted and wired. The freeze protection thermostat shall be wired to close the outside air damper and stop the unit fan motor should temperature drop to freeze protection thermostat setting. The control shall be wired as described in AUTOMATIC TEMPERATURE CONTROL.

B. The units shall be complete with two (2) or more multi-blade fans, motors having at least two (2) speeds, control switches with motor overload protection, hot water heating elements, face and bypass dampers, outside and return air dampers, duct collars, directional flow grilles and cabinets, arrangement as shown on the plans.

C. Each unit ventilator taking outside air through the wall shall be provided with a 4" louver, as specified in "Ductwork and Air Devices" Section, sized as shown on the DRAWINGS.

D. Units shalI be designed so that they admit a minimum of 0% outside air and a maximum of 100%. The unit shall be fastened in accordance with manufacturer's instructions and details shown and checked to make sure that they set firmly on the floor and are level, plumb and tight against the wall or properly hung. A careful check shall be made of the intake louvers to make sure they are set in accordance with manufacturer's instructions. The unit manufacturer shall mount in the unit cabinets the Temperature Control manufacturer's damper motors, air stream thermostats, freeze protection thermostats, and other required controls. Provide three complete sets of filters for each of the units.

E. Provide non-fused toggle switch.

F. RIS vibration isolators.

G. The units shall be manufactured by Trane or equal .

2.22 RADIATION

A. Finned-Tube Radiation (FTR)

Finned-Tube radiation shall include element, 1 1/4" copper aluminum Series 60, one or two (2) rows as indicated with element supports, wall mounting strip and brackets, enclosure and accessories including corners, trims, ends and access panels as necessary. Wall brackets shall be placed a maximum of 4' apart and shall be located at access panels, enclosure ends, etc. for a rigid enclosure installation. Element lengths are net active lengths. Enclosure shall be 16 gauge steel with baked enamel finish. Unit enclosure style and capacities as scheduled. Provide manual knob operated dampers as indicated. Units shall be manufactured by Sterling Radiator Co., Vulcan, Trane Co. or equal.

2.23 FUEL OIL SYSTEM

A. Code Compliance

1. Installation of the fuel oil system shall comply with applicable federal, state and local codes including:
   a. NFPA 30
   b. NFPA 31
   c. OSHA
   d. UL 58

B. Steel Tank

Furnish steel tank of capacity and dimensions shown on drawings, manufactured in accordance with Underwriters Laboratories UL-142 Construction Standard for above ground tanks.

The entire exterior surface of the tank will be sandblasted to a SSPC-6 commercial finish and then clad with one coat of suitable rust inhibitive paint.

Tank shall be furnished with 24" tight bolt manhole and mounting cradles.

Tank shall be furnished with a minium 8" diameter emergency vent.

Tank manufacturer must provide 1-year unlimited warranty protection covering internal and external corrosion and structural failure.

Tank installation shall conform to manufacturer’s installation instructions and supplements.

C. Pipe

1. Fuel oil lines for supply and return shall be type “K” soft temper below grade and type “K” hard temper above grade.
2. Fuel oil fill lines shall be schedule 80 galvanized steel with Enviroflex or equal SP-4500, 4-1/2" secondary containment. Provide an Enviroflex or equal TA-4500 termination assembly and CS-3920 insert at the remote fill port. Vent lines shall be fiberglass.
3. Provide sump model number SU-2000 on wall bracket at piping entrance to tank room. Provide UB200 bulkhead fitting for the leak sensor conduit and FB3950 fitting for attachment to secondary containment pipe.

4. H & V contractor shall furnish and install FOS/R piping and specialties for three boilers.
5. Vent piping shall terminate with vent cap. Provide vent alarm.

D. Valves and Piping Specialties
1. Bodies shall be cast iron or bronze with end connections compatible with piping system.
2. Gate Valves: Wedge disc, non-rising stem, 125 lb. class.
3. Check Valves: Lift check or swing type, 125 lb. class, with renewable composition discs or metallic disc or regrinding type.
4. Fusible link valve: Dead weight loaded gate valve with fusible thermal link.
5. Strainers at equipment shall be single basket type, with inlet and outlet connections at the same horizontal line with honeycomb filters, suitable for 20 gph and 15 psi Fulflo Model FB4.
6. Provide Scully Unifil System including a 45° male adaptor and Fairfield Industries remote fill port model # RFP-2

E. Tank Level Gauge
1. Electronic tank guage model TMS-2000 with LS-600 leak detector in sump.
2. Integral hand pump.
3. Cast iron air bell.
4. Liquidometer Inc.
5. Preferred Utilities, Model TG-HP.
6. Or approved equal.
7. OPW-61F overfill valve for tank
8. LC-1001 fill alarm and control panel suitable for outdoor location. Low voltage wiring to the tank guage is by the mechanical contractor. Panel to have label WHEN ALARM SOUNDS - STOP PUMPING

F. Installation and Testing
Tank shall be tested at 5 psi and piping shall be tested 150 psi. After testing the tank shall be filled with #2 oil provided by the owner.

2.24 CONDENSATE RECEIVER PUMP SET

A. Provide cast iron receiver, two pumps, automatic make-up water solenoid valve, strainer, starter/control panel, overflow connection.

B. The make-up water valve is a float-switch-operated solenoid valve with cushioned closing and epoxy resin encapsulated coil.

C. Pumps are centrifugal type with open drip-proof motors.

D. The float switch, ½" solenoid valve and "Y" strainer are included in the make-up water assembly.

E. Provide NEMA 2 UL listed control panel factory mounted and wired with:
1. Magnetic starters
2. Disconnect switches and circuit breakers
3. Control circuit disconnect
4. Auto-Off-Hand selector switches
5. Transformers
6. Pilot lights
7. Inlet basket strainer
8. Float switches
9. Control panel

F. Unit shall be Domestic or equal.

2.25 DUCTWORK AND AIR DEVICES

A. General

1. Standing seams shall not be used on any HVAC ductwork 24 inches or less. Unreinforced flat seams shall be used using appropriate SMACNA material gauges. On larger ducts all protruding edges and corners shall be rounded and/or turned down to eliminate a potential hazard to workers around ductwork.

2. The work under this section includes all the required sheet metal extensions for grilles, manual dampers, automatic shutter deflectors, setting of control dampers, louvers, grilles, registers, diffusers, flexible connections, fire dampers, etc., as shown on the DRAWINGS or required to make the installation complete in accordance with the intent of the DRAWINGS and specifications.

B. All work shall conform to ASHRAE duct construction recommendations, SMACNA "Low Velocity Duct Construction Standards", and applicable NFPA requirements (see Table #2).

C. Ducts

The size of ducts as marked on the DRAWINGS will be adhered to as closely as possible. The right is reserved by the Architect/Engineer to vary the sizes of ducts 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. Sizes given are "inside clear" dimensions. All ducts shall be arranged to adjust to "field conditions". The ductwork trade shall coordinate his work with other trades.

D. Ductwork Material and Application - Ducts shall be constructed of the following materials, in the locations indicated.

1. Galvanized Sheet Metal - Generally used throughout H & V system for supply, return, exhaust and outside air intakes unless noted otherwise.
2. Factory Fabricated Flexible Round Duct - Where shown on Drawings.
3. Provide United McGill Corporation (or equal) “Uni-Seal” round spiral lockseam construction duct and fittings for all exposed ductwork in the gym and track areas. All ducts and fittings shall be a minimum of G-60 galvanized sheet metal in accordance with ASTM A525 and A527 specifications. Gauges shall be in accordance with current SMACNA standards.
4. Aluminum ductwork shall be used for all cabinet unit heater supply and return ductwork and exhaust ductwork at locker rooms.

E. Requirements

1. All dampers and deflectors shall be #22 gauge minimum and stiffened as required. Splitter dampers shall be adequate size to perform the control of the air desired and provided with locking mechanism.
2. All joints in ducts shall be made substantially airtight. Substantially airtight shall mean that no air leakage is noticeable through the senses of feeling or hearing at all joints and connections. All branches, turns, etc., shall be made with long radius elbow and fittings or small be provided with fixed 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.
3. All ducts shall be installed with necessary offset, changes in cross sections, risers, or drops, etc., which may be required. They shall be constructed with approved joints and be substantially supported in an approved manner.
4. Furnish and install flexible equipment connections at the intake and discharge of each

fan. Connections shall be made from Venglas neoprene coated glass fabric as furnished by Ventfabrics, Inc.

5. Every precaution shall be taken to keep the interior of the duct system free from dirt, rubbish, etc., and to protect all ducts and equipment during construction. At completion, this Contractor shall thoroughly clean all equipment, ductwork, etc., to the satisfaction of the Architect/Engineer.

F. Galvanized Steel Ducts

1. Ducts shall be constructed of copper bearing (or primer grade) galvanized steel sheets of lock-forming quality in accordance with SMACNA and ASHRAE recommendations and requirements as to gauge, support, bracing, seams, joints, connections, cross breaking, and accessories.

G. Duct Sealant

All new ducts shall be sealed with sealant/mastic equal to Airseal #33. Sealing of ducts shall be done in accordance with SMACNA, Seal Class A, all transverse joints, longitudinal seams and duct wall penetrations. Sealant shall be fiber reinforced suitable for indoor and outdoor use and shall comply with U.L. Class 1 construction. Sealant shall have a flame spread of 0 and smoke developed of 5, per ASTM-E-84. Sealant shall be suitable for duct pressures up to 10" W.C. and shall be applied in accordance with the manufacturer's recommendations. All new and existing ducts shall be thoroughly cleaned prior to application of sealant.

TABLE #2

RECOMMENDED RECTANGULAR DUCT CONSTRUCTION

Dimension of Longest Side (Inches)	Galvanized Sheet Gauge	Min. Reinforcing Angle Size and Max. Longitudinal Spacing Between Transverse Joints
	(Low Pressure)	
thru 12	26	None
13-18	24	None
19-30	24	1 x 1 x 1/8 @ 60 in.
31-42	22	1 x 1 x 1/8 @ 60 in.
43-54	22	1½ x 1½ x 1/8 @ 60 in.
55-60	20	1½ x 1½ x 1/8 @ 60 in.
61-84	20	1½ x 1½ x 1/8 @ 30 in.
85-96	18	1½ x 1½ x 3/16 @ 30 in.
97-120	18	2 x 2 x 1/4 @ 30 in.
over 120	18	2 x 2 x 1/4 @ 30 in.
	(Medium Pressure)	
thru 12	24	None
13-18	24	1 x 1 x 16 ga @ 48 in.
19-24	22	1 x 1 x 1/8 @ 48 in.
25-36	22	1 1/4 x 1 1/4 x 1/8 @ 40 in.

37-48	22	1½ x 1/8 @ 24 in.
49-60	20	2 x 2 x 3/16 @ 24 in.
61-72	20	2½ x 2½ x 3/16 @ 24 in.
73-84	18	2½ x 2½ x 3/16 @ 24 in.
85-96	18	1½ x 1½ x 1/8 @ 24 in.
97 & over	18	2 x 2 x 1/8 @ 24 in.

	(High Pressure)	
thru 12	22	None
13-18	22	1 x 1 x 16 ga. @ 48 in.
19-24	22	1 x 1 x 1/8 @ 48 in.
25-36	22	1 1/4 x 1 1/4 x 1/8 @ 32 in.
37-48	22	2 x 2 x 1/8 @ 30 in.
49-60	20	2 x 2 x 3/16 @ 24 in.
61-72	20	1½ x 1½ x 1/8 @ 24 in.*
73-84	18	1½ x 1½ x 1/8 @ 24 in.*
85-96	18	1½ x 1½ x 1/8 @ 24 in.*
97 & over	16	2 x 2 x 1/8 @ 24 in.

H. Flexible Duct

Flexible duct shall be insulated, wire reinforced, with vapor barrier coating, and shall be U.L. listed. Performance specifications include: Temperature range -20°F to 250°F; pressure range -1/2" to +2" W.G.; 4000 FPM max. velocity and thermal conductance .19. Type GSL as manufactured by Genflex.

I. Aluminum Backdraft Damper

1. Low leakage backdraft damper shall be furnished and installed to exhaust air from classrooms. Leakage rate shall be less than 12 CFM per square foot at 1/2" W.G.
2. Frame construction shall be extruded aluminum with .09" wall thickness.
3. Linkage shall be 1/8" x 1/2" aluminum tie bars concealed in frame with Zytel bearings.
4. Blades shall be .025" formed aluminum with overlapping vinyl edge seals.
5. Temperature range shall be -40°F to +200°F.
6. Units shall be Ruskin Model BD2/A1.

J. Fire Dampers

1. Fire dampers shall be installed to comply with NFPA Code No. 90A for 2 hour fire wall or 3 hour fire wall (fuel oil tank room), refer to Architectural drawings. Each unit shall bear a U.L. label in accordance with the latest version of UL 555.
2. Fire dampers at ceiling diffusers shall be specifically listed and designed for such use and shall have 1-1/2 hour minimum rating. Fusible element shall be accessible by removing ceiling diffuser.
3. Fire dampers to be equal to Ruskin. All blades shall be spring loaded and located outside the air stream. Provide types as shown and required. Provide wall sleeves as shown and required. Provide accessible insulated doors in duct at all fire dampers.

K. Volume Dampers

Provide volume dampers at each branch take off for supply, return, exhaust and outside air ducts. Dampers shall be located as close to main duct as possible.

L. Louvers

1. General - Louvers shall be provided as a portion of this Contract. All louvers shall be tested and rated for free area, pressure drop, and water penetration in accordance with AMCA Standard 500. Shop drawings shall be submitted certifying AMCA compliance, and showing free area and pressure drop for each louver submitted. Free area shall be minimum as shown on DRAWINGS, pressure drop shall not exceed 0.1 inches of water. Louver performance shall be in area below point of zero water penetration.
2. Materials - All louvers shall be constructed of extruded aluminum blades and channels not less than .081 inch thick. All corners shall be mitered. Mullions, when required by louver width, shall be hidden architectural style. Mullions shall be maximum 4 feet on center. Provide rain sill for all louvers.

3. Finish - Louvers shall have a Kynar finish.

4. Louver Type - Louver shall be 4 inch thick, equal to Ruskin ELF-375D. Louvers of other manufacturers are acceptable providing free area, performance, and construction are similar. Louvers shall be provided with removable aluminum bird screen and demountable frame.

M. Diffusers, Grilles and Registers

1. Grilles and registers shall be installed at the air supply, return and exhaust openings and as shown on the DRAWINGS. The equipment schedule is based generally on model numbers of Anemostat to establish a standard of quality; units of equal distribution, air throw and noise generated as manufactured by Tuttle and Bailey, Titus or equal are acceptable. Units to be provided with white baked enamel finish as noted.
2. Supply Air
   a. DM square and rectangular ceiling diffusers, removable extruded aluminum interchangeable cores, extended, beveled overlap margin, control grid, white paint finish.
   b. X2V/X2H supply grilles, double deflection, adjustable louvers, extruded aluminum.
   c. S2V/S2H same as X2H/X2V only with steel frame.
   d. Registers - Same as 2H/2V with opposed blade damper.
   e. IJ Drum diffuser, aluminum, unit adjustment is 0 to 30 degrees vertically with horizontal adjustment, optional finish and color to be selected by Architect.
3. Return/Exhaust Air
   a. GC5 grille with 1/2"x-1/2"x1/2" grid core, aluminum construction, white finish, suitable for surface mount.
   b. GC5L grille similar to GC5 with flat border for lay-in ceiling.
   c. HDD/S heavy duty grille, 16 ga. frame, 14 ga. fins with 3/4" spacing, $45^{o}/0^{o}$ fins, steel construction and white finish.
   d. 3HD grille, formed steel, fixed horizontal bars on 3/4 centers, 45^{o} deflection.
   e. 3HD-81 grille formed steel, fixed horizontal bars on 3/4 centers, 45^{o} deflection, hinged grille with lock and filter rack.
   f. Registers - Same as 3HD with opposed blade damper.

N. Shop drawing submittals shall show CFM, size, throw, SP and NC levels in tabular form for each grille or diffuser.

O. All dampers, grilles, registers, ducts, air handling units and fans shall be adjusted to the satisfaction of the Architect/Engineers, to obtain an even distribution of the air throughout the system. AlI of the supply outlets and exhaust registers must be balanced to the air volumes shown to produce the required results. A copy of the balancing report shall be submitted to the Architect/Engineer for approval.

P. Aluminum Steel Ducts

Ducts shall be constructed of aluminum alloy 3003-H14 sheets in accordance with SMACNA and ASHRAE recommendations and requirements as to gauge, support, bracing, seams, joints, connections, cross breaking, and accessories. The following steel gauge table must be adjusted for aluminum properties as recommended by SMACNA.

Q. Brickvents

1. General - Brickvents shall be provided as a portion of this Contract. Pressure drop shall not exceed 0.1 inches of water for a 16"x8" unit at 400 cfm or for a 16"x5" unit at 260 cfm..
2. Materials - All brickvents shall be constructed of extruded aluminum blades and channels. Units shall not be provided with insect screens.
3. Finish - Brickvents shall have a Kynar finish.

4. Brickvent Type - Unit shall be 4 inch thick, equal to Penn model B100 or B68 as indicated on the drawings. Brickvents of other manufacturers are acceptable providing free area, performance, and construction are similar.

2.26 ROOF MOUNTED OUTSIDE AIR INTAKES AND AIR RELIEF HOODS

A. Provide and install low profile aluminum, roof curb mounted outside air intakes and air relief hoods where shown and of the size capacity and arrangement as shown on the DRAWINGS. All units shall include heavy gauge (16GA for base and 18GA for hood) aluminum housing, 18" high insulated roof curb, and bird screen. Units and roof curbs shall have painted epoxy finish, color by Architect.

B. Outside air intakes shall additionally have snow screens.

C. Units shall be manufactured by Penn Ventilator, Powerline, or Davidson Fan Company.

2.27 VENTILATION FANS

A. General
1. Return and exhaust fans with the capacities and of the types shown on the DRAWINGS shall be provided and installed.
2. All fans shall carry the AMCA Certified rating seal and shall be zone rated in accordance with AMCA Bulletin 300, when so indicated.
3. Direct drive fans shall have performance similar to that shown. If performance is higher, provide a speed control for mounting at fan.
4. Provide motors with thermal overload protection.

B. Power Roof Ventilator - Power ventilators shall be all aluminum construction. Units shall consist of aluminum housing, belt or direct drive, centrifugal wheel, motor mounted outside of air stream, adjustable drive sheave, automatic shutters, bird screen, and built-in disconnect switch. Fans shall be Penn Ventilator "Domex", Cook or Acme. Provide 18-inch high roof curb and painted epoxy finish for all roof fans and curbs.

C. Power Roof Fume Exhauster - Power ventilators shall be all aluminum construction. Units shall consist of aluminum housing, belt or direct driven, aluminum spark proof, centrifugal wheel, motor mounted outside of air stream, adjustable drive sheave, hinged base and built in disconnect switch. Fans shall be PennVentilator, Fumex, Cook or Acme. Provide 18" high roof curb and painted epoxy finish for all roof exhaust fans and curbs.

D. Ceiling/Wall Cabinet Fans - Fans shall include an insulated housing, back draft damper, centrifugal fan wheel, aluminum grille and flange, terminal box, motor, cord and plug. Fan speeds shall not exceed 1500 RPM. Units shall be manufactured by Penn Ventilator Company, Cook or Acme.

2.28 DIRECT DIGITAL CONTROLS (DDC)

A. Description of Work
Furnish and install a complete system of automatic temperature controls to provide the sequences as described in these specifications. The system shall be electric/electronic direct digital control with DDC operators and shall include required components, including low voltage (24 V) and line voltage wiring. The installation diagrams shall be a part of the temperature control system design and installation.

The DDC system shall serve the new addition and shall be suitable for future expansion including the existing building, the Loyola building and the future cafeteria addition.

All new equipment in the existing building shall be on the DDC system but shall have pneumatic controls. The ATC shall also be responsible for sizing and providing a new air compressor that will be located in the new boiler room. New air compressor shall be suitable for 480V / 3 ph power. ATC shall extend pneumatic air lines from the existing boiler room to the new boiler room and shall relocate the existing air dryer.

B. Quality of Compliance

1. Control systems shall be installed by trained control mechanics regularly employed in installation and calibration of ATC equipment by the manufacturer of temperature control equipment. Acceptable installers:
   a. Trident Controls - 187A Gray Road, Cumberland, Maine
   b. Maine Controls - Presumpscot Street, Portland, Maine
   NOTE: Control installation is not acceptable by wholesalers, contractors and franchised dealers, or by any firm whose principal business is not direct manufacture and installation of ATC systems.
2. The temperature control contractor shall be independent of both the installing contractor and other equipment suppliers for this contract.
3. Guarantee
   The entire control system shall be guaranteed for a period of one (1) year from the date of acceptance by the Owner.
4. Supervision
   a. Provide any necessary wiring diagrams and supervise the installation. These diagrams shall be incorporated into the Owning and Operating Manuals.
   b. ATC contractor shall have capability to service ATC settings remotely from Contractor's place of business.
5. Shop drawings of entire control system shall be submitted for approval before work is started.
6. Coordinated Work by Others
   a. The following work shall be furnished by designated contractor under supervision of the Control Contractor.
      (1) Heating Contractor shall:
         (a) Install automatic valves and separable wells that are specified to be supplied by the Control Contractor.
         (b) Furnish and install all necessary valved pressure taps, water, drain and overflow connections and piping.
         (c) Provide on magnetic starters furnished, all necessary auxiliary contacts with buttons and switches in the required configurations.
      (2) Sheet Metal Contractor shall:
         (a) Install all automatic dampers.
         (b) Provide necessary blank-off plates required to install dampers that are smaller than duct size.
         (c) Assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.
         (d) Provide access doors or other approved means of access through ducts for service to control equipment.
      (3) Install smoke detectors in duct or equipment for Electrical Contractor.
      (4) The General Contractor shall:
         (a) Provide all necessary cutting, patching, and painting.

(b) Provide access doors or other approved means of access through ceilings and walls for service to control equipment.

7. Wiring
   a. All wiring for installation of temperature controls shall be by Temperature Control Contractor. Electrical Contractor shall furnish and install power wiring for equipment and wiring for smoke detectors.
   b. All wiring shall comply with requirements of Electrical Section, 16000, of the Specification.
8. Submittal Brochure The following shall be submitted for approval:
   a. Control drawings with detailed wiring diagrams, including bill of material and description of operation for all systems.
   b. Panel layouts and name plate lists for all local and central panels.
   c. Valve and damper schedules showing size, configuration, capacity and location of all equipment.
   d. Product data for all control system components.
9. Instruction and Adjustment
   Upon completion of the project, the Temperature Control Contractor shall:
   a. Adjust for use by Owner, all thermostats, controllers, valves, damper operators, and software relays provided under this section.
   b. Furnish two (2) instruction manuals covering function and operation of control systems. Provide factory authorized Technician to instruct Owner's personnel in operation and care of control systems and equipment.
   c. A competent technician shall be provided for instruction purposes to instruct the owner's representative. Instructions shall be given by the ATC as scheduled by the Owner for a period not more than eight hours.

C. Control Equipment
1. Control Panels
   In general, relays, controllers, transformers and other control devices (not including room thermostats or duct-mounted instruments) shall be grouped and mounted in a factory-built cabinet enclosure. Locations of temperature control panels shall be as indicated on the Drawings.
2. Automatic Control Dampers
   a. All control dampers shall be furnished as part of the automatic temperature control system unless specifically specified to be furnished as an integral portion of equipment. Dampers shall be low leak equal to Ruskin CD36.
   b. All dampers shall be installed by sheet metal trades under supervision of the automatic temperature control trades.
   c. General
      (1) Dampers shall be opposed blade for modulating application and opposed or parallel blade for open-closed application.
      (2) Provide end and edge blade seals for all dampers.
      (3) Maximum allowable leakage shall be 1% at 4 inch W.C. differential pressure for all outdoor air dampers.
      (4) Bearings shall be nylon or similar material with oil impregnated sintered metal bushings.
      (5) Linkages shall be furnished with fusible links where indicated.
      (6) Maximum blade width shall be 6 inches, maximum unsupported length shall be 48 inches.
   d. Aluminum Dampers
      (1) Required for locker rooms ductwork.

(2) Extruded aluminum 6063T5 frame and blades.
(3) Corrosion resistant shaft.

e. Galvanized Steel Dampers
(1) General use where aluminum dampers not required.
(2) Channel or fabricated sheet steel or aluminum frames.
(3) Blades constructed of two 22GA sheets spot-welded together or a single sheet 16GA minimum.

f. Damper Actuators: For each automatically controlled damper, a suitable damper actuator or actuators shall be provided in accordance with the following specifications:
(1) Actuator: Damper actuators shall be of the spring-return type and have a rating of not less than twice the torque needed for actual operation of the damper.
(2) Mounting: Damper actuators shall be provided with suita ble mounting base and frame. The damper actuators and mounting base shall not be mounted directly on cold or insulated ducts and casings, but shall be mounted outside the insulated covering in such a manner as to prevent sweating and interference with the insulation.
(3) Where indicated, damper actuators shall be provided with an auxiliary switch rated at 120 V AC.

3. Automatic Control Valves (Hot Water, 250^{o}F Max.)
a. Valves shall have removable composition discs with monel stem. Bodies two inches or smaller shall be bronze with screwed ends. Bodies 2-1/2 inches and 'larger shall be cast-iron with flanged ends. Valve bodies, trim and stuffing boxes shall be designed for not less than 125 psi working pressure. Valve packing shall be non-lubricated Teflon packing suitable for hot water service, as required.
b. Modulating valves shall be sized for CV's required. Valve pressure drop shall not exceed 5 psig.
c. Automatic control valve differential shut-off pressure shall be a minimum of 15 psig.
d. Two-position control valves shall be full line size.
e. Three-way valves shall be mixing pattern.
f. Heating valves shall fail to the "normally-open" position.
g. Electrically actuated valves shall have a clearly located position indicator as part of the operating linkage.
h. All heating valves shall be NO and fail in the open position.
i. Steam valves where indicated suitable for 15 psig.

4. Room Thermostats/Temperature Sensors
a. Room Elements
(1) Room thermostats shall have a range of 55^{o} to 90^{o} adjustable sensitivity with a minimum sensitivity of not less than one degree plus or minus. Thermostats shall be securely attached to a suitable base mounted on the wall or other building surface. Each thermostat shall be located where shown or if not shown, where it will respond to the average temperature in the room. Thermostats, generally, shall be mounted 48 inches above the floor and shall not be mounted on outside walls or partitions between offices if other locations are possible. If located on outside wall, it shall have an insulated base. Thermostats shall have locked or concealed adjustment devices, by means of which the operating points can be adjusted through a range of not less than 10 degrees above and below the operating points specified. Room thermostats shall be provided with thermometers. Thermostats shall be provided with tamperproof cast aluminum guards in the gymnasium, track and locker rooms.

(2) Thermostats shall be furnished with manual override switches. Override switches shall bring the space temperature and ventilation up to occupied settings for units controlling ventilation units.

5. Direct Digital Control System (DDC)

a. General: This specification defines the minimum equipment and performance requirements for a distributed processing direct digital control building control system.

b. Scope of Work: Furnish and install equipment, accessories, wiring and instrument piping required for a complete and functioning system. Materials and equipment shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. Components shall have been thoroughly tested and proven in actual use. The building control system shall possess a fully modular architecture, permitting expansion through the addition of more stand-alone control units (SCU), sensors, actuators, and/or operator terminals.

c. Wiring: The entire building control system shall be installed by skilled electricians and mechanics, who are properly trained and qualified for this work. Wiring shall be installed in accordance with the Project Electrical Specifications. Supervision and checkout of the system shall be by local branch engineers and technicians directly employed by the Contractor.

d. Submittals/Drawings: Submit prior to installation a set of installation drawings and control strategies for the review by the consultant and/or Owner's representative. These drawings shall include the physical location of building control system equipment and system architecture. The complete sequence of operation of the control system shall be provided. Upon completion of the installation and final system adjustment, provide a full set of As-built Drawings of the installation and the control strategies.

e. System Turn-Over and Service: Upon completion of the installation, start up the system and perform necessary testing and run diagnostics to ensure proper operation. An acceptance test in the presence of the Owner's Representative, the Architect, and the Engineer shall be performed. When the system performance is deemed satisfactory by these observers, the system parts will be accepted for beneficial use and placed under warranty.

f. Training/Owner's Instructions: Provide two copies of an operator's manual describing operating and routine maintenance service procedures to be used with the system. Instruct the Owner's designated representatives in these procedures during the start-up and test period. These instructions are to be a minimum of 8 hours long and conducted during normal working hours. The instructions shall consist of both hands-on and classroom training at the job site.

g. Proven Experience: Provide a list of no less than ten similar projects which have building control systems specified. These projects must be on-line and functional such that the Owner's Representative would observe a direct digital control system in full operation. The Contractor must be a direct, wholly owned branch of a national control's manufacturer, or a representative not a wholesale distributor.

h. Building Control System: The building control system specified herein shall be a direct digital control system which can, without additional equipment, perform the automatic temperature control and energy management functions as required in this specification.

The system, as specified, shall independently control the building's HVAC equipment to maintain the specified environmental conditions in an energy-efficient manner. The building operator shall be able to communicate with the system and control the sequence of operation within the building.

i. System Architecture: The building control system shall consist of a network of

independent control units. Each control unit shall be capable of performing specified control functions in a completely independent manner. Operator communication with the system shall be via operator terminals provided as specified. Each control unit shall be able to support its own directly connected operator's terminal through an input/output port contained within each control unit.

j. Control Unit: Each control unit shall be capable of full operation either as a completely independent unit or as a part of the building-side control system. Units shall contain the necessary equipment for direct interface to the sensors and actuators connected to it. It shall be possible to define control strategies at each control unit and for the control units in the system from any operator terminal in the system. Each control unit shall provide the ability to support its own operator terminal.

Each control unit shall include its own micro-computer controller, power supply, input/output modules, termination modules and battery. The battery shall be self-charging and be capable of supporting memory within the control unit if the commercial power to the unit is interrupted or lost for a minimum of 24 hours. Data base shall be non-volatile. The control unit shall be listed by Underwriters' Laboratories (UL) against fire and shock hazard as a signal system appliance unit.

k. Sensors/Input Signals: Each control unit shall be capable of direct interface to a variety of industry standard thermistors, dry contacts, pulse accumulators, sensors and input devices such as 4-20 Ma, 0-10 VDC.

l. Actuators/Output Signals: The control unit shall directly control electronic actuators through a 4-20 Ma or 1-16V DC signal. Also, control fans, pumps, and motors through digital contact closures.

m. Building Control Functions: Each control unit within the building control system shall perform both temperature functions and energy management routines as defined by the operator.

Temperature control functions shall execute within the control unit via direct digital control algorithms. The user shall be able to customize control strategies and sequences of operation and defining the appropriate control loop algorithms and choosing the optimum loop parameters.

Control loops shall be able to utilize any of the following control modes:

two position (on-off, slow-fast, etc.)
proportional (P)
proportional plus integral (PI)
proportional, integral, plus derivative (PID)

It shall be possible to fully create, modify, or remove control algorithms within a specific control unit while it is operating and performing other control functions. The Owner shall be able to modify any system function while this system is totally on-line. Each control loop shall be fully user definable in terms of:

sensors/actuators that are part of the control strategy
control mode
gain
control action.

It shall be possible to define a control loop which receives its input signals from other sensors connected to other stand-alone control units within the network. Control units must be able to share common point and program information. If the network communication link fails or other control unit malfunctions, the

control loop shall continue to function using the last value received from the stand-alone control units. Each control unit shall contain the capability of performing energy managements routines such as:

time of day scheduling
start/stop time optimization
duty cycling (temperature compensate)
supply air reset

In addition, the Owner shall be able to create customized control strategies based upon arithmetic, Boolean or time-delay logic. The arithmetic function's shall permit simple relationships between variables (i.e., addition, subtraction, division, and multiplication), as well as more complex relationships (i.e., square root, exponential, and/or any combination of the above in a program control statement).

The system shall permit the generation of job-specific control strategies that can be activated in any of the following ways:

continuously
at a particular time of day
on a pre-defined date
when a specific measured or controlled variable reads a selected value of state
when a piece of equipment has run for a certain period of time

Upon a loss of commercial power to any control unit, the other units within the network shall not be affected. Control strategies and energy management routines defined for the control unit shall not be affected. Control strategies and energy management retained during a power failure via the battery with the unit for a minimum of eight (8) hours. Upon resumption of commercial power, the control unit shall resume full operation without operator intervention.

The unit shall also automatically reset its clock such that proper operation of timed sequences is possible without the need for manual reset of the clock. Should a loss of power exceed memory back-up the Building Operator shall be able to manually restore system programs from cassette tapes or floppy disks.

n. Operator Interface

The building control system shall permit full English language operator communication including: obtaining information about performance of his system, allowing the operator to change the system operation, and diagnosing system malfunction. Operator communication shall be through a portable laptop computer. Laptop is not part of this contract.

There shall be three levels of pre-defined security. The first level shall allow an operator to simply display point values and status. The second level shall permit the user to display and command points. The third level shall permit the user to access the entire system including energy management routines, programs, the points data base.

It shall be possible to have one operator's terminal at each control unit or to have a single operator's device which can be connected to any panel in the network. The building control system shall permit complete operation of any control unit within the network, from any operator terminal within the system. The operator shall be able to change a program in the control unit he is presently connected to and also change the program in another control unit while the terminal is still connected to the first control unit.

o. User Programmability

Temperature control strategies and energy management routines shall be definable by the operator through the operator's terminal. It small be possible for the operator to modify system functions independently after receiving the training from the Control Contractor.

Through the operator terminal, any trained building operator shall be able to:

- read the value of a measured variable (i.e., temperature)
- start or stop equipment
- monitor the status of equipment being controlled
- read the setpoint of a control loop
- determine the control signal to an actuator
- set or change alarm limits
- determine the control strategies that have been defined for a specific piece of equipment
- generate displays of control strategies

The system shall provide an operator with the ability to:

- add control loops to the system
- add points to the system
- create, modify, or delete control strategies
- assign sensors and/or actuators to a control strategy
- tune control loops through the adjustment of control loop parameters
- enable or disable control strategies
- generate hard copy records of control strategies on a printer
- select points to be alarmable and define the alarm state(s)
- select points to be trended over a period of time and initiate the recording of values

The Owner shall not require any assistance to perform any of these functions. Equipment required to perform any of these functions shall be included as part of the Contract and be fully documented in the submittal data. This equipment should be used by the Owner or his operator with minimum training required.

p. System Head End

The building control system, as installed, shall be provided with a central host computer and operator terminals. The network shall be fully compatible with the central computer.

The computer shall include the following functions:

- dynamic color graphic displays
- maintenance management
- wide range of English language reports

(1) CRT Terminal: Cathode Ray Terminal (CRT) with microprocessor and keyboard shall De supplied as an operator's display terminal to display real-time data, allow operator's commands and report system activity. The display terminal shall have a minimum of 13-inch diagonal screen with 24 rows of 80 characters. The CRT shall have a keyboard with standard ASCII characters. The terminal shall be located in the office. The central computer shall be an IBM-compatible personal computer Dell model XPS R400 MHz.

(2) Hard Copy Terminal: A compact, desk-top printer shall be provided for hard-copy data printouts. The minimum acceptable print speed shall be 100 characters per second. The printer shall have a line length of at least 132 characters, and the character set shall be the standard 94-character ASCII upper-case subset. The printer shall include the ability to serve as an alarm, data and report generation device without any additional hardware. The printer shall be located beside the CRT terminal.

(3) Modem: Provide a US Robotics 56.6 K to allow access to the system from a remote location through a telephone line.

D. Description of Operations

1. Hot Water Reset:

Hot water reset system: Provide a dual input controller, having one sensor in the outside air with sun shield and the other in the hot water supply leaving the heat exchanger which shall modulate the steam valve to the heat exchanger to supply the following loop water temperatures:

Outdoor Air Temperature	HWS Temperature
0^o F or below	200^o F
10^o F	190^o F
20^o F	180^o F
30^o F	170^o F
40^o F	160^o F
50^o F	150^o F
60^o F	140^o F

2. Hot Water Pumps:

a. Hot Water Pump, P-1, P-2:

Hot water pumps: Provide an outdoor air sensor with sun shield via relay which shall turn one pump on when the outdoor air temperature drops below 62^o F and off when above 64^o F. Pumps are to be provided with a VFD (by electrical) to vary the speed of the pump in response to a pressure sensor. All setpoints shall be adjustable.

b. Boiler Pump P-3 and DHW Pump P-6:

Provide aquastat in DHW tank to cycle both pumps to maintain designated temperature in the domestic hot water tank.

c. DHW Recirculation Pumps P-4,5:

Pumps to cycle through DDC time schedule (TS-1).

d. Pumps P-7:

P-7 is a sump pump and shall cycle through integral controls.

3. Cabinet and Unit Heaters:

Electric line voltage wall or unit mounted thermostats shall cycle fan to maintain set point. Thermostat shall cycle steam valve and fan on steam units.

4. Finned Tube Radiation:

Finned-tube radiation shall have two position, 2-way automatic hydronic control valves with wall mounted DDC sensor. Steam finned-tube shall have two-way modulating steam valves. Provide 2-way modulating valves for radiation controlled in conjunction with

UV's. Unit shall maintain night setback temperature in the unoccupied mode.

5. Boiler B-1,2 / Feed Pumps / Condensate Receiver Pumps:
   a. Boiler controls shall modulate to maintain low steam pressure setting. Boilers shall operate on a lead-lag schedule. Second boiler shall come on in the event the lead boiler cannot maintain pressure setting.
   b. Boiler level controls in BF-1 shall cycle feed pumps BFP-1 and BFP-2 respectively.
   c. Boiler low level control shall activate alarm.
   d. Float control in CR-1, condensate receiver, shall control solenoid valve to maintain water level. Float controls and solenoid shall be supplied with condensate receiver
6. Fans:

   General: All fans with speed switches are to have the switch mounted at the unit for balancing. The switch is to be provided by the mechanical and wired by the electrical unless noted otherwise.
   a. Elevator machine room fan EF-3 shall cycle on through and electric wall mounted thermostat whenever the temperature rises above 90^{o} F in the elevator machine room.
   b. EF-10, 11 fans shall be controlled by local wall switches (by electrical).
   c. EF-1 (TS-8), EF-2 (TS-9), EF-5, 6 (TS-10) shall be cycled by the indicated DDC time schedule.
   d. EF-4, 7, 8, 9 fans have two speed motors and shall be interlocked with their respective unit ventilators to come on at low speed whenever the UV OA damper exceeds its minimum position. They are to come on to high speed whenever their respective UV OA damper exceeds 75%. Percentages at which the fans come on shall be adjustable. Additionally EF-4 and EF-7 shall be provided with a a manual 0-6 hour timer wall mounted to override the above sequence.
7. Unit Ventilators (UV):

   UV's shall include: HW or steam coils, face and bypass dampers, OA/RA dampers, OA shut off dampers, low and high temperature limit controls. The units will cycle through the DDC time schedule to run during the occupied period and to cycle during the unoccupied periods to maintain the nite set back temperature. In rooms with radiation the UV will be the second stage of heat in the night setback mode. UV shall cycle in conjunction with the radiation in the occupied mode. The OA shut off dampers shall be 100% open during occupied periods with the UV on and closed during the unoccupied periods. All UV's shall be controlled in accordance with the ASHRAE II Cycle. After the initial warm-up cycle the UV OA/RA dampers shall open to the minimum OA CFM as scheduled.

   For the steam coil, with the fan running, the OA damper shall modulate in proportion to the OA/RA damper position and remain closed with the fan off. Below 40^{o} F (outside air temperature) the steam valve shall be 100% open and the face and bypass dampers modulated to control the discharge air temperature. Above 40^{o} F the face damper shall be fully open, the bypass damper closed and the control valve modulating steam flows to the heating coil to maintain temperatures.

   Provide unit coil freeze protection sensor to de-energize the unit and close the OA damper below 38^{o} F.

   Provide high limit to de-energize unit in the event of a fire.

   UV-1 Multi-Purpose Room
   On DDC time schedule (TS-2)
   Minimum OA 40%

   UV-2 Multi-Purpose Room

On DDC time schedule (TS-3)
Minimum OA 35%

UV-3 Training
On DDC time schedule (TS-4)
Minimum OA 63%

UV-4 Chemistry
On DDC time schedule (TS-5)
Minimum OA 33%

8. Air Handling Unit (AHU-1, 2 and 3):

AHU's shall be provided with H-O-A switches, OA closure damper, OA/RA dampers, 2-way modulating valve, face and bypass dampers, low limit thermostats and remote wall mounted temperature sensors.

AHU's shall run continuously in the occupied mode and cycle in the unoccupied mode, with the OA damper closed, to maintain temperature as cycled by the DDC time schedule TC-1. Unit shall maintain night setback temperature in the unoccupied mode. The manual override switch on the temperature sensor for each unit will bring the temperature up to occupied setting as well as to bring the ventilation on to the minimum OA setting.

With the fan running, the OA damper shall modulate in proportion to the OA/RA damper position and remain closed with the fan off. Below 40^{o} F (outside air temperature) the HW coil valve shall be 100% open and the face and bypass dampers modulated to control the discharge air temperature. Above 40^{o} F the face damper shall be fully open, the bypass damper closed and the control valve modulating HW flows to the heating coil to maintain temperatures.

AHU's shall maintain discharge air temperatures at a minimum of 55^{o}F with the set point to vary as the cooling load decreases as sensed by return air.

All units shall include a warm-up cycle to bring space temperatures up to occupied setting. OA/RA dampers shall open to minimum settings following warm-up based on TC setting. Additionally, provide a carbon dioxide sensor for AHU-1 (gym) to vary the amount of OA up to 63%.

All AHU's shall include an enthalpy fresh air cooling cycle to vary the amount of OA in response to heat gain within the space.

Provide unit coil freeze protection sensor to de-energize the unit and close the OA damper below 38^{o}F.

Outside air quantity shall be monitored via airflow monitoring station in the AHU's.

Wire smoke detectors in the supply and return ducts (by electrical) to de-energize unit in the event of a fire. Wiring of detectors to alarm system is by others.

AHU-1
On DDC time schedule (TS-6)
Minimum OA 5%

AHU-2
On DDC time schedule (TS-7)
Minimum OA 25%

AHU-3
On DDC time schedule (TS-8)
Minimum OA 80%

9. Low Temperature Alarm
Provide two channel automatic dialer, Aquastat and flow switch in heating system hot water supply. System shall activate a two channel automatic dialer whenever there is either a pump or boiler failure. Provide a 30 minute time delay relay on temperature alarm to prevent nuisance tripping on boiler start-up. Alarm system shall only be activated when outside air temperature is 10°F below set point for heating pump. ATC contractor shall coordinate with building alarm system using central dialer when available.

10. Motor Operated Dampers (MOD)
In general all AHU's will be provided with OA and RA dampers. The following list applies to dampers that are exterior to the AHU's.
   a. MOD Schedule
      EF-1, 2, 3, 4, 5, 6, 7, 8, 9, 11 one each
      GRV-1, 2, 3, 4 one each
      L-1, 2 one each
      L-3, one, combustion air
   b. EF MOD's shall be interlocked to open with respective unit on and remain closed otherwise.
   c. L-1, 2 and GRV-1, 2 MOD's shall be interlocked to open whenever their respective UV is in the occupied mode and are to remain closed otherwise.
   d. GRV-3, MOD is to open whenever AHU-1 OA damper exceeds 25% (adjustable) open and is to remain closed otherwise.
   e. GRV-4, MOD is to open whenever AHU-1 OA damper exceeds 50% (adjustable) open and is to remain closed otherwise.
   f. L-3 combustion air MOD is to open whenever either of the three boilers are firing and is to remain closed otherwise. Unit must be proven to be open prior to starting the boiler. Unit shall close whenever there is a failure of both boilers B-1 and B-2.
11. Boiler B-3:
Boiler controls shall maintain boiler temperature at 180°F adjustable.

E. Input/Output Summary
1. Exhaust fans - Control relay
2. AHU's: Control relay
Relay switch
Equipment Status
Smoke detector
Scheduled start/stop
Optimum start/stop
Day/night setback
Economizer
Ventilation/recirculation
Temperature controls
Return air temperature
Outside air temperature
Space temperature
Mixing dampers (20 MA module)
Mixing valve (20 MA module)
Intake dampers (20 MA module)
Face and bypass (dampers (20 MA module)

Exhaust dampers (20 MA module)
Outside air quantity

3. Pump - 1, 2, 3, 4, 5:
   Control relay
   Flow
4. Hot water reset — HW OA reset
   Supply water — Temperature
   OA — Temperature
5. UV' s: Control relay
   Flow switch
   Equipment status
   Scheduled start/stop
   Optimum start/stop
   Day/night setback
   Economizer
   Ventilation/recirculation
   Temperature controls
   Return air temperature
   Outside air temperature
   Space temperature
   Mixing dampers (20 MA module)
   Mixing valve (20 MA module)
   Intake dampers (20 MA module)
   Face and bypass (20 MA module)
   Exhaust dampers (20 MA module)
6. Alarms Boiler flame failure
   Boiler low level
   Pump 1 failure
   Pump 2 failure

2.29 ANTI-FREEZE PROTECTION

A. Provide propylene glycol with corrosion inhibitors equal to "Noburst" by the Noble Co. or "Dowfrost" by Dow Chemical Co. to protect the glycol system from freezing. The solution throughout the system shall consist of percentages indicated below.

B. Solution properties at 50/50 are:
System efficiency 94% thermal conductivity
.288 BTU/Hr./Ft./^{o}F
Viscosity .90 centipoises
Foam character none
Burst protection -20^{o}F
Toxicity very low
Flash point none
Fire point none

C. Schedule:
1. Heating System - 40%

2.30 BOILER FEED PUMP SET

A. Boiler Feed System shall be Domestic model as scheduled or equal.

B. The unit shall consist of the following components:
1. The pump(s) shall be guaranteed for one year against defects in workmanship and

material. The pump(s) shall be equipped with mechanical seals for temperatures up to 225 /F.

2. One non-code welded receiver made of structural grade steel with epoxy resin lining applied to a clean surface to resist corrosion while in service. The tank shall be furnished with integral supports and connections for inlet, outlet drain, makeup valve, thermometer and gauge glass. Tank size shall be 36 inches diameter by 72 inches long with a 302 gallon capacity.
3. One fresh water makeup valve consisting of a float type mechanical valve suitable for tight shutoff against 100 psig inlet pressure.
4. Piping between the receiver and the pump shall consist of three section(s) containing a gate valve(s), one flexible hose(s) and Y-type strainer(s) to ensure minimum pressure drop between receiver and pump.
5. One of the triplex pumps shall be used as a spare.
6. Provide gauge glass (with shutoff valves) of proper size and tank thermometer.
7. Provide starter/control panel and disconnect.
8. Low level cut-off switch.
9. Inlet basket strainer
10. High and low water alarms.
11. Provide tappings as indicated on detail.

PART 3 - EXECUTION

3.1 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 such work is complete to the point where this installation may properly commence.
2. Verify that H & V work 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 the Architect/ Engineer.
2. Do not process with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.2 INSTALLATION OF PIPING AND EQUIPMENT

A. General

1. Install all piping and ductwork promptly, capping or plugging all open ends. Install pipe generally level and plumb, free from traps, and in a manner to conserve space for other work.
2. Inspect each piece of pipe, tubing, fittings, and equipment for defects and obstructions; promptly remove all defective material from the job site.
3. Install pipes and ducts to clear all beams and obstructions; do not cut into or reduce the size of load carrying members without approval of the Architect/Engineer.
4. All risers and off-sets shall be substantially supported.
5. Make all changes in pipe size with reducing fittings.
6. All low points in water piping shall be drained with 1/2 inch gate valve with hose nipple.

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 heating system copper tube with 95-5 tin antimony solder applied in strict accordance with the manufacturer's recommendations.

3.3 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 of the work be covered up or enclosed prior to all required inspections and approvals, uncover the work as required, and after it has been completely inspected and approved, make all repairs and replacements with such materials as are necessary to the approval of the Architect/Engineer and at no additional cost to the Owner.

3.4 TEST AND ADJUST

A. During the installation, all concealed hot water heating piping shall be tested with water to a pressure of 100 psi and held for a period of 4 hours. Any leaks shall be repaired and another test applied to the piping. All piping shall be tested before it is insulated or otherwise concealed.

B. Before operating the system all of the piping shall be flushed out to remove oil and foreign

materials. Boilers shall be "boiled" clean in accordance with manufacturer's instructions.

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/Engineer and demonstrated that the system functions as designed.

D. It shall be demonstrated that all parts of the heating system have a free and noiseless circulation of hot water and that all parts, including stuffing boxes, are tight. It shall also be demonstrated that all units are functioning properly and that the control system operates correctly.

E. Should any defects in operation develop during the test periods, the Contractor shall proceed to correct them immediately and additional tests will then be conducted.

3.5 CLEANING

Prior to acceptance of the buildings, thoroughly clean all exposed portions of the heating installation, removing all labels and all traces of foreign substance. Provide clean air filters in all air handling equipment.

3.6 INSTRUCTIONS

On completion of the job, the Contractor shall provide a competent technician to thoroughly instruct the owner's representative in the care and operation of the system. The time of instruction shall be arranged with the Owner.

3.7 EQUIPMENT IDENTIFICATION

A. Valves shall be provided with brass tags and chains securely attached to the stem or body. They shall be suitably identified by number or name to indicate the service. A framed and glazed directory of these items shall be prepared to show the location and function of each item. The directory shall be mounted in the mechanical room and will be incorporated as part of the Operating and Maintenance Instructions.

B. All mechanical equipment including pumps, air handling units, boilers, fan coil units, unit heaters, condensers, etc., shall be neatly stenciled in a conspicuous place indicating the service or equipment number.

C. All pipes shall be identified and provided with flow arrows with the exception of drops or risers to terminal units.

3.8 TEMPORARY HEAT

The Mechanical Contractor shall comply with the requirements for temporary heat as specified under the GENERAL CONDITIONS.

END OF SECTION