SECTION 15500

HVAC GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. These Sections and Drawings cover(s) the general requirements of the HVAC work to be performed and shall not void any of the requirements specified under the General Conditions or General Requirements.

1. Specification Sections

15250	Thermal Insulation
15505	Piping
15509	Chemical Treatment
15541	Centrifugal Pumps
15550	Heating Equipment
15555	Boilers
15575	Flue Stacks, Breechings and Vents
15620	Chillers
15855	Air Handling Units
15860	Fans
15890	Ductwork and Accessories
15950	Electric Automatic Temperature Control System
15990	Testing, Adjusting and Balancing

2. Drawing Number

H-1	LEGEND AND ABBREVIATIONS
H-2	OVERALL FLOOR PLAN
H-3	FLOOR PLAN I OF III – CHEMICAL AND FILTER STORAGE AREAS
H-4	FLOOR PLAN II OF III – EAST
H-5	FLOOR PLAN II OF III – MEZZANINE LEVEL – EAST
H-6	FLOOR PLAN II OF III – WEST
H-7	FLOOR PLAN II OF III – MEZZANINE LEVEL – WEST
H-8	FLOOR PLAN III OF III – HEADWORKS AREA
H-9	SECTIONS
H-10	SECTIONS
H-11	HVAC DETAILS I
H-12	HVAC DETAILS II
H-13	HOT AND CHILLED WATER/GLYCOL – FLOW SCHEMATICS
H-14	SCHEDULES I
H-15	SCHEDULES II

B. The requirements specified herein shall be modified only if specified otherwise for particular application in other Divisions.

C. Work to be included under the "Scope of Work" of each HVAC Section listed above shall include all labor, material, equipment, tools and services necessary to furnish, deliver, unload, install, test and place in satisfactory operation the equipment, services and systems as called for under each HVAC Section including any incidental work not shown, or not specified but which can reasonably be inferred as belonging to the various systems and necessary in good practice to provide a complete and satisfactory operating system.

D. This HVAC specification is incomplete without the information contained on the Drawings and in the Schedules.

E. Description of the work included in each Section is not intended to in any way limit the above broad statement, but is intended as a more specific mention of the most important items included therein.

F. Without limiting the scope of work as shown on the Drawings and required in this Section the following specific mention of items of included work is made.

1. The filter room shall be supplied with tempered and filtered air by hot water/glycol makeup air units, and exhausted by exhaust fans. The space shall be heated by hot water/glycol unit heaters.

2. The chemical room shall be supplied with tempered and filtered air by a hot water/glycol makeup air unit, and exhausted low by an exhaust fan. The space shall be heated by hot water/glycol unit heaters. The ductwork for this room shall be stainless steel and the unit heater located in the space shall be corrosion resistant. An emergency breakglass ventilation shutoff switch shall be mounted on exterior entrance of the room.

3. Electrical Room 2 shall be cooled by a chilled water air conditioning unit. The room shall be heated by an electric unit heater.

4. The administration area shall be heated and cooled by a variable air volume system. The system shall have a hot water/glycol and chilled water air handling unit to supply the spaces with filtered, heated, cooled and dehumidified air. The individual spaces temperatures shall be controlled by variable air volume terminal units. Supplemental heating shall be provided by finned tube radiators and heating coils mounted in the VAV terminals. Spaces which recirculation of air is not permitted shall be exhausted by an exhaust fan. The air handling unit shall be capable of running in an economizer mode.

5. The laboratory shall be supplied by filtered, heated, cooled and dehumidified air by a hot water/glycol and chilled water makeup air unit. The laboratory fume and exhaust hoods shall be exhausted by an FRP exhaust fan through stainless steel ductwork.

6. The garage area shall be supplied with tempered and filtered air by hot water/glycol makeup air units, and exhausted by exhaust fans. The space shall be heated by hot water/glycol unit heaters.

7. The sludge handling and headworks areas shall be supplied with tempered and filtered air by hot water/glycol makeup air units, and exhausted by the odor control system installed by others. The HVAC contractor shall provide the exhaust ductwork inside the building and shall provide a flanged connection outside the building as indicated on the drawings for connection to the odor control system. The space shall be heated by hot water/glycol unit

heaters. The ductwork for these spaces shall be stainless steel and the unit heater located in the space shall be corrosion resistant.

8. The blower room shall be cooled with heat removal ventilation provided by exhaust fans and outside air intake dampers. Additionally the space shall provide energy recovery to the sludge handling makeup air unit when heat is available through an energy recovery unit. The space shall be heated by hot water/glycol unit heaters.

9. A hot water/glycol heating system shall be provided with a central boiler plant and distribution piping to the heating equipment. The boiler plant shall consist of three cast iron, power vented, natural gas boilers controlled by a microprocessor based controller to maximize boiler efficiency. The boiler plant shall have a primary piping loop for each boiler and the distribution system shall a separate pump for each zone of heating equipment.

10. A chilled water cooling system shall be provided with a water cooled chiller, plant effluent cooled heat exchanger and a piping distribution system to the cooling equipment. The chiller shall be controlled by a microprocessor based controller to maximize chiller efficiency.

11. A DDC control system shall be provided for control of all equipment. The system shall comprise of several local standalone ATC panels located as shown on the drawings. All panels shall have a connection for a laptop computer, which will provide a platform for adjustment to setpoints, system monitoring and alarm history through the use of system graphic screens.

12. Provide testing and balancing of all air and hydronic systems by competent and certified technicians.

G. The design conditions of the HVAC systems are as follows:

1. Outdoor Design Conditions

Summer:	89°F Dry-bulb,	73°F Wet-bulb
Winter	13°F Dry-bulb,	
Approximate Heating Degree Days		4910
Approximate Cooling Degree Days		873
Site Elevation		167 ft. Above Sea Level

For air-cooled condensing unit selection, the summer design dry bulb temperature plus 10 degrees F shall be used.

2. Indoor Design Conditions

	Summer		Winter	
Space	Space Temp. °F	Outdoor Air Vent.	Space Temp. °F	Outdoor Air Vent.
A-100 Vestibule	78	0.05 CFM/SF	72	0.05 CFM/SF
A-101 Lobby	78	15 CFM/PERS.	72	15 CFM/PERS.
A-102 County Office	78	20 CFM/PERS.	72	20 CFM/PERS.
A-103 Storage	78	0.15 CFM/SF	72	0.15 CFM/SF

A-104 County Office	78	20 CFM/PERS.	72	20 CFM/PERS.
A-105 Conference	78	20 CFM/PERS.	72	20 CFM/PERS.
A-106 Kitchen	78	20 CFM/PERS.	72	20 CFM/PERS.
A-107 A/V Storage Coats	78	0.15 CFM/SF	72	0.15 CFM/SF
A-108 Control Room	78	20 CFM/PERS.	72	20 CFM/PERS.
A-109 Men's Room	78	75 CFM/FIXT.	72	75 CFM/FIXT.
A-110 Women's Room	78	75 CFM/FIXT.	72	75 CFM/FIXT.
A-111 Electrical Room	78	NATURAL	72	NATURAL
A-112 Storage Room	78	0.15 CFM/SF	72	0.15 CFM/SF
A-113 Janitor	78	100 CFM	72	100 CFM
A-114 East Corridor	78	0.05 CFM/SF	72	0.05 CFM/SF
A-115 Data	78	20 CFM/PERS.	72	20 CFM/PERS.
A-116 Telephone	78	20 CFM/PERS.	72	20 CFM/PERS.
A-117 Office	78	20 CFM/PERS.	72	20 CFM/PERS.
A-118 Files/Plan Room	78	20 CFM/PERS.	72	20 CFM/PERS.
A-119 Women's Room	78	75 CFM/FIXT.	72	75 CFM/FIXT.
A-120 Locker Room	78	0.5 CFM/SF	72	0.5 CFM/SF
A-121 Shower	78	50 CFM/FIXT.	72	50 CFM/FIXT.
A-122 West Corridor	78	0.05 CFM/SF	72	0.05 CFM/SF
A-123 Laboratory	78	12 ACH	72	12 ACH
A-124 Men's Room	78	75 CFM/FIXT.	72	75 CFM/FIXT.
A-125 Locker Room	78	0.5 CFM/SF	72	0.5 CFM/SF
A-126 Shower	78	50 CFM/FIXT.	72	50 CFM/FIXT.
A-127 Mechanical Room	104	2 ACH	60	2 ACH
A-128 Lunch/Staff Work Room	78	20 CFM/PERS.	72	20 CFM/PERS.
A-200 Vehicle Garage	104	1.5 CFM/SF	60	1.5 CFM/SF
A-201 Boiler Room	104	1 CFM/2.4MBH	60	1 CFM/2.4MBH
A-202 Maintenance Office	104	4 ACH	72	4 ACH
A-203 General Storage	104	4 ACH	60	4 ACH
A-204 Large Parts Storage	104	4 ACH	60	4 ACH
A-300 Chemical Room	104	4 ACH	60	4 ACH
A-301 Electrical Room 2	78	NATURAL	72	NATURAL
A-302 Filter Room	104	4 ACH	60	4 ACH
A-401 Electrical Room 1	78	NATURAL	72	NATURAL
A-402 Blower Room	104	Natural	60	Natural
A-500 Headworks	104	12 ACH	60	12 ACH
A-501 Electrical Room 3	78	NATURAL	72	NATURAL
A-502 Sludge Truck Bay	104	6 ACH	60	6 ACH
A-503 Sludge Handling	104	6 ACH	60	6 ACH

H. All ductwork, piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

1.02 RELATED WORK

A. Cutting and patching, except for items specified herein, is included in Division 1.

B. Temporary heating, electric power and lighting is included in Division 1.

C. Trenching, excavation and backfill except for items specified herein, is included in Division 2.

D. Concrete work except for furnishing of required anchor bolts, sleeves and templates, which shall be furnished with equipment, is included in Division 3.

E. Structural steel and miscellaneous metal except for supplementary steel required for hangers, equipment supports, anchors and guides, which shall be furnished with equipment, is included in Division 5.

F. Flashing and counterflashing, except for items specified herein is included in Division 7.

G. Painting except for factory finished equipment, shop painting and identification labeling is included in Division 9.

H. Exterior louvers are included in Division 10.

I. Plumbing except water and drain closing in connections to HVAC equipment is included in other Sections of this Division.

J. Electrical field wiring except for field wiring for automatic temperature controls as specified and as shown on the HVAC Drawings is included in Division 16.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, all shop drawings specified in the individual Sections. Submittals shall include the following:

1. Catalog data for all motors to include operating efficiency.

2. Catalog data on vibration isolator, including operating efficiency and layout diagram that locate the isolates on the equipment by model number.

3. Catalog data on bearings and confirmation of bearing life for the service specified.

4. Information on coatings as specified in the coating section.

B. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit

C. All submittals shall contain a statement that Section 15500 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

D. Submit to the Engineer as provided in Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

1. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

2. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

3. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

4. Contents - Each volume shall contain the following minimum contents:

   a. Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

   b. Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

   c. Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

5. Spare Parts List

6. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

E. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

F. All of the above submittals shall be included with the submittal for the equipment they are associated with.

1.04 REFERENCE STANDARDS

A. The latest published issue of Standards or Recommendations of the following listed Societies, Associations or Institutes in effect 3 months prior to the date of this Contract are part of this Section. These shall be considered as minimum requirements. Specific requirements of this Section and/or Drawings shall have precedence. In case of conflict between published requirements, the Engineer shall determine which is to be followed.

B. Abbreviation and the title of Federal, State and industry standards, technical societies, associations and institutes and other organizations used are as follows:

1. AABC - Associated Air Balance Council
2. ACGIH - American Conference of Governmental Industrial Hygienists
3. ADC - Air Diffusion Council
4. ABMA - American Bearing Manufacturers Association
5. AMCA - Air Movement and Control Association
6. ANSI - American National Standards Institute
7. ARI - Air-Conditioning and Refrigeration Institute
8. ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
9. ASME - American Society of Mechanical Engineers
10. ASTM - American Society for Testing and Materials
11. CTI - Cooling Tower Institute
12. FM - Factory Mutual Engineering and Research Corp.
13. IBR - Institute of Boiler and Radiator Manufacturers
14. IEEE - Institute of Electrical and Electronics Engineers
15. NIST - National Institute of Standards and Technology
16. NEBB - National Environmental Balancing Bureau
17. NEC - National Electrical Code
18. NEMA - National Electrical Manufacturers Association
19. NFPA - National Fire Protection Association
20. OSHA - Occupational Safety and Health Administration
21. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
22. UL - Underwriters Laboratories

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this Section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 DEFINITIONS

A. Particular terminology used under this Division is defined as follows:

1. Air Conditioning - Environmental control of temperature, humidity, cleanliness and air circulation, including the cooling of an enclosed space.

2. Air Conditioner or Air Conditioning Unit - One or more field-erected or factory-made assemblies, which includes the refrigeration compressor-condenser assembly, for the handling and control of air temperature, humidity, and cleanliness used for cooling.

3. Fan-Unit - Any unit or assembly containing a fan, motor and drive.

4. Temperature Controller - Any device which is used to modulate the automatic temperature control system by a change in temperature at the location of the controller.

5. Explosion Proof - Any equipment or device, which is called to be explosion proof, shall be certified as explosion proof as a complete unit.

1.08 COORDINATION

A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the Drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.

C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including; scheduling, and verification that all structures, ducts, piping and the mounting of equipment are compatible.

1.09 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.10 ELECTRIC MOTORS

A. Electric motors in NEMA frame sizes shall conform to the requirements in Section 01171, unless otherwise specified herein.

B. The motor manufacturer shall confirm that motors used to power equipment are provided with bearings that will provide a bearing life equal to the driven equipment or better. Confirmation shall be included with shop drawing submittal.

C. Motors will be selected to be non-overloading over the entire operating range of the equipment. A safety factor of 25 percent will be added to all motors up to and including 50 horsepower. A safety factor of 15 percent will be added to all motors over 50 horsepower. Motors indicated in the schedules are to be considered a minimum. The schedule sizing is not to limit compliance with the above requirements.

1.11 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:

   a. One complete set of drive belts for each piece of belt driven equipment

3. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Panel light bulbs
   b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.12 WARRANTY

A. In the event that the equipment or components fail to perform satisfactorily at any time within the Defects Liability Period, the Contractor shall replace it with one capable of operating as specified, and shall comply with the requirements in Division 1. The Contractor shall be responsible for all cost incurred in furnishing and installing the replacement equipment.

PART 2 PRODUCTS

2.01 ELECTRICAL EQUIPMENT

A. Certain items of electrical equipment which are furnished under this Section shall meet the requirements specified in Division 16:

1. Disconnect switches, motor starters and combination motor starters (starters with disconnecting means and short circuit protection) shall be as specified in Section 16191.

2. Cord-connected controls for hazardous areas shall be provided with intrinsically safe relays, which shall be as specified in Section 16191.

3. Raceways, boxes and fittings shall be as specified in Section 16110.

4. Wires and cables shall be as specified in Section 16120.

B. Electrical enclosures and panels, to include automatic temperature control panels and components shall be suitable for the environment and electrical classification for the space they are located in. The type of enclosure for the various spaces shall be as specified in Division 16. Refer to the electrical drawings for the space classifications.

C. Where location designations are not shown on the HVAC Drawings refer to the Electrical Drawings

2.02 EQUIPMENT VIBRATION ISOLATORS AND MOUNTINGS

A. General

1. Unless otherwise specified in this Division all machinery or vibrating mechanical equipment shall be isolated from the building structure by vibration isolators with a minimum deflection as specified. Operating equipment that can transmit objectionable vibration and noise must be installed with special types of vibration isolators such as flexible connectors to ductwork, piping and wiring. In more critical areas and under particular conditions, additional vibration isolators shall be installed as specified in other related Sections in this Division, or in specific equipment schedules.

2. All equipment shall be provided with attachment points for floor or suspended mounting that will safely transmit all loads including seismic to the supports.

3. The vibration isolator manufacturer shall be responsible for the proper selection of vibration isolators suitable for the particular application. Selection of the vibration isolator shall include the following factors:

   a. Equipment Weight

   b. Equipment operating frequencies

   c. Type of building support structure

   d. Seismic forces as required by the applicable building codes to include shear, tension and compression due to the code specified loads

4. All floor mounted vibration isolators shall be bolted to the floor or framing on which they rest. Bolts shall be arranged to prevent transmission of vibration through the bolts.

5. All isolation devices for a single piece of equipment shall be selected for a uniform static deflection according to distribution of weight in the equipment.

6. All pieces of equipment that have a variation in weight during operation or maintenance such as, but not limited to, cooling towers and hoppers, shall have built-in vertical limit restraints to limit motion to a maximum of 1/4-in.

7. After installation of equipment, isolators shall be adjusted for proper loading and distribution of weight.

B. Types - The following types of vibration isolators may be used.

1. Isolation Types for Floor Mounting

   a. Single elastomer-in-shear isolators, molded mound shaped element designed for 1/4-in deflection under the imposed static load. Double elastomer-in-shear isolators shall be two such elements assembled in series or a molded element designed to provide 1/2-in deflection under the imposed static load. Elastomer-in-shear isolators shall be properly housed to prevent bulging and shall be provided with adequate facilities for bolting to equipment and floor slab.

b. Spring isolators shall be free standing and laterally stable and shall be equipped with acoustical-friction pads, leveling bolts and bolt holes for anchoring to floor slab. Springs shall have a minimum ratio of outside diameter to operating spring height of 0.8 and an additional travel to solid equal to 50 percent of the specified deflection. Where housed springs are specified or required, provide units with telescoping cast iron or steel housing, containing one or more springs, complete with resilient alignment insert and a minimum of 1/4-in thick rubber or neoprene sound deadening pad bonded to the base of housing.

c. Heavy load pads shall be 1-1/4-in thick and shall consist of a high load capacity elastomer pad and sandwiched between two 1/8-in thick steel load distribution plates capable of supporting loads up to 250 psi. For large pad area, steel plates of suitable thickness shall be provided to distribute the load.

d. Light load pads shall be neoprene corrugated single, laminated double or laminated with 1/2-in thick fine granular composition cork sandwiched between two 1/4-in layers of corrugated, oil resistant neoprene. Pads shall be capable of loading to 50 psi.

2. Isolation for Suspension

a. Isolation hangers for suspension of equipment and piping shall have a single element of elastomer for 1/4-in deflection, a double or a single molded element of 1/2-in deflection, a single spring element with an elastomer grommet for up to 3/4-in deflection and a combination of an elastomer and spring elements in series for 1-in deflection and up contained within a structural rigid one piece steel hanger box. Springs shall have a minimum ratio of outside diameter to operating spring height of 0.8 and an additional travel to solid equal to 50 percent of the specified deflection.

b. The neoprene element shall have a bushing to prevent hanger rod contact with the housing box. The lower rod shall be free to swing in a 30 degree arc without touching the spring or the housing.

3. Rails and Bases - Rails and bases shall be of the following types based on the equipment and deflection required.

a. Rubber in shear type shall be steel rails running the full length of the supported equipment and extending under any overhang to counteract cantilever effects. The rails shall incorporate single or double deflection elastomer-in-shear fastened in place and a continuous steel floor bearing plate running the full length of each rail. The rails shall be drilled and tapped to accept the supported equipment and shall serve as a template.

b. Steel spring type shall be steel rails running the full length of the supported equipment and extending under any overhang to counteract cantilever effects. The rails shall consist of structural members supported by individual free standing springs. The rails shall be drilled to accept the supported equipment and shall serve as a template.

c. Fans and their driving motors shall be mounted on structural steel channel members forming a rigid base. A common member, parallel to the V-belt drive, shall run the full length of the fan and motor and shall be of sufficient rigidity to resist the bending stress of belt pull. The structural steel base shall incorporate single or double deflection

elastomer-in-shear elements or free standing springs located for proper weight distribution. The base shall be drilled and tapped to accept the fan and motor and shall serve as a template. Integral motor slide rails shall be provided and welded in place.]

d. Unless specifically noted in other Sections or on specific equipment schedules, all equipment will be provided with vibration isolation as defined by the following table:

Type of Equipment	Vibration Isolation Type	Minimum Deflection for Slab on Grade Inches	Minimum Deflection for up to 20-ft floor span inches	Minimum Deflection for 20-ft to 30-ft Floor Span Inches	Minimum Deflection for 30-ft to 40-ft Floor Span Inches
Chillers					
	Rubber	0.25	--	--	--
	Spring	--	0.75	1.75	2.5
In line Pumps					
25 HP and less	Spring	0.75	1.75	1.75	1.75
30 HP and greater	Spring	1.75	1.75	1.75	2.50
Axial & Cabinet Fans					
22-in dia. and less	Rubber	0.25	--	--	--
	Spring	--	0.75	0.75	0.75
Over 22-in dia. Less than 2-in S.P.	Spring	0.75	1.75	1.75	1.75
Over 22-in dia. Over 2-in S.P.	Spring	0.75	1.75	1.75	2.50
Centrifugal Fans					
22-in dia. and less	Rubber	0.25	--	--	--
	Spring	--	0.75	0.75	1.75
24-in dia. and greater					
40 HP and less	Spring	0.75	0.75	0.75	1.75
Condensing Units	Rubber	0.25	--	--	--
	Spring	--	0.75	1.75	1.75
Air Handling Units					
10 HP and less	Spring	0.75	0.75	0.75	0.75
15 HP and greater					
4-in S.P. and less	Spring	0.75	1.75	1.75	1.75
4-in. S.P. and greater	Spring	0.75	1.75	1.75	2.50
Duct Mounted Fans					
600 CFM and less	Spring	0.50	0.50	0.50	0.50
600 CFM and greater	Spring	0.75	0.75	0.75	0.75

4. Isolation for Piping

a. Flexible piping for systems with operating temperatures over 200 degrees F shall be flexible annular corrugated stainless steel hose. The hose shall be provided with an external stainless steel braid to minimize elongation under pressure. Hoses 2-1/2-in and smaller shall be threaded and hoses 3-in and larger shall be flanged. The manufacturer shall confirm the suitability of the flexible piping for the temperature and pressure of the systems.

b. Flexible piping for systems with operating temperatures 200 degrees F and less shall be spherical EPDM connections. Connections shall have multiple plies of corded fabric reinforcing. Connection shall be rated for 150 psi at 220 degrees F. For equipment with connections from 2-1/2 to 12-in, 90 degree bend connections can be used. Straight connections shall be double sphere and bend connections shall be single sphere. Provide control cables to prevent excessive elongation on straight connection where required. The manufacturer shall confirm the suitability of the connections for the temperature, pressure, and pipe contents for the systems.

C. Rigidly Mounted Equipment

1. When equipment doesn't require vibration isolation, it shall be firmly attached to the building structure. Bolts and support structure shall include allowances for seismic loads as required by the applicable building codes to include shear and moment loads.

2.03 SEISMIC RESTRAINTS

A. Seismic restraints shall be provided for all piping and equipment as required by applicable codes. All seismic criteria and design shall comply with the New York State Building Code.

B. Materials of construction for seismic supports shall be the same as those specified for equipment supports and hangers, and duct and pipe hangers. All bolts shall be stainless steel regardless of the specified support material.

C. Where the seismic criteria and size of piping and ductwork are within the limits of the latest edition of the SMACNA Seismic Restraint Manual, the restraints as defined in the manual can be used. Restraints shall be selected from Tables for Seismic Hazard Class C.

D. The Contractor shall retain a professional engineer to provide seismic loadings and designs of seismic restraints. This will include but not be limited to the following:

1. Provide seismic loadings to the vibration isolation supplier based on actual equipment being used to allow the proper selection of vibration isolators.

2. Provide sizing of bolts for attachment of non-vibrating equipment to the structure based on the actual equipment being used.

3. Provide design of required additional bracing for equipment when vibration isolators or bolts are not adequate to withstand seismic forces.

4. Provide design of bracing for all suspending equipment.

E. Provide design of bracing for all piping and ductwork that exceeds the limitations of the SMACNA Seismic Restraint Manual.

F. Signed and sealed calculations and details shall be submitted for record purposes.

2.04 BEARINGS

A. Grease lubricated bearings (except where driven by motors smaller than 1/2 Hp) shall be equipped with Zerk lubrication fittings and with provision for automatic relief of lubricant pressure away from fan wheel or pump seal. The latter may be accomplished by either built-in relief devices or automatic ball-and-spring relief fittings at the bottom of the bearing housing.

B. Pressure relieves shall be located outside of the units and shall be visible from maintenance locations. Lubrication fittings shall be located to be easily accessible from maintenance or operating levels. Where necessary, extension tubes shall be provided to bring the service fitting to an accessible location and the relief visible from the same location.

C. Bearings for all equipment in the schedule below shall have heavy-duty grease lubricated ball or roller bearings. Bearings shall have ample thrust provision to prevent end play during the normal life of the bearing. Unless specifically noted otherwise, all fans and pumps shall have bearings for both the equipment and motors with the following ABMA L-10 life.

1. Fans over 3000 cfm – 40,000 hours.
2. Pumps over 500 cfm – 40,000 hours.
3. Continuous duty fans or pumps with motors over 25 horse power 100,000 hours.
4. All fans or pumps with motors over 50 horse power 100,000 hours.

D. For systems with bearings requiring L-10 lives of 100,000 hours or greater, the equipment supplier shall provide calculations for both the equipment bearings and the motor bearings to confirm the bearing selections. For belt drives, the calculations shall include the effect of the sheave size, number of belts, the sheave location on the shaft, and the location of the motor to the driven sheave.

E. The equipment manufacturer shall provide confirmation of the required life based on the actual drive components. For motors 50 horsepower and greater, the bearing life calculations for both the equipment bearings and the motor bearings shall be provided.

2.05 FLAME AND SMOKE RATINGS

A. All materials, including adhesives, surface coatings, sealers, assemblies of several materials, insulation, jacketing, finish, etc, shall have flame spread ratings not over 25 (fire resistive) and smoke development ratings not over 50 and fuel contributed rating not over 50, as established by tests conducted in accordance with the Federal Standard 00136B, National Bureau of Standards Radiant Energy Fire Test and the National Fire Code of the NFPA.

B. These requirements shall apply to all circumstances whether the materials are field applied or have been applied by a manufacturer in his/her shop, or elsewhere, prior to delivery to the project for installation.

2.06 V-BELT DRIVE

A. V-belt drives shall consist of the driver and driven sheaves and one or multiple matched V-belts. Drives furnished to transmit less than 3/4 Hp may be a single groove, single belt type. Drives to transmit 3/4 Hp or more shall consist of at least two belts. Belts smaller than "A" cross-section shall not be used.

B. Each sheave shall be grooved to match the belt selection, bored and keyed to fit the receiving shaft, and grooves shall be in parallel planes exactly perpendicular to the bore for the full 360 degrees. Sheaves shall have keys and setscrews. Sheave material may be cast iron.

C. The drive shall be sized 1.5 times the motor nameplate rating and also shall have ample strength to start the driven equipment by full voltage across-the-line motor starting.

D. Where variable speed drive is specified, the drive sheave shall be of the variable pitch type which will provide a 5 percent speed variation of the driven equipment at the nominal rated speed. However, the higher speed side shall not cause the driven equipment to draw more than full nameplate rating horsepower from the driver.

2.07 NOISE CRITERIA

A. The selection of pumps, fans, air handling equipment, air conditioners, heating ventilating and air conditioning machinery and mechanical equipment and the installation of the system components such as duct work and piping shall be such as not to exceed to maximum permissible noise for non-equipment spaces as defined in Table 2, Design Guidelines for HVAC System Noise in Unoccupied Spaces contained in the 1995 edition of the ASHRAE Application Handbook. Under no conditions shall the noise created by equipment exceed the levels of permissible noise exposures of occupational areas as established by the OSHA and other Federal, State and local safety and health standards, codes and ordinances.

B. The equipment supplier shall provide actual data for the equipment submitted. If the space does not meet the required criteria, and the noise level of the equipment is found to be the cause, the equipment supplier shall be responsible for the modifications required to correct the condition.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

3.02 CLEANING AND DISINFECTION

A. All piping, ductwork and equipment shall be left in a thoroughly cleaned condition. All piping shall be thoroughly flushed to remove all foreign materials prior to any cleaning procedure. All strainer baskets shall be removed, cleaned and reinstalled at the completion of the cleaning

operation and also at the completion of all system and equipment final tests. All flushing and cleaning shall be to the satisfaction of the Engineer. Furnish, install and remove all temporary piping and equipment used in the cleaning and flushing operations. Cleaning and flushing shall be performed as specified in other Sections.

3.03 TESTS AND BALANCING

A. General - Balance and test all systems. Test the work as required by the Engineer during the progress of the work to demonstrate the strength durability and fitness of the installation. Furnish all instruments, ladders, lubricants, test equipment and personnel required for the tests; including manufacturer's representatives for testing and start-up of all supplied equipment. Balancing and testing shall be performed as specified in other Sections. Before testing and balancing, all systems shall be cleaned and disinfected as specified. Four copies of records of all tests, measurements, settings of throttling devices and nameplate data shall be presented to the Engineer.

B. Final Tests - Tests of all systems shall be carried out as required by the Engineer prior to final acceptance of the systems for the purpose of demonstrating satisfactory functional and operating efficiency as well as adjustment. During this period, the setting of all automatic controls shall be checked and sufficient measurements taken to ensure that conditions are correct and that capacities are adequate to meet the specified requirements. Provide competent personnel to conduct all tests. Systems will not be considered complete until all tests have been concluded to the satisfaction of the Engineer and all other parties having jurisdiction. In event of leakage or defects, tests must be repeated until all faults are corrected. All tests shall be performed in the presence of the Engineer. The general operating tests shall be performed under as near design conditions as possible.

C. Testing and balancing of all heating, ventilating and air conditioning air and water systems shall be performed by an AABC or NEBB certified agency, which is independent of all suppliers and installers on the particular job. All testing, adjusting and balancing shall be done under the supervision of a qualified heating, ventilating, and air conditioning Engineer employed by the air balance and testing agency. Reporting forms for testing and balancing shall be as recommended by the AABC or the NEBB.

3.04 START-UP AND TEMPORARY OPERATION

A. Properly maintain and service all equipment and systems until the particular equipment or the system has been accepted by the Owner.

B. This maintenance shall include compliance with the manufacturers operating and maintenance instructions as well as periodic checking and cleaning of the strainers and filters and the lubrication of moving parts and all required adjustments.

C. Records of all maintenance and lubrication work performed on Owner or Contractor furnished equipment shall be maintained at the construction or installation site and shall be available at all times for a review by the Owner or Engineer. At the request of the Owner or Engineer copies of these records shall be submitted to the Owner for information and/or review.

3.05 PAINTING AND COATINGS

A. Unless otherwise specified, all machinery and factory finished equipment such as pumps, fans, air handling units, air conditioning units, and other items of manufacture shall be hot dipped galvanized or will have a factory applied finish, color as standard with the manufacturer. Components fabricated from stainless steel do not require a coating finish unless otherwise specified. All tanks, supporting steel, hangers, rods and all other uncoated or non galvanized steel other than standard piping and fittings shall have a shop coat consisting of a suitable primer and finish coat. If not factory applied, the prime coat shall be as specified in Division 9. All items not factory or shop primed prior to installation shall be suitably cleaned of rust and mill scale by wire brushing, sanding, or other means and prime painted, immediately after installation.

B. The Contractor shall be responsible for the repair of all defects, blemishes, holidays and the like apparent in manufactures coatings and shall ensure that the materials used for such repair shall match and be compatible with the manufacturer's standard color, coatings and practices. Surfaces to be repaired or recoated are to be prepared as recommended by the paint or coating supplier. Care shall be taken not to paint over nameplates.

C. Furnish touch up paint for the various types of equipment furnished and deliver unopened paint to the Owner at completion of the project. The amount of touch-up paint supplied shall be sufficient to cover 15 percent of the applicable painted surfaces or one pint, whichever is greater.

D. Where specified, or called for on the following schedule, special corrosion resistant/protective coatings shall be provided. Whenever a protective coating is specified, the equipment shall be coated both inside and out. Whenever necessary to provide full coverage of the equipment, the equipment shall be completely disassembled to allow proper preparation and coating application. Any component that would block the coating process shall be removed. Equipment provided with gaskets or liners shall be coated before the application of the gasketing or liner. The equipment Vendor shall test rotating equipment after coating to confirm dynamic balance. If work needs to be done to correct the equipment balance, the integrity of the coating must be corrected after such work.

E. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self tapping screws or other fastening methods that will damage the coating are not acceptable.

F. All items to be provided with a protective coating shall have the following data on the coating included with the unit submittal. Submittal shall include vendor data sheets on the specific coating being used, corrosion resistance data sheets, detailed application data sheets to include surface preparation procedures. For baked coatings submit a letter from the coating manufacturer, that the company doing the actual coating operation is an approved coating company. When an equipment supplier provides the coating, the information shall be supplied by the coating manufacturers.

G. Coating shall be factory applied by the equipment manufacturer/supplier. If this is not possible, coating shall be applied by a specialty shop under contract to the equipment manufacturer/ supplier. After coating application is completed, the equipment manufacturer/supplier shall test the equipment and certify system operation prior to releasing the equipment to the job site.

H. Coatings shall be of the following types:

1. Manufacturer Standard Coatings

   a. Coating material shall be manufacturers standard as specified in the schedule below. Surfaces shall be prepared, primed and coated as required be the coating supplier. Heat curing shall be provided where required by the coating supplier.

2. Baked Phenolic (For Heat Transfer Coils, Dipped) Type 1

   a. Coating Material Heresite P-413C baking phenolic with a plastizer or approved equal. The surface shall be degreased and etched or phosphatizing by immersion. The coating shall be applied by immersion, with a baking following each immersion. After the final immersion, the coating shall be completely cured with a baking at 400 degrees F. The coating shall provide a final dry film thickness of approximately 2 mils.

3. Baked Phenolic (Equipment) Type 2A

   a. Coating Material Heresite baked phenolic coating. The surface shall be prepared by degreasing with an appropriate solvent. Steel surfaces for emersion shall be sand blasted in accordance with NACE No.1 or SSPC-SP5. Steel surfaces for non-emersion shall be sand blasted in accordance with NACE No. 3 or SSPC-SP6. Surface profile shall be 20 to 25 percent of dry film thickness in accordance with the supplier's recommendations. Thinner where required shall be of the same manufacturer as the coating. Coating shall be applied by spraying in multiple passes. The piece shall be baked in accordance to the manufacturer's time and temperature schedules with the final baking at 400 degrees F.

   b. Type 2A - Heresite P-403 baked phenolic coatings. Dry film thickness shall be 5 to 7 mils applied in 3 to 4 coats.

I. Any holidays, runs, sags, blisters, or inclusions in the coating are unacceptable and will be corrected. With the approval of the Engineer, small areas no more than 4-in by 4-in may be corrected in the field. Larger faults shall be returned to the coater to be repaired. The faulty material shall be removed by sanding and in the case of blisters, the edges feathered. The material used for recoating shall be manufactured by the same manufacturer as the original coating and shall be suitable for field repairs. The touch up material shall have the same corrosion resistance as the original coating, and if the original coating required an ultraviolet protection, the same protection will be provided as part of the repair. The final mil thickness of the repaired coating shall be equal to the originally specified thickness. Where baked coatings have been damaged, the repair shall be made with heat applied to the repaired surface to cure the coating. After curing a solvent test as recommended by the manufacturer shall be used to confirm that the coating is cured.

J. The coating manufacturer shall supply direct to the Engineer, a set of coupons showing the final appearance of the cured coatings. Any coating that does not match the supplied coupons will be rejected.

COATING SCHEDULE

EQUIPMENT IDENTIFICATION	LOCATION	CONTAMINANTS	COATING TYPE
MAU-5 Casing	Sludge Handling	H2S	Type 2A
MAU-5 Coil	Sludge Handling	H2S	Type 1
MAU-6 Casing	Headworks	H2S	Type 2A
MAU-6 Coil	Headworks	H2S	Type 1
Unit Heaters	All	H2S / NaCl	Manufacturer's Standard

3.06 BALANCE OF ROTATING EQUIPMENT

A. All machines shall be balanced both statically and dynamically by the manufacturer within the limits of best commercial practices. The term machine, as used above, is to be considered as any piece of equipment which contains rotating components. All machines furnished shall have operating speed not exceeding 80 percent of the first critical speed.

END OF SECTION

SECTION 15505

PIPING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all piping, valves, fittings and accessories to be used for the various systems as specified herein.

B. Furnish and install pipe hangers, supports, guides, shields, concrete inserts and anchor bolts for supporting piping.

C. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility for providing them

D. Furnish and install seismic restraints and braces for all piping and accessories.

E. All piping, and equipment shown on the drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

1.02 RELATED WORK

A. Thermal insulation is included in Section 15250.

B. This Section specifies the type and insulation thickness for the equipment and systems specified herein.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Detailed layout drawings of piping in boiler rooms and mechanical rooms and other congested areas shall be provided. Drawings shall show the locations of piping appurtenances, specialties, flow stations and circuit setters, and all valve banks for equipment control.

2. Provide typical piping details of coils, unit heaters, air handling units, heat exchangers, pumps, and other major items.

3. Submit data for the glycol solution, and the de-ionized water to be used to fill the water systems.

4. Submit in tabular form for each system the following: pipe material, joint methods, fitting types and hangers with proposed spacing.

5. Catalog cuts and data sheets for all equipment to include pipe hangers, piping specialties, traps, strainers, gauges, thermometers and vents. Submittal items will be marked with the system type in which it will be installed.

6. Complete valve schedules including the following for each type or model of valve to be furnished for the project: materials of construction, flow characteristics; options to be furnished; general installation and maintenance instructions. Valve schedules shall include type; service; size; pipe size and joint type.

7. Piping layout drawings in boiler, mechanical rooms and other congested areas, showing locations of piping appurtenances and specialties and in particular flow station and flow station/circuit setter locations.

8. Typical piping details at coils, unit heaters, air handling units, heat exchangers, pumps and other major system components.

9. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

10. All submittals shall contain a statement that Sections 15500, 15250 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

2. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

3. ASTM B32 - Standard Specification for Solder Metal.

4. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

5. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV)

6. ASTM A234 - Standard Specification for Piping Fittings of Wrought Carbon Steel Pipe.

7. ASTM A312 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipe.

8. ASTM A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings.

9. ASTM A536 - Standard Specification for Ductile Iron Pipe.

B. American National Standards Institute (ANSI)

1. ANSI B16.18 -Cast Copper Alloy Solder Joint Pressure Fittings

2. ANSI B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

3. ANSI B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings (DWV).

4. ANSI B31.1 - Power Piping.

C. American Society of Mechanical Engineers (ASME)

D. American Institute of Steel Construction (AISC)

E. Pipe Fabrication Institute (PFI)

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The piping manufacturer shall furnish an affidavit of compliance certifying that all materials used and work performed shall comply with the specified requirements. The Contractor shall provide copies of mill test confirming the type of material used in the various components.

D. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 ENGINEER SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the state issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.08 COORDINATION

A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the Drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.

C. The Contractor shall assume full responsibility for coordination of the piping systems, including; scheduling, and verification that all structures, piping and the mounting of equipment are compatible.

1.09 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Thermometers
   b. Pressure gages
   c. Valve operators
   d. Valve packing

3. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Panel light bulbs
   b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. Condenser and Chilled Water, and Hot Water/Glycol Piping

1. Pipe shall be ASTM A53, Grade A or B Schedule 40 seamless. Fittings for piping 2-1/2-in and less shall be 125 lb cast iron screwed, 150 lb malleable iron screwed or forged socket welded. Fittings for piping 3-in and greater shall be wrought carbon steel Schedule 40 butt weld.

2. Flanges shall be 150 lb forged carbon steel flat face. Flanges for piping 2-1/2-in and less shall be socket weld and for piping 3-in and greater shall be welding neck or slip on.

3. Unions for piping 2-1/2-in and less shall be 300 lb malleable iron ground joint and for piping 3-in and greater shall be flanges.

4. Nipples for piping 2-1/2-in and less shall be Schedule 40, ASTM A53, Grade A or B seamless and shall be a minimum of 4-in long. Close nipples are not permitted.

5. Gaskets shall be full face 1/16-in thick compressed non-asbestos sheet packing with synthetic fibers and fillers and elastomeric binder suitable for use with glycol solution.

6. An acceptable alternate for piping 2-1/2-in and less is ASTM B88, Type L hard copper tubing. Fittings shall be soldered wrought copper ANSI B16.22. Solder shall be 95 percent tin and 5 percent antimony per ASTM B32 Alloy 95TA.

B. Condenser and Chilled Water, and Hot Water/Glycol Piping Grooved Joint.

1. An acceptable alternate for piping is grooved pipe joints and fittings. Couplings shall be cast ductile iron or malleable iron. Gasket material to be certified for the system service by the supplier.

2. Pipe:

   a. ASTM A53 Grade A or B Schedule 40 seamless.

   b. Copper tubing sized grooved joint couplings and fittings may be used on ASTM B88 Type L hard copper tubing for sizes 2-in and above.

   c. An acceptable alternate for piping 2-1/2-in and less is ASTM B88, Type L hard copper tubing.

3. Fittings for piping 2-in and less:

   a. Elastomer O-ring seals. (Grade to suit the intended service) similar to Vic Press 304™ may be used in lieu of other fittings

4. Fittings for piping 2-1/2-in and greater:

   a. For steel piping, ductile iron conforming to ASTM A395 and A536; forged steel conforming to ASTM A234; or fabricated from carbon steel pipe conforming to ASTM A53, with factory grooved ends.

   b. For copper tubing, fittings shall have copper-tubing sized grooved ends designed to accept grooved end couplings of the same manufacturer. Couplings shall be complete with ductile iron housings, coated with copper colored alkyd enamel, and synthetic rubber gasket of a FlushSeal® pressure responsive design. Housings cast with offsetting, angle-pattern bolt pads to provide rigidity.

5. Flanges shall be 150 lb forged carbon steel flat face. Flange adapters for grooved end pipe shall be flat faced, complete with pressure responsive synthetic rubber gasket. (Grade to suit the intended service.)

6. Unions for piping 2-1/2-in and less shall be 300 lb malleable iron ground joint. Unions for piping 3-in and greater shall be flanges. Where grooved joint couplings are used, unions are not required. (Couplings shall serve as unions.)

7. Nipples for piping 2-1/2-in and less shall be Schedule 40, ASTM A53, Grade A or B seamless and shall be a minimum of 4-in long. Close nipples are not permitted.

8. Gaskets shall be full face 1/16-in thick compressed non-asbestos sheet packing with synthetic fibers and fillers and elastomeric binder suitable for use with glycol solution.

C. Condensate Drains

1. Pipe shall be copper tube ASTM B88, Type K or ASTM B306, Type DWV hard drawn. Fittings shall be soldered cast brass or wrought copper drainage fittings ANSI B16.29.

2. Solder shall be 95 percent tin and 5 percent antimony per ASTM B32, Alloy 95TA.

2.02 VALVES

A. Condenser and Chilled Water, and Hot Water/Glycol Valves

Steel Piping

Type	Size Inches	Press. Rating	Conn	Style	Stem	Body and Bonnet	Seat	Disc	Typical Valve
Gate	2-1/2-in and less	200 psig	Scr.	ISRS	CuZn	Bronze Threaded	Integral	Solid Wedge	Walworth Fig. 5
	3-in to 12-in	200 psig	Flg.	OS&Y	Bronze	CI Bolted	Bronze	Solid Wedge	Walworth Fig. 8726F
Globe	2-1/2-in and less	400 psig	Scr.	ISRS	Bronze	Bronze Union	SS	SS	Walworth Fig. 245P
	3-in to 10-in	200 psig	Flg.	RS	Brass	CI Bolted	Bronze	Bronze	Walworth Fig. 8906F
Check	2-1/2-in and less	200 psig	Scr.	Swing	--------	Bronze Screwed	Integral	Bronze	Walworth Fig. 406
	3-in to 12-in	200 psig	Flg.	Swing	--------	CI Bolted	Bronze	Bronze	Walworth Fig. 8928F
	2-1/2-in to 3-in	300 psig	Grvd.	Spring Asstd.	SS	Ductile Iron	EPDM	Alum. Bronze	Victaulic Series 716
	4-in to 14-in	300 psig	Grvd.	Spring Asstd.	SS	Ductile Iron	EPDM	Alum. Bronze	Victaulic Series 716
Butter-fly	3-in to 4-in	200 psig	Thrd Lug	Lever Oper.	SS	Ductile Iron	EPDM	316SS	Jenkins Fig. 231BG
	2-1/2-in to 12-in	300 psig	Grvd.	Lever Oper.	Integral	Ductile Iron	Ductile Iron	DI w/ EPDM	Victaulic Vic-300
	6-in to 12-in	200 psig	Thrd Lug	Gear Oper.	SS	Ductile Iron	EPDM	316SS	Jenkins Fig. 231BG
	2-1/2-in to 12-in	300 psig	Grvd.	Gear Oper.	Integral	Ductile Iron	Ductile Iron	DI w/ EPDM	Victaulic Vic-300

Ball Valve	3/4-in to 2-in	300 psig	Vic Press	Lever Oper.	Brass	Forged Brass	TFE	Brass	Victaulic Series 589
	2-1/2-in to 6-in	800 psig	Grvd.	Lever Oper.	Chrome Plated	Ductile Iron	TFE	Carbon Steel	Victaulic Series 726

If grooved pipe joints are used, valves shall be equivalent with grooved connections or a flange to groove adapter provided.

Copper Tubing

Type	Size Inches	Press. Rating	Conn	Style	Stem	Body and Bonnet	Seat	Disc	Typical* Valve
Gate	3-in and less	125 psig	Sold'd ends	ISRS	CuZn	Bronze Union	Integral	Bronze	Walworth Fig. 2SJ
Globe	3-in and less	150 psig	Sold'd ends	ISRS	Bronze	Bronze Union	Integral	Bronze	Walworth Fig. 955J
Check	3-in and less	125 psig	Sold'd ends	Swing	--------	Bronze Screwed	Integral	Bronze	Walworth Fig. 406SJ
Butter-fly	2-in to 3-in	300 psig	Grvd.	Lever Oper.	Integral	Cast Bronze	Bronze	DI w/ EPDM	Victaulic Series 608
Ball	2-in and less	150 psig	Sold'd ends	Stand. Port	Steel	Bronze Screwed	TFE	Chrome Plated	Apollo Fig. 70-200

* Figure numbers are given here to give a pictorial description of the specified valve and to indicate the quality of valves specified. Similar types of other approved manufacturer's valves are acceptable.

2.03 PIPING SPECIALTIES

A. All large piping specialties shall be provided with lugs, brackets or field supplied devices to allow the equipment to be firmly fastened to the structure. The lugs and brackets shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachment shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

B. Thermometers

1. Direct Mounting Location - Thermometer shall be installed as indicated on the Drawings and/or as specified herein.

a. Type - Industrial thermometer, straight, angle or adjustable, mercury tube type.

b. Case - 9-in die cast aluminum with metallic blue black finish or brass with suitable finish.

c. Accuracy - Plus or minus one scale division.

d. Scale - White background with jet black embossed figures and markings.

e. Range - Shall be selected so that the normal operating temperature of the material being measured will fall approximately in the middle of the scale and shall read to the reasonably expected extremes of the system fluid temperatures.

Fluid	Location	Range (degree F)
Water	All	30 to 240
Water/Glycol	All	30 to 240

f. Socket and Stem - Thermometers shall be provided with 3/4-in NPT brass separable sockets with 2-3/4-in insertion length. Extension necks for sockets and stem length for thermometers for insulated piping shall be as follows:

Insulation Thickness	Socket Extension L.	Thermometer Stem Length
0-in	0-in	3-1/2-in
2-1/2-in and less	2-1/2-in	6-in
3-in to 4-1/2-in	4-1/4-in	8-in

g. Acceptable manufacturers shall be Marshalltown Mfg. Co.; H.O. Trerice Co.; Palmer Instruments, Inc.; Moeller Instrument Co.; Weiss and Son, Inc.; U.S. Gauge, Inc. or equal.

C. Pressure, Vacuum and Compound Gauges

1. Location - Pressure gauges shall be installed at the following locations:

   a. Inlet and outlet of all pressure regulating valves (steam, water, gas, oil, air, etc).

   b. Discharge of all pumps.

   c. Suction of pumps with positive suction head.

   d. Supply and return headers to each air conditioning system.

   e. Inlet and outlet side of all strainers (unless below atmospheric; then use compound gauges).

   f. Other locations as indicated on the Drawings and/or as specified herein.

2. Vacuum gauges shall be installed at pump inlets (pumps having a continuous suction lift).

3. Combination gauges may be installed at pump inlets having varying suction heads.

4. Case - Drawn black steel or cast aluminum with black finish with black slip ring.

5. Dial - 4-1/2-in diameter with white background and black markings and pointer.

6. Movement - Bronze bushed movement.

7. Bourdon Tube - Phosphor bronze (drawn alloy for steam service).

8. Accuracy - 2-1/2 percent over middle half of scale range.

9. Recalibration - Gauges shall be arranged so that they can be recalibrated without removing from the line.

10. Range - Shall be selected so that the average operating pressure falls approximately in the middle of the scale and covers the reasonably expected operating pressures.

Fluid	Location	Range (psig)
Water	All	0 to 60
Water/Glycol	All	0 to 60

11. Socket - 1/4-in NPT male bottom or back connection, non-corrosive material.

12. Gauge cocks or small ball valves shall be provided to isolate all gauges from the system fluid.

13. Accessories - Gauges for liquids shall be provided with pressure snubbers and steam gauges with coil syphon.

14. Acceptable manufacturers shall be Marsh Instrument Co.; H.O. Trerice Co.; Ashcroft Gauge; Crosby Valve and Gage Co.; Dresser Industries, Inc.; Lonergan Company; Weiss and Son, Inc. or equal.

D. Test Stations - Pressure/Temperature

1. Install SISCO, or equal, 1/4-in or 1/2-in NPT fittings (Test Plug) of solid brass where shown on the Drawings and as specified herein. Test plugs shall be capable of receiving a 1/8-in OD pressure or temperature probe. Dual seal core shall be neoprene for temperature to 200 degrees F, Nordel to 350 degrees F and shall be rated zero leakage from vacuum to 1000 psig.

2. Furnish the following: four spare pressure gauge adapters with 1/8-in OD probe, 5-in stem pocket testing thermometers for 25 to 125 degrees F (chilled water); for 0 to 220 degrees F (hot water); for 50 to 500 degrees F (temperatures above 220 degrees F)

3. Two Master Test Kits shall be provided to the Owner. Kit shall contain one 2-1/2-in test gauge of suitable range, one gauge adapter 1/8-in OD probe and two 5-in stem pocket thermometers.

E. Condenser and Chilled Water, and Hot Water/Glycol Water

Type	Size Inches	Pressure Rating	Conn.	Service and Notes
Std. Exp. Tank	All	125 psig	Scr.	Carbon steel constructed in accordance with ASME Boiler & Pressure Vessel Code and so stamped, with two 1/2-in gauge glass tappings. Max. operating temp 375 degrees F. Finish, std red oxide paint. Tank shall be provided with gauge glass and angle shut off cocks, and connections and fittings as shown on the Drawings. Bell & Gossett ASME expansion tank or equal.
Std. Exp. Tank Fittings	Up to 100 gallon tanks	125 psig	Scr.	Bell & Gossett ATF tank fittings with manual air vent included.
	100 gallon tank and larger	125 psig	Scr.	Bell & Gossett ATFL tank fitting with separate air vent tube.
Captive Air Bladder Type Exp. Tank	All	125 psig	Scr.	Carbon steel ASME Section VIII construction with replaceable heavy duty rubber bladder, max. operating temp 240 degrees F. Tank shall be provided with charging valve, air connection, system connection and drain. TACO CA Series or equal.
Air Vents	All Sizes	150 psig	Scr.	Float type automatic air vent CI Body, SS Float, provide test cock. Armstrong No. 1-AV, automatic air vent.
Flexible Connection	All Sizes	150 psig	Flg.	Rubber flexible pipe with steel wire. Reinforcing FF Flg with retaining rings. Garlock 7250 Flexo-Matic Pipe.
	All Sizes		Grvd.	Flexible type grooved joint couplings may be used in lieu of flexible connectors. Victaulic Style 75 or 77.
Air Separator	All Sizes	125 psig	Scr./ Flg.	External combination air separation and strainer with valved blowdown full size of unit tapping. Bell & Gossett "Roll Air Trol."

Strainers	All Sizes	400 psig	Scr./ Flg.	Cast iron body "Y" type strainer. Stainless steel screen with 0.045-in. perforations.
	2-in to 12-in	300 psig	Grvd.	Ductile iron body "Y" type strainer. Stainless steel screen with 1/16-in or 1/8-in perforations.
	3-in and less copper tubing	250 psig	Scr.	Bronze body "Y" type strainer. Stainless Stainless steel basket with 0.045-in perforations.

If grooved pipe joints are used, specialties shall be equivalent with grooved connections and a grooved adaptor provided.

On all strainers provide a blowdown valve the full size of the strainer blowdown tapping, with a capped hose end connection.

Acceptable manufacturers shall be as follows or equal:

- Leslie Co.
- Mueller Steam Speciality Co.
- Sarco Co., Inc.
- Yarnall-Waring Co.
- Victaulic Co. of America

1. Flow Station/Circuit Setters

   a. For pipe sizes 3-in and smaller furnish and install where shown on the Drawings and details, calibrated flow station/balancing valves equipped with readout valves suitable for the connection of a differential pressure meter. Valves shall be designed for a minimum 125 lb working pressure at 200 degrees F. Valves shall have an indexing pointer and calibrated nameplate to measure flow rate, based on pressure differential across valve and the degree of closure of the precision machined orifice. Valves shall be selected to provide a minimum meter reading of 1-ft of water column and a maximum meter reading of 5-ft of water column in a fully open condition at the design flow rates shown on the equipment schedules. Valves shall be installed in strict accordance with manufacturer's instructions. Valves shall be Bell & Gossett, Type CBV; Sarco, Type MPP-G, Victaulic/TA Hydronics Style 787 (Threaded) or equal by Armstrong.

2. Flow Meters (For Pipe Sizes 4-in and Larger)

   a. All flow meters shall be of the averaging pitot differential pressure type. The design and construction of the flow meter shall meet ANSI B31.1 power piping code requirements. Flow sensors shall be diamond shaped and shall be made of Type 316 stainless steel. The permanent pressure loss to the system shall not exceed 5-in of water head for pipe sizes over 1-1/2-in. Each flow sensor shall be provided with 1/4-in SAE flare safety shut-off instrument valves and a permanent metal tag showing design flow rates, meter reading at design flow rate, metered fluid and line size.

b. The accuracy of the flow meter shall be plus or minus 0.1 percent of valve with plus or minus repeatability as verified by Certified Laboratory Tests.

c. Install flow meters in accordance with manufacturers' recommendations to ensure accurate reading. Meters shall be manufactured by Annubar or equal. Furnish a meter kit, complete with hoses and all required accessories and deliver to Owner.

d. If grooved pipe joints are used, venture or orifice type flow meters with grooved connections and a grooved adaptor provided in lieu of pitot type flow meters. Meters shall be Victaulic Style 733 (Venturi) or Style 734 (Orifice).

3. Triple Duty Valve

a. A triple duty valve may be used in place of the gate, balancing and check valve in a pump discharge. Triple duty valves shall have cast iron body and plug, bronze gland, stainless steel sleeve and brass clapper and seat. Valves for piping 3-in and below are to be threaded and valves 4-in and above are to be flanged.

b. The valve shall be suitable for horizontal or vertical installation and shall provide a bubble tight shut off. A memory stop is to be provided to allow returning to the original balance point after shutoff.

c. Triple duty valves shall be Taco, "Plus One" Multi-purpose Valve or equal.

b. A grooved end triple duty valve assembly may be used in place of triple duty valve in a pump discharge. Triple duty valve assemblies shall be assembled of Vic® 300 butterfly valve with memory stop feature assembled with Series 716 Vic-Check® or Series 779 Venturi-Check. Couplings used for assembly shall be of the same manufacturer as the grooved valves.

4. Pump Suction Diffuser

a. Where space conditions do not allow sufficient room for ten pipe diameters of straight run before a pump suction, or where shown on the Drawings, a suction diffuser shall be provided. In addition to straightening the flow of the fluid into the pump, the suction diffuser shall provide a strainer at the pump suction. Pump suction diffusers shall have ductile iron or cast iron body and straightening device, stainless steel start-up strainer and stainless steel permanent strainer.

b. Pump Suction Diffusers shall have integral flow straightening device, removable strainer, blowdown connection and adjustable support foot. Connections for all unit sizes shall be flanged. A tapping is to be provided in the flange of the unit for installation of a pressure gauge up-stream of the suction diffuser. A magnetic insert is to be provided to collect ferrous materials.

c. Provide a capped blowdown valve at the blowdown connection full size of the unit tapping.

d. Pump suction diffusers shall be Taco, "SD" Series Suction Diffuser; Victaulic Series 731-G or equal.

F. Automatic Glycol Make Up System

1. Furnish and install for all heating and cooling systems using glycol heat transfer media, an automatic glycol feed system. The system will automatically maintain pressure by adding glycol solution to make-up losses in the system.

2. Control will be by an adjustable pressure control switch. The pressure range shall be selected based on the pressures expected in the system.

3. Unit shall operate on 115 volt power.

4. The unit shall include the following:

   a. Hand-Off-Auto selector switch
   b. 1.5 gpm bronze gear pump
   c. Float switch for pump shutoff and activate light and audible alarm
   d. Support base
   e. Dry contact for remote alarm

5. The discharge shall include the following:

   a. Shutoff ball valve
   b. Check valve
   c. Relief valve
   d. Pressure valve
   e. Pressure switch

6. The suction shall include the following:

   a. Shutoff ball valve
   b. Strainer

7. Unit shall be model G-50-1A-RC as manufactured by Neptune Chemical Pump Co. Inc. of Lansdale PA or equal.

G. Anti-Freeze Solution

1. Furnish and install anti-freeze solutions to systems as indicated on the Drawings. The entire system shall be filled with an anti-freeze solution of de-ionized water and propylene glycol to produce a freezing point of 0 degrees F or lower. The propylene glycol solution shall contain corrosion inhibitors suitable to minimize corrosion of the piping system and heat exchangers and a dye to indicate the presence of the propylene glycol. Where the specified systems include connections to underground piping or piping shown on other drawings, that piping shall be filled with anti-freeze solution by this Contractor.

2. Following acceptance by the Owner of each glycol/water system, furnish, deliver and make ready for use at each glycol system injection point, one unopened drum (30 gallons capacity, minimum) of 50 percent concentration anti-freeze, for use by the Owner. Replacement anti-freeze shall be provided by the Contractor as needed due to system leaks and repairs which occur during the warranty period.

3. A non-oxidizing micro-biocide shall be added with the chemical treatment to provide control of microbial growth and associated deposits in closed water systems.

2.04 HANGERS AND SUPPORTS

A. All of the equipment specified herein is intended to support the various types of pipe and piping systems. The details shown on the Drawings are intended to indicate the generally desired methods of support under normal conditions. Develop final details and any details associated with special conditions not already covered to meet the system conditions specified in the respective Division 15 Pipe Sections. All hangers shall be of a type to permit vertical adjustment after installation.

B. All pipe and tubing shall be supported as required to prevent significant stresses in the pipe or tubing material, valves, fittings and other pipe appurtenances and to support and secure the pipe in the intended position and alignment. Piping support systems shall include restraints as required by the applicable building codes to withstand seismic loading. Design shall be provided by a professional engineer hired by the Contractor as specified in other Sections. All supports shall be designed to adequately secure the pipe against excessive dislocation due to thermal expansion and contraction, internal flow forces and all probable external forces such as equipment, pipe and personnel contact. Any structural steel members required to brace any piping from excessive dislocation shall conform to the applicable requirements of Section 05500 and shall be furnished and installed under this Section.

C. The Contractor is responsible for determining expansion and contraction requirements. This data is to be used for design expansion compensation.

D. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit certification stating that such requirements have been complied with.

E. All hangers, supports and appurtenances shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under all operating conditions. The minimum working factor of safety for all supporting equipment, with the exception of springs, shall be five times the ultimate tensile strength of the material.

F. No work shall be installed using hangers or supports of other trades except where specifically shown on the Drawings as being furnished for HVAC work. Hanger and supports shall be designed and installed so that no load will be transmitted to equipment connections.

G. Provide all supplementary steel required to properly transmit the load to the building structural frame or floor and to meet the maximum spacing requirements. Supplementary (support) steel shall be in accordance with the AISC standards for Design, Fabrication and Erection of Structural Steel for Buildings.

H. Where piping is supported from the structure of a pre-engineered building the Contractor will coordinate the location of pipe hangers with the building supplier. Piping is to be supported only from members and locations as agreed to by the building supplier.

I. Hangers shall not be supported from roof decking or bulb tees. Where required provide supplemental steel to span between building structures.

J. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for pipe supports shall be furnished with the materials scheduled below. In locations or systems not scheduled all rods, clamps, hangers, inserts, anchor bolts, brackets and components for pipe supports shall be furnished with galvanized finish, hot dipped or electro-galvanized coated, except where field welding is required, where cold-applied galvanizing may be used. Interior clamps on plastic pipe shall be plastic coated. Supports for copper pipe shall be copper plated or shall have a 1/16-in plastic coating.

Room #	Area	System	Material
A-500	Headworks	Hot Water/Glycol Chilled Water	Type 316 Stainless Steel
A-502	Sludge Truck Bay	Hot Water/Glycol Chilled Water	Type 316 Stainless Steel
A-503	Sludge Handling	Hot Water/Glycol Chilled Water	Type 316 Stainless Steel
	Outdoors	Hot Water/Glycol	Type 316 Stainless Steel
	Outdoors	Chilled Water	Type 316 Stainless Steel

K. Where hangers must be supported from concrete slabs, the required number and size of inserts shall be installed at their proper location prior to pouring of such slabs and continuous inserts shall be installed in the general pattern as shown on the structural slab drawings. Where continuous inserts are provided, threaded rod and nut compatible with the inserts shall be provided.

L. Expansion shields, where required, shall be two unit self-drilling shell type. Expansion shields shall be installed so that the major loading is in shear. They shall not be used when the major load is in tension.

M. Drilling of building structural steel for attachment of hangers or supports is not permitted under any circumstances. Welding to building structural steel is permitted only where specified or specifically indicated on the Drawings. When special conditions arise, shop drawings and/or other descriptive information detailing proposed methods of welding hangers, supports, or anchors shall be submitted for written approval by the Engineer prior to welding.

N. Unless shown otherwise, supports shall originate at or transmit the load to the truss or joist panel points when hung from such members. Furnish supplementary supports where indicated on the Drawings to spread the load between joists and panel points.

O. Hangers shall not be secured to roof decking or to bulb tees.

P. Floor stands may be used on pipes running close to the floor. They shall be placed under elbows of vertical risers, at changes of direction and as otherwise required by the table of allowable pipe spans. Where floor stands are used on pipes covered with anti-sweat insulation or on hot lines, they shall be the saddle type. Otherwise, they may be an adjustable welded pipe stanchion, or cast integral with the fitting.

Q. All pipe hangers shall conform to ANSI B31.1. Where two or more lines run parallel and adjacent to each other they may be supported by trapeze hangers. All hangers shall be of the type to permit vertical adjustment after installation of piping.

R. Where flexible couplings are required at equipment, tanks, etc, the end opposite to the piece of equipment, tank, etc, shall be rigidly supported, to prevent transfer of system forces to the equipment. No fixed or restraining supports shall be installed between a flexible coupling and the piece of equipment.

S. Pipe runs in areas with steel construction shall be supported from the beams or joist with approved beam clamps unless otherwise shown on Drawings.

T. All vertical pipes shall be supported at each floor or at intervals of not more than 12-ft by pipe collars, clamps, brackets, or wall rests and at all points necessary to insure rigid construction. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

U. Anchors and guides shall be installed in accordance with the details as shown on the Drawings or as otherwise required by good piping practice.

V. All hangers and supports for copper tubing shall be copper plated and sized for tubing.

W. A metal insulation shield shall be provided at support point of insulated lines except where a pipe saddle is required. Shields shall be secured with 1/2-in wide metal bands set 2-in from either end of the shield and one in the middle of the shield. Pipe shields and metal bands shall be galvanized steel unless otherwise specified.

Nom. Pipe Size Inches	Shield Length Inches	U.S. Std. Gage
1/2 to 3	12	18
4	12	16
6	18	16
8 to 14	24	14
16 to 24	24	12

Nom. Tube Size Inches	Shield Length Inches	U.S. Std. Gage
1/4 to 3-1/2	12	18
4	12	16
5 to 6	18	16
8	24	14

1. Omit the specified shield insulation at pipe supports and substitute ridged insulation such as cellular glass, calcium silicate or expanded silica. The length of the ridged insulation shall equal the pipe shield.

2. Lengths indicated are for strap hangers; where roller hangers are used increase length to keep rolling point of contact within the middle 1/3 of the shield length.

X. Insulation protection saddles shall be provided on all hot lines which are supported by pipe roll or trapeze type hangers. Saddles shall be welded to the pipe and sized for the specified insulation thickness.

Y. Pipes Supported from Below - Where piping is located in areas where it can not be supported by hangers or where there is no structure above to hang from, provide support members from below. Support spacing and loadings shall be as previously described for pipe hangers. Pipe support structures shall be fabricated from structural steel square tube sections. Attachments to concrete structures shall be by inserts for concrete work where possible and by means of cinch anchors for existing concrete work. Attachments to structural steel shall be by means of locking clamps and fixtures. "C" or "G" type clamps without retaining strips are not acceptable. Where there is no available concrete or structural steel to attach to, the support member shall be provided with an adequate concrete foundation. Pipes supported by vertical members shall be supported by a bracket with saddles and clamps. Pipes supported by horizontal members shall be supported by the member if it is below the pipe or by hangers as previously specified if it is above the pipe. Framing members shall be steel square tube sections. Supports shall be designed and detailed for each condition with Drawings submitted for review.

Z. Attachments to Structure

1. Concrete inserts shall be malleable iron, cast iron, or steel of type required by load.

2. Clamps for fastening of hangers and supports to structural steel shall be as follows:

   a. Clamp shall be selected for the hanger load imposed.

   b. "C" clamps shall be used for 1-1/2-in and smaller pipe only. The use of "C" clamps for larger piping or other uses is not allowed. "C" clamps shall be malleable iron body with hardened steel cup point set screw, lock nut and retaining clip similar to Figure 87 of ITT Grinnell.

   c. Beam clamps shall be used on all members with double flanges. Clamp shall be positive locking type such that the load on the clamp will increase the grip on the beam. The load shall be suspended at the center of the flanges and shall not induce a moment load on the structural member. Clamps shall be similar to Figures 218, 228, 229, 292 of ITT Grinnell.

   d. Channel and angle clamps shall be positive locking type. The load shall be suspended below the vertical flange of the support member. Clamps shall be similar to Figure 235 of Carpenter Patterson.

   e. All clamps shall be galvanized.

3. Pipe Support Spacing

   a. Unless otherwise shown on the Drawings, provide support for all horizontal piping in accordance with the following maximum spans for straight pipe without fittings or accessories:

PIPE SUPPORT SPACING

Maximum Span (Feet)

Nominal Pipe Size (Inches)	Water Service	Steam, Gas or Air Service
1	7	9
1-1/2	9	12
2	10	13
2-1/2	11	14
3	12	15
3-1/2	13	16
4	14	17
5	16	19
6	17	21
8	19	24
10	22	28
12	23	30
14	25	32
16	27	35
18	28	37
20	30	39
24	32	42

Standard reference: ANSI B31.1

b. Copper Tubing (Water filled)

Tube Size	Maximum Span
1-1/2-in and smaller	6-ft
2-in and larger	10-ft

c. Plastic pipe shall have continuous horizontal support with an 18 gauge V-shaped sheet metal trough supported at intervals of 10-ft or less or as recommended by the specific manufacturer.

AA. Unless otherwise specified herein, pipe hangers and supports shall be standard catalogued components, conforming to the requirements of MSS-SP-58 and -69; and shall be as manufactured by Grinnell Co., Inc., Providence, RI; Carpenter & Patterson, Inc., Woburn, MA; F&S Central, Brooklyn NY; Elcen Metal Products Co., Franklin Park, IL and Unistrut Northeast, Cambridge, MA or equal. Any reference to a specific figure number of a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary.

AB. Any required pipe supports for which the supports specified in this Section are not applicable shall be fabricated or constructed from standard structural steel shapes, concrete and anchor hardware similar to items previously specified herein and shall be subject to the approval of the Engineer.

AC. Individual Pipe Hangers

1. General - Individual hangers shall be sized on the pipe O.D. for uninsulated pipe and on the O.D. of the covering for the insulated cold piping and insulated hot piping with insulation protection saddles. All insulated pipes must have saddle or protection shields to prevent deterioration due to movement of pipe and hanger.

   a. All individual hangers shall be of the types indicated as follows, unless otherwise designated on the Drawings.

SERVICES	PIPE SIZE	TYPE
Water	6-in and smaller	Clevis
Water (except domestic and process)	8-in and larger	Pipe Roll
Drain lines	All	Clevis
All other piping	All	Clevis

2. Clevis Pipe Hangers - Shall be adjustable carbon steel clevis.

3. Swivel Pipe Hangers - Shall be steel yokes with cast iron pipe roll.

4. Pipe Roll Pipe Supports - Shall be cast iron rolls of the type required for the specific installation.

5. Unless otherwise specified herein, pipe hangers and supports shall be as manufactured by Grinnell Co., Inc., Providence, RI; Carpenter & Patterson, Inc., Woburn, MA; F & S Central, Brooklyn NY; Elcen Metal Products Co., Franklin Park, IL and Unistrut Northeast, Cambridge, MA or equal. Any references to a specific figure number of a specific manufacturer, is for the purpose of establishing a type and quality of product and shall not be considered as proprietary. Any item comparable in type, style, quality, design and performance shall be considered as equal.

AD. Suspended multiple pipes, running parallel in the same horizontal plane, which are adjacent to each other shall be suspended by trapeze type hangers or wall brackets. Trapeze hangers shall consist of galvanized structural steel channel supported from galvanized threaded rod or attached to concrete walls, columns or structural steel support members as required to meet the intent of this Section. Channel shall be similar to F&S, Figure 710, rods, concrete inserts, "C" clamps, beam clamps, welded beam attachments and expansion shields shall be as specified above.

AE. Except as otherwise specified herein pipe anchors used for attaching pipe to trapeze or multiple pipe wall brackets shall be anchor or pipe chairs similar to F&S, Figures 158, 419, 160A, 160B as required. Material of construction shall be galvanized steel. Chair "U" bolts shall be tightened

to allow freedom of movement for normal expansion and contraction except where pipe must be anchored to control direction of movement or act as a thrust anchor.

AF. Hanger rods shall be hot rolled steel, machine threaded and galvanized after fabrication. The strength of the rod shall be based on its root diameter.

AG. Where pipes are near walls, beams, columns, etc, and located an excessive distance from ceilings or underside of beams, welded steel wall brackets similar to Carpenter and Patterson Figure No. 69-68, 84 or 139 shall be used for hanging pipe. Brackets shall be galvanized. Where single pipes rest on top of bracket pipe supports, attachments shall meet requirements as specified under multiple pipe hangers.

AH. Where grooved joint piping is used, couplings shall be rigid type, with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with ANSI B31.1, ANSI B31.9 and NFPA 13.

2.05 THERMAL EXPANSION OF PIPING

A. In general thermal expansion of piping shall be compensated for by the use of flexible hose, and flexible expansion joints. Flexible hose is to be used for lateral deflection and flexible expansion joints are to be used for axial displacement.

B. Flexible piping shall be flexible annular corrugated stainless steel hose. The hose shall be provided with an external stainless steel braid to minimize elongation under pressure. Hose 2-1/2-in and smaller shall be threaded and hoses 3-in and larger shall be flanged. The manufacturer shall confirm the suitability of the flexible piping for the temperature and pressure of the systems.

C. Flexible expansion joints shall be spherical EPDM. Connections shall have multiple plies of corded fabric reinforcing. Connections shall be rated for 150 psi at 220 degrees F. For equipment with connections from 2-1/2 to 12-in, 90 degree bend connections can be used. Straight connections shall be double sphere. The manufacturer shall confirm the suitability of the connections for the temperature, pressure, and pipe contents for the systems. Provide pipe guides on each side of expansion joints to prevent misalignment and squirm.

D. If grooved pipe joints are used, expansion joints shall be equivalent with grooved connection and a grooved adaptor provided. Victaulic Mover Style 150 or equal.

2.06 PIPE SLEEVES AND SEALING MATERIALS

A. Unless otherwise shown, all pipe sleeves shall be Schedule 40 galvanized steel pipe conforming to ASTM A53. Where indicated, provide a 2-in minimum circumferential water stop welded to exterior of sleeve at its midpoint. Ends of sleeves shall be cut, ground smooth and shall be flush with the wall or ceiling and extend 2-in above the finished floors. Sleeves to be sealed by caulking shall be sized as required. Sleeves to be sealed with mechanical seals shall be sized in accordance with the seal manufacturer's recommendations. Sleeves for insulated piping shall be sized as required.

B. Sealant shall be a two part foamed silicone elastomer as manufactured by Dow Corning Co., Product No. 3-6548 silicone R.T.V.; 3M brand fire barrier products caulk C.P. 25 and 3M brand putty 303 or Flame-Safe fire stop systems Figure No. FS-500 Thomas & Betts Corp. Packing shall be a fire retardant pliable material, Figure No. 310 by Sealtite Co.; White Oakum WS-600

by American Manufacturing Co. or equal. Sealant bead configuration, depth and width shall be in accordance with manufacturer's recommendations.

C. Bonding compound shall be Sikadur Hi-Mod epoxy by Sika Corp., similar by Euclid Chemical Corp.; Master Builders Co. or equal.

D. Non-shrink grout shall be Masterflow 713 by Master Builders Co.; Euco N-S by Euclid Chemical Co.; Five Star Grout by U.S. Grout Corp. or equal.

E. Furnish escutcheon plates at both sides of wall penetration and at ceiling penetrations. Escutcheons shall be 16 gauge galvanized steel in dry areas, 16 gauge, Type 316 stainless steel in wet and corrosive areas and chrome plated in finished areas. When a pipe has metal insulation jacket the escutcheon will be the same material as the metal jacket.

2.07 VALVE IDENTIFICATION

A. Valve tags will be provided by the General Contractor, for installation by this Contractor as specified in Section 01170.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING

A. Proceed with the installation of piping and supports only after any building structural work has been completed and new concrete has reached its 28-day compressive strength.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Finished metal surfaces subject to corrosion that are not galvanized or protected in some other way, shall be grease coated to prevent rust.

D. Pipe and Fittings

1. Install piping in a neat manner with lines straight and parallel or at right angles to walls or column lines and with risers plumb. Run piping so as to avoid passing through ductwork or directly under electric light outlets and/or interference with other lines or extending beyond furring lines as determined by architectural drawings. All work shall be accomplished using the best methods and procedures of recognized pipe fabrication in a good and workmanlike manner in accordance with the latest revision of applicable ANSI Standards, ASME Codes and PFI Standards.

2. Pipe lengths and dimensions and drillings of flanges shall be coordinated with the lengths and flanges for the valves, pumps, flow switches, and other items to be installed in the piping. All mating flanges shall have the same diameter, facing, and drilling and shall be suitable for the pressure to which they are subjected

3. The installed systems shall not interfere with maintenance and operational access to any equipment installed under this Section, or any other related Sections.

4. Use full length of pipe except where cut lengths are necessary. Do not spring or deform piping to make up joints.

5. Pipe shall be cut square, not upset, undersize or out of round. Ends shall be carefully reamed and cleaned before being installed.

6. Bending of pipe is not permitted. Use fittings for all changes in direction.

7. Do not use bushings except where specifically approved by the Owner's Representative. Reducers shall be eccentric to provide for drainage from all liquid-bearing lines and facilitate air removal from water lines.

8. Verify the locations and elevations of any existing piping and manholes before proceeding with work on any system. Any discrepancies between the information shown on the Drawings and the actual conditions found in the field shall be reported at once to the Owner's Representative. No claim for extra payment will be considered if the above provision has not been complied with.

9. Erect piping with proper provision for expansion and contraction. Cold sprung pipe shall be erected with metal filler pieces bolted between flanges or tack welded between weld joints. After the pipe, anchors, hangers and supports have been erected spacers shall be removed and the joint made.

10. Where lines of lower service rating tie into services or equipment of higher service rating the block valve between the two shall conform to the higher rating.

11. Welded lines shall have long radius elbows except at expansion loops where elbow radius shall be equal to six times the pipe diameter (R=6D). Welding tees shall be used wherever the branch line diameter is equal to or one size smaller than the main line diameter, otherwise the branches shall be fabricated using "Weldolet" or "Sockolet" fittings as manufactured by Bonney Forge Inc. or equal. Reinforced welded tees will be used only where shown on the Drawings. Tapped connections in welded lines shall be provided by means of "Thredolet" or "Latrolet" fittings welded to the piping, as manufactured by Bonney Forge Inc. or equal.

12. Mitering of pipe to form elbow is not permitted.

13. All flange faces or weld faces shall be in perfect alignment.

14. Where flanges are to be connected directly to welded fittings, only welding neck flanges will be allowed.

15. End caps on pre-cleaned pipe shall not be removed until immediately before assembly. All open ends shall be capped immediately after completion of installation.

16. All piping interiors shall be thoroughly cleaned after installation and kept clean by approved temporary closures on all openings until the system is put in service. Closures should be suitable to withstand the hydrostatic test.

17. Steam piping shall pitch down in the direction of flow at a rate of not less than 1/4-in per 10-ft wherever possible.

18. Dielectric pipe fittings shall be installed at changes in pipe material. Fittings shall provide electrical continuity on the pipe.

E. Valves

1. Locate valves so as to be readily accessible for operation. All valves, except isolating, larger than 3-in and located 7-ft-0-in from floors and platforms shall be provided with chainwheels. Chains shall extend to 5-ft-0-in above floors and platforms. Chains shall be draped so that they may be clipped or tied (i.e. with an S-hook) from aisles and walkways.

2. Install stems of valves up wherever possible. Where this is not possible, point stems in a horizontal position.

F. Test Connections

1. Provide 1/2-in female NPT test connection equipped with 1/2-in brass plug on all pump suction and discharge lines. Where indicated on the Drawings, test connections should be equipped with bar stock valve and gauge. Provide test connections at all steam traps. The connection shall be located on the discharge side of the trap between the trap and the first valve. It shall consist of a 1/2-in branch connection terminated with a gate valve.

G. Unions - Unions screwed, grooved joint couplings or flanged shall be provided where indicated and in the following locations even if not indicated.

1. In long runs of piping to permit convenient disassembly for alterations or repairs.

2. In by-passes around equipment.

3. In connections to tanks, pumps and other equipment between the shut-off valve and the equipment.

4. In connections on both sides of traps, controls and automatic control valves.

5. If grooved joints couplings are used, unions are not required. (Couplings shall serve as unions.)

H. Vents and Drains - Provide vents and drains in the following places:

1. Water Lines - Vents at high points and drains at low points.

2. Air Lines - Drains at low points.

3.02 JOINING OF PIPE

A. Welding

1. Welding of joints shall be by metal-arc welding process. Welding shall be by qualified welders meeting the requirements outlined in Section IX of the ASME Boiler and Pressure Vessel Code and certified by the Hartford Steam Boiler Inspection Company.

2. Welding shall not be done when the atmospheric temperature is less than 32 degrees F or when surfaces to be welded are wet.

3. Surface to be welded shall be free from loose scale, slag, rust, paint, oil and other foreign material. Joint surfaces shall be smooth, uniform and free from fins, tears and other defects, which might affect proper welding.

4. Bevels shall be accurately cut by machining or by a mechanically guided cutting torch.

5. Piping shall be carefully aligned before welding and maintained in alignment during welding. Tack welds may be used to maintain alignment. They shall be the same quality as the final welds and shall be fused thoroughly therein. Defective tack welds shall be removed before the final weld is made.

6. The surface of the finished welds shall have a bright metallic luster after cleaning, a fairly smooth and uniform contour with regular ripples and be free from overlaps, undercuts and excessive convexity.

7. Welds shall be sound throughout, fused thoroughly and free from gas pockets, oxide, slag inclusions and surface porosity. The inside of the pipe shall be free from globules of weld metal, spacers or other material which would restrict the pipe area or become loose to enter the fluid stream.

8. Defective or unsound welds shall be corrected by removing and replacing the welds. Pipe or fittings, which cannot be rewelded satisfactorily, shall be replaced with new pipe or fittings at the Contractor's expense.

9. All welded joints will be visually inspected by the Owner's Representative for defects beyond those acceptable in ANSI B31.1. Method of repair shall be in accordance with instructions as received from the Owner's Representative.

B. Flanged Connections

1. All flange faces shall be in perfect alignment with the holes straddling the vertical center line of the piping.

2. All bolts shall be well lubricated over the entire thread length with a heavy graphite and oil mixture prior to the tightening operation. Bolts shall be tightened with proper wrenches, care being taken to secure uniform pressure on the bolts and gasket and to avoid overstressing of the bolts, dishing of the flanges and compression of the gasket beyond its proper limits.

   a. Commercial grade carbon steel bolts, ASTM A307, Grade B shall be tightened to obtain approximately 15,000 psi stress based on the root area of the thread. Alloy steel bolts, ASTM A193, Grade B7 shall be tightened to obtain a stress of 45,000 psi.

3. All bolts shall be of sufficient length so that when fully tightened, a minimum of two full threads shall extend beyond the nut.

C. Screwed Connections

1. All screwed connections shall have full thread of true taper, accurate to gauge and conform to ANSI.

2. Reduction in size shall be made using reducing fittings.

3. The use of bushings or close nipples is prohibited. Nipples shorter than 4-in in length shall be Schedule 80.

4. Plugs shall be steel or brass with square head.

5. Screwed joints shall be made with an approved joint compound applied to the male thread only. Caulking of screwed joints will not be allowed.

D. Soldering (Copper Tubing)

1. Tubing shall be cut with square ends and reamed to prevent burrs, out-of-round or improperly sized ends.

2. After cutting, all surfaces to be soldered shall be thoroughly cleaned to a metal-bright finish, free from dirt, grease or other material before fluxing and soldering. This cleaning shall be performed by using emery cloth, sandpaper or steel wool. Clean the outside end of the tubing for a length of 1/2-in greater than the depth of the fitting. The inside of the fittings shall be cleaned in a similar manner. Apply non-corrosive flux and assemble the joint. Acid solder or acid flux will not be allowed.

3. The surfaces to be joined shall be heated up slowly and uniformly to the melting point of the solder. The surface being soldered shall be maintained above the melting point of the solder for sufficient time to draw the solder completely into the joint. When the solder congeals to a plastic state the excess metal shall be removed with a cloth brush, leaving a fillet around the end of the fitting. Full penetration of the solder uniformly throughout the entire socket is required. The soldered joints shall be allowed to cool in still air until only warm to the hand after which the work may be quenched.

4. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Peening for closing up defects shall not be permitted.

5. Heating torches of sufficient size shall be used for heating of large fittings prior to soldering. Multiple tips or ring burners for use on combination torches may be used.

6. Remove all external and internal loose solder and flux after joint cools.

E. Grooved Joints

1. Grooved piping joints are to be made in strict accordance with the joint manufacturer's recommendations. The depth, width and distance from the end of the pipe are to all be within the joint manufacturers tolerances.

2. Grooves are to be cut in steel piping systems. Piping shall be cut to length and squared before grooving.

3. Lubricant for the gaskets shall be supplied by the joint manufacturer. Gaskets are to be checked to be sure that they are the proper gasket for the piping system. Lubricant shall be applied to the gasket prior to installing the gasket on the pipe.

4. The gaping between the ends of the pipe being joined is to be set based on the piping systems needs to expand and contract. In general pipe expansion and contraction in grooved piping systems is to be taken up by the proper gaping of the individual joints.

5. The housing is to be assembled around the piping being sure that the housing does not pinch the gasket and that it also drops into the grooves on the two sections of piping. Bolts are to be tightened by hand uniformly. Only metal to metal contact is required between the segments of the housing. Do not over tighten the bolts.

6. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

7. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components

F. Pressed Grooved Joints

1. Pipe shall be certified for use with pressed groove piping systems.

2. Pipe shall be square cut, plus/minus 0.030-in, properly deburred and cleaned.

3. Pipe ends shall be marked at the required location to ensure full insertion into the coupling or fitting during assembly.

4. Use a tool provided by the coupling manufacturer with the proper sized jaw for pressing.

3.03 CLEANING

A. General

1. When part of the piping system to be cleaned is buried piping or shown on the other Drawings, it shall be treated as part of the system and will be cleaned by this Contractor using the same procedures as the other parts of the system.

B. Condenser and Chilled Water, and Hot Water/Glycol and Other Closed Water Systems

1. Flush pipe, valves and fittings of closed water systems until water runs clear to remove foreign materials prior to cleaning.

2. Provide temporary valved inlet and necessary tanks and pumps to inject cleaning solution. Remove strainer baskets prior to cleaning. Provide temporary pipe, valves and fittings required to by-pass coils and tubes of heat exchangers. Coils and heat exchanger tubes are not to be flushed and cleaned in the field.

3. Clean by circulating a hot high alkaline type oakite solution of 1 lb of oakite per 50 gallons of water for a minimum of 6 hours. Then flush the system until the drain water runs clear.

4. Remove temporary pipe, valves and fittings except for valved inlet used for injecting cleaning solution, which will remain for future use. Strainer screens shall be removed, cleaned and reinstalled after flushing is completed.

3.04 TESTS AND BALANCING

A. Pipe Testing Procedure

1. The equipment to which any piping system is attached shall not be subject to any line tests. Items which may be damaged by the test pressure shall be either removed or blanked off. The test pressures apply to the piping materials as specified, but shall not be assumed to apply to piping specialties, accessories, or equipment including safety heads, rupture discs, relief valves, expansion joints, instruments or filters.

2. Prior to pressure testing, the following precautions shall be taken:

   a. Insulation shall not be applied over piping prior to completion of testing. Welds or other type joints shall not be painted prior to completion of testing. This may require testing in certain specific areas ahead and separate from other areas to allow other trades to complete their work.

   b. Lines containing check valves shall have the source of test pressure located on the upstream side. Control valves shall be set in the open position for the duration of the test.

   c. Any piping supported by springs shall be blocked up temporarily to a degree sufficient to sustain the test liquid load.

3. Lines requiring hydrostatic testing shall be provided with test connections at high points in the line. System shall be filled with water through a low connection point, care being taken that air is completely vented from the top at the test connection so that there are no air pockets remaining.

4. Hydrostatic test pressure readings may be taken at the lowest point of the line or system of lines providing static head is added to the minimum hydrostatic test pressure. Care should be taken to ensure that at no point a dangerous overpressure is experienced.

5. The hydrostatic test shall be considered satisfactory if no leakage is discovered on the piping or at any joints. The test pressure shall be maintained for the minimum time specified plus any additional time required for a thorough examination of all joints. Lines requiring repairing shall be retested to the pressure originally specified.

6. After completion of a hydrostatic test, the system shall be completely drained and purged with air to remove all water and to prevent damage due to freezing. Special attention shall be paid to such items as instrument connections, valves, orifice plates and pockets where water may be trapped.

7. Air pressure at 2 times operating pressure (not less than 50 psi) with soap solution on each joint shall be used for piping intended for gaseous fluids and fuel oil lines.

8. The piping system shall be tested at the pressure indicated in the individual pipe material specification's section or 1-1/2 times normal working pressure whichever is greater for the respective systems. Leakage or loss of head will not be acceptable.

9. When necessary to expedite hydrostatic tests, due to possibility of freezing of water in piping or due to extremely large volume of water to be used, air may be used as testing medium with the approval of the Engineer.

B. Condenser and Chilled Water, and Hot Water/Glycol Piping Testing

Test Press.	Medium	Duration	Allowable Loss
100 psig	Water	2 hours*	None

* Or longer as required for a complete system inspection.

C. Condensate Drains Testing

Test Press.	Medium	Duration	Allowable Loss
10-ft column	Water	2 hours	None
10-in mercury	Air	15 min.	None

3.05 INSTALLATION OF HANGERS AND SUPPORTS.

A. All pipes, horizontal and vertical, requiring rigid support shall be supported from the building structure by approved methods. Supports shall be provided at changes in direction and elsewhere as shown on the Drawings or as specified herein. No piping shall be supported from metal stairs, ladders and walkways unless specifically directed or authorized by the Engineer.

B. All pipe supports shall be designed with liberal strength and stiffness to support the respective pipes under the maximum combination of peak loading conditions to include pipe weight, liquid weight, liquid movement and pressure forces, thermal expansion and contraction, vibrations and all probable externally applied forces. Prior to installation, all pipe supports shall be approved by the Engineer.

C. In certain locations, pipe supports, anchors, guides, and expansion joints may be indicated on the drawings. The Contractor shall be responsible to provide a complete system of supports, expansion joints, and anchors. Additional supports may be required adjacent to expansion joints, couplings, and valves.

D. Inserts for pipe hangers and supports shall be installed on forms before concrete is placed. Before setting these items, all Drawings and figures shall be checked which have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports is included under this Section.

E. The installation of pipe support systems shall in no way interfere with the operation of the overhead bridge cranes, monorails, access hatches, etc.

3.06 INSULATION

A. Insulation for Hot Piping (Type I-1). Insulation thickness shall be as follows:

Service	Pipe Size	Insulation Thickness
Hot Water/Glycol	2-in and less	1-1/2-in
	2-1/2-in and greater	2-1/2-in

B. Insulation for Cold Piping with vapor barrier (Type I-3). Insulation thickness shall be as follows:

Service	Pipe Size	Insulation Thickness
Potable Cold Make-up	All Sizes	1-1/2-in
Condenser and Chilled Water	2-in and less	1-1/2-in
	2 1/2 in and greater	2 in
Condensate Drains	All Sizes	1-in

C. Insulation for Cold Tanks (Type I-8). Insulation thickness shall be as follows:

Chilled Water Expansion Tank	2-in

D. Insulation for Cold Piping Closed Cell Foam (Type I-12)

Service	Pipe Size	Insulation Thickness
Condensate Drains	All Sizes	1-in

END OF SECTION

SECTION 15509

CHEMICAL TREATMENT
(GLYCOL)

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all sensors, controllers, equipment, piping and fittings and provide chemical treatment for all individual systems of the following types as specified herein.

1. Hot Water/Glycol Heating System (40 percent Propylene Glycol and 60 percent Water)

B. Where a system can be separated by valves into two or more independent systems, each shall be provided with separate treatment systems.

C. Provide a contract for a 1 year period, transferable to the Owner, to include the following: initial water analysis and recommendations, system startup assistance, training of operating personnel, periodic field service and consultation, all performed by a qualified full-time local representative; customer report charts and log sheets at no additional charge; plus laboratory and technical assistance and the furnishing of all chemicals for the 1 year period.

1.02 GENERAL

A. Chemicals, service and equipment shall be supplied by a single water treatment company for undivided responsibility. The water treatment company shall have a regional water analysis laboratory, development facilities and service department, plus full time personnel located within the trading area of the job site.

1.03 SUBMITTALS

A. Submit, in accordance with Section 15500, the following:

1. Piping, chemical shot feeder tank and appurtenances, materials and valving methods.

2. Testing equipment with operating instructions for Owner's testing personnel.

3. A contract agreement for a 1 year period as specified under Scope of Work.

4. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

5. All submittals shall contain a statement that Sections 15500, 15505, 15509 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

B. Submit, in accordance with Section 01730 Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

1. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

2. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

3. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

4. Contents - Each volume shall contain the following minimum contents:

   a. Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

   b. Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

   c. Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

5. Spare Parts List

6. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

C. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the Contract Documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 SERVICE CONTRACT

A. A Contract Agreement satisfactory in form and substance to the Owner shall be executed between the Contractor and the water treatment company, through its authorized agents, binding upon the water treatment company to furnish supervisory service to assure the use of proper chemical treatment to and for the various systems involved for a period of 1 year from the date of the initial treatment thereof, as described in the following paragraphs. The furnishing of the necessary chemicals for the treatment of the boiler during temporary heating periods and supervision of their use shall be included in the Contract Agreement. The Contract shall be

assigned to the Owner on the date that the facilities are accepted by the Owner so that water treatment will continue uninterrupted during the 1 year life of the Contract.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this Section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

PART 2 PRODUCTS

2.01 CLOSED SYSTEMS

A. Provide treatment for the following hot water propylene and chilled water propylene systems.

B. Furnish and install a by-pass type chemical shot feeder, 5 gallon (minimum) capacity, complete with valves and fittings and pressure gauges, installed across the primary water pumps.

C. Systems shall be chemically treated for protection against scale and corrosion, with chemical levels as recommended by the water treatment company. Treating chemicals shall be compatible with propylene glycol and anti-freeze additives where specified.

D. A non-oxidizing micro-biocide shall be added with the chemical treatment to provide control of microbial growth and associated deposits in closed water systems.

E. No galvanized materials shall be used or installed in direct contact with the hot water and chilled water system consisting of a mixture of 60 percent water and 40 percent propylene glycol.

F. All large piping specialties shall be provided with lugs, brackets or field supplied devices to allow the equipment to be firmly fastened to the structure. The lugs and brackets shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachment shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

G. The absence of pipe supports and details on the drawings shall not relieve the contractor of the responsibility for providing them.

2.02 GLYCOL FEED SYSTEM

A. Furnish a complete glycol feed system for each individual glycol system.

B. The feed system shall automatically maintain pressure in the piping by adding glycol. Glycol addition shall be controlled by a pressure switch with adjustable high and low pressure set points. Maximum and minimum set points shall be selected for each individual system.

C. Each unit shall contain the following:

1. 55 gallon polyethylene tank mounted on a steel frame over the feed pump.

2. Bronze rotary 1.5 gpm gear pump

3. Float switch for low level shut off and alarm.

4. NEMA 4X control panel.

5. Pump suction with PVC ball valve and "Y" strainer.

6. Pump discharge with PVC ball valve, brass check valve, pressure gauge and relief valve with return to tank.

D. Control panel shall contain the following:

1. Hand-Off-Auto pump motor selector switch.

2. Pump on indicator light.

3. Low tank level indicator light.

4. Audible alarm with push button to silence.

5. Dry contact for remote alarm.

E. Glycol feed system shall be as manufactured by Neptune; Chemical Pump Co. Inc. or equal.

2.03 TESTING EQUIPMENT

A. The water treatment chemical and service supplier shall furnish basic water test equipment, including carrying case and reagents for use with the supplier's products and apparatus for determination of pH and treatment residual. Where specialized or supplementary equipment is required, it shall be furnished as part of the offering.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

B. Copies of test reports during start-up with corrective action taken shall be sent to the Engineer for review.

C. Supervise the flushing-out of all systems. After completing the installation of each system, it shall be properly flushed-out prior to startup. Flush-out chemicals and procedures shall be furnished by the water treatment subcontractor.

D. Tests shall be made following the flush-out procedure and a written report submitted to the Engineer and Contractor stating that the flushing-out has been completed satisfactorily. Residual chemical levels shall be limited as follows: phosphate-zero, alkalinity to 100 ppm maximum, suspended solids-zero, and pH value of 8.4 or less. All side loops and low points shall be drained and flushed.

E. Systems shall be refilled and treated chemically in accordance with recommendations of the water treatment subcontractor.

F. Secure an agreement between the circulating pump manufacturer and the water treatment company as to the proper level of treatment to be maintained in such systems to avoid damage to pumps and pump seals. A letter stating such understanding shall be submitted to the Owner's representative before approval of the pumps and the water treatment program.

G. Supervise and instruct the operating personnel in the initial introduction of water treatment to all systems and the control thereof.

H. Provide service calls at a frequency of not less than one call per 30 days thereafter.

I. Furnish all chemicals required for proper treatment of all systems described together with the necessary control testing apparatus and reagents for field analyses of the water during the one year contract period.

J. Assume responsibility for the field testing and control and the regular addition of chemical treatment in whatever amounts are necessary for each system until the date of acceptance of the facilities by the Owner.

END OF SECTION

SECTION 15541

CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all pumps as shown and scheduled.

1.02 RELATED WORK

A. Thermal insulation is included in Section 15250

B. This Section specifies the type and insulation thickness for the systems and equipment specified herein.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Pump data sheets: to include pump size, type, arrangement, materials of construction, dimensional data, seal data, motor horsepower, motor type, power supply and motor frame size.

2. The submittal shall include pump data sheets with a description of the proposed pump, pump size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, and frame size. Provide catalog data and selections for vibration isolators, include materials of construction. Each submittal shall include pertinent equipment dimensional data, pump performance (operating data) information, and a performance curve showing the pump operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the proposed equipment shall be noted on the equipment submittal. The contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service.

3. Provide a recommended list of spare parts to be provided.

4. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

5. All submittals shall contain a statement that Sections 15500, 15250, 15505, 15541 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

6. Submit, in accordance with Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

   a. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

   b. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

   c. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

   d. Contents - Each volume shall contain the following minimum contents:

      1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

      2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

      3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

   e. Spare Parts List

   f. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be dynamically balanced at the factory.

1.05 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.06 SCHEDULES

A. This Section is incomplete without the information contained in the schedules. All pumps shall be of the type, capacity and arrangement as listed on the schedules. Particular attention must be paid to the remarks and notes in these schedules.

1.07 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:

   a. One complete seal for each pump using a seal.
   b. One complete set of gaskets for each unit.

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Thermometers
   b. Pressure gages
   c. Control relays
   d. Valve operators
   e. Control transmitters
   f. Control transformers
   g. Valve packing

4. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Panel light bulbs
   b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

PART 2 PRODUCTS

2.01 GENERAL

A. All base mounted pumps shall be provided with cast iron or steel base with open grout area and flexible coupling and coupling guard. Mechanical seals shall be Type 303 stainless steel with "Buna-N" elastomers, Ni-Resist seat and carbon washer. Shaft sleeve shall extend the length of the seal box. Mechanical seal boxes shall be equipped with heavy cast, one piece O-ring sealed glands. Impeller shall be vacuum cast, dynamically balanced, and key locked to the shaft. Pump casing shall be high quality cast iron, suitable for 125 psig working pressure. Flanged connections shall be 125 lb standard. Pumps shall be supplied with threaded air vent connection at high points, threaded drain connections at the low points, pressure gauge tappings at pump inlet and discharge flanges, bronze (stainless steel) casing rings. Pump shafts shall be carbon steel with a maximum deflection of 0.002-in at the sealing faces at maximum load. Stuffing boxes shall be equipped with heavy, cast, split glands with extra length for easy removal for packing, inspection and maintenance.

2.02 END SUCTION PUMPS (VERTICAL AND HORIZONTAL)

A. Casing shall be vertical split-case design. Pump shall have back pullout construction to allow servicing without disassembly of piping. Manufacturers shall be Aurora; Bell and Gossett; TACO or equal.

2.03 INLINE PUMPS

A. Pump shall be close coupled with suction and discharge connections 180 degrees apart. Manufacturer shall be Aurora; Bell and Gossett; Taco; Thrush or equal.

2.04 ATTACHMENTS

A. All pumps shall be provided with lug, brackets or field applied devices to allow pumps to be firmly attached to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the seismic loads for the area and type application.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Set base mounted pumps on the steel or cast iron base and check for alignment in accordance with the standards of the Hydraulic Institute and then grout base. Unless inertia block is specified on the Drawings, base mounted pumps shall be installed and grouted on a housekeeping pad. In line and suspended pumps shall be properly supported by the suspension clips as recommended by the manufacturer to prevent any strain on the connecting piping.

D. Each pump shall be installed with the following:

1. Suction and discharge pressure gauges or combination gauge.

2. Temperature gauge.

3. Suction and discharge line-size flexible connectors.

4. Line-size gate valve and strainer at the pump suction and check valve and combination shut-off and balancing valve at the pump discharge.

5. End suction pumps shall be provided with suction elbows.

6. Suction diffuser with integral strainer can be used in lieu of strainer and suction elbow.

7. Triple valve can be used in lieu of check valve and balancing and shut-off valve.

3.02 INSULATION

A. Insulation for Hot Equipment (Type I-10). Insulation thickness shall be as follows:

1. Hot Water/Glycol Pump: 2-in

B. Insulation for Cold Equipment (Type I-11). Insulation thickness shall be as follows:

1. Chilled Water: 2-in

2. Condenser Water: 2-in

END OF SECTION

SECTION 15550

HEATING EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all heating units as specified herein and as shown and scheduled on the Drawings.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Catalog cuts for each type of equipment and accessory.

2. Data sheets for each piece of equipment listing the applicable information. The information shall include heating output, capacity, energy/fuel input, air flow, entering and leaving air temperatures, heat transfer fluid flow, entering and leaving fluid conditions, electric power characteristics, motor data, dimensional data and installation instructions for items that are field assembled.

3. Provide a recommended list of spare parts to be provided.

4. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

5. All submittals shall contain a statement that Sections 15500, 15550 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

6. Submit, as provided in Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

a. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

b. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

c. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

d. Contents - Each volume shall contain the following minimum contents:

1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

e. Spare Parts List

f. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.03 REFERENCE STANDARDS

A. Air Movement and Control Association (AMCA)

B. National Electrical Code (NEC)

C. Factory Mutual (FM)

D. Underwriters Laboratories (UL)

E. American Society of Heating, Refrigeration and Air Conditioning Engineers. (ASHRAE)

F. Where reference is made to one of the above standards, the revisions in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be dynamically balanced at the factory.

1.05 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.06 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Thermostats
b. Pressure gages
c. Control relays
d. Damper operators
e. Valve operators
f. Control transmitters
g. Control transformers

4. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Panel light bulbs
b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.07 SCHEDULES

A. This Section is incomplete without the information contained on the drawings and schedules. All units shall be of the manufacturer, type, capacity and arrangement as listed on the schedules. Units shall consist of the components listed in the schedule and those components obviously required for the type of unit. The order of component assembly will be as called for on the schedule and Drawings. Particular attention must be paid to the remarks and notes in these schedules and Drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. Casings shall be sheet metal, steel, aluminum, extruded aluminum or as specified on the schedules, constructed with structural framing members as required. All heating equipment shall be provided with lugs, brackets or field supplied devices to allow the equipment to be firmly fastened to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules. The casing shall enclose all components. Gasketed access doors shall be provided to facilitate maintenance.

B. Fans shall be factory assembled, complete with fan wheel, fan housing or cabinet, bearings, drives, motor and motor base unless otherwise specified. All fans shall be statically and dynamically balanced before shipment. Where belt drives are used, motors shall be provided with adjustable slide bases, adjustable sheaves and pulleys. All fans shall be AMCA rated for sound and air performance. Centrifugal fans shall be provided with the following accessories: scroll case flush-mounted access door, inlet and/or outlet screen for fans that are not direct duct connected. Fan shafts shall be solid steel, installed with shaft seals. Propeller fans shall be provided with inlet and discharge screens for fans that are not direct duct connected. Fans shall be steel construction with cast aluminum wheels, fabricated steel, aluminum or as specified on the schedules. Plastic fan wheels are not acceptable.

C. Heating Sections

1. Hot-water heating coils shall be copper or cupro-nickel as noted on the schedules, aluminum fins, galvanized steel frame and non-ferrous headers. Fins shall be mechanically attached to the tubes. Vents and drain connections shall be provided with extension through the unit casing. Coils shall be proof tested at 300 psig and leak tested at 200 psig with air under water and shall be suitable for 200 psig working pressure at 200 degrees F.

2. Sheath electric heating elements shall consist of 80-20 nickel-chromium coil within a tubular steel sheath filled with compacted magnesium oxide powder. The tubular elements shall have steel edgewound fins copper-brazed to the tubular sheath. The entire assembly shall be coated with high-temperature aluminum paint. Ends of elements shall be closed with a ceramic washer and a threaded terminal. Tubular heaters shall consist of U-bent elements.

2.02 UNIT HEATERS

A. Unit heaters shall be substantially constructed, self-contained factory-assembled unit consisting of heating element, fan, motor, housing, outlet diffuser or vanes. They shall be the suspended or wall-mounted type arranged for horizontal or vertical air flow, as shown on the Drawings and schedules. Casings shall be painted with a primer and finished with baked-on enamel at the factory. All parts shall be heavily braced and stiffened to prevent vibration and hold all working parts rigidly in line. Casing sides shall be readily removable for access to interior parts. Casings of suspended-type units shall be designed for direct attachment of the hangers. Adjustable, horizontal and vertical vanes, nozzles or diffusers, arranged to give uniform air distribution without objectionable drafts, shall be provided for each heater.

2.03 CABINET HEATERS

A. Units shall consist of chassis, heating element, fan, housing, motor, filters and insulation. Chassis will be galvanized steel with all edges flanged. Insulation will be faced, heavy-density glass fiber. Filters shall be fiberglass throw away type. Vertical units shall have front panel removable. Access door for coil. Top discharge grille with return air from toe space. All cabinet parts shall be shop cleaned and prime coated.

B. Electric wall heaters shall be designed for recessed, semi-recessed of surface mounting as indicated in the schedules.

C. Heating element shall be of the type specified in the schedules.

D. A fan delay switch shall be provided to delay operation of the fan until the heating element reaches a preset temperature.

E. The fan shall be balanced, and the fan and motor assembly shall be mounted for vibration-free operation. The fan motor shall be totally enclosed and self-lubricated. The unit shall be a non-radio interfering type.

F. A hydraulic action unit mounted thermostat shall be provided for positive temperature control when a two-button switch is in the on position.

G. A DPST manual ON/OFF switch shall be provided which disconnects all ungrounded conductors from the heater circuits when in the OFF position.

H. The heater shall include a built in SPST relay for a remote wall-mounted thermostat when called for in the schedules.

2.04 FINNED TUBE RADIATION

A. Radiation shall be complete with all required mounting accessories and components. Heating sections shall be constructed of copper tubes and aluminum fins spaced no more than 60 fins per foot. Enclosures and accessories shall be fabricated from electro-zinc coated, rust-resistant, bonderized steel. Enclosures shall be 16 gauge, with prime coat finish. Enclosure brackets and gauges shall be installed at 4-ft on centers. Element supports shall be double-saddle design fabricated from 16 gauge electro-zinc coated, bonderized steel. Element support shall be sliding type allowing lateral movement for expansion and contraction. For hot water or steam units without a control valve provide enclosure dampers for capacity control. Damper shall be operated with knob through threaded damper screw and trunnion. Provide access doors to all valves installed within enclosures. Where indicated on the Drawings provide continuous wall to wall covers to match covers over active elements.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

B. Equipment shall be installed in accordance with manufacturer's recommendation. Provide piping and ductwork connections in accordance with the requirement of the other related Sections.

C. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

END OF SECTION

SECTION 15555

BOILER(S)

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all hot water boiler(s) as shown on the Drawings, scheduled and as specified herein.

B. Startup and commissioning of boilers, burners, and control systems.

1.02 SCHEDULES

A. This Section is incomplete without the information contained in the schedules. All boilers shall be of the type, capacity and arrangement as listed on the schedules. Units shall consist of the components listed in the schedule and those components obviously required for the type of boiler. Particular attention shall be paid to the remarks and notes in these schedules.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300 and Section 15500, the following:

1. All required data. The submittal shall include boiler data sheets with a description of the proposed boiler, boiler size and connection locations, materials of construction, weight, burner type and model number and boiler efficiency. Efficiency shall be provided for high fire and low fire. If the boiler is modulating control, provide efficiency data for the mid point of the modulating range in addition to high and low fire. Provide burner data sheets with a description of the burner to be used, burner size, connection locations, motor horsepowers, materials of construction and combustion efficiency. Provide efficiency data for the same points as the boiler. List of accessories with catalog data where applicable shall be provided. Submit wiring diagrams and fuel train piping diagrams.

2. Provide control descriptions, wiring and control diagrams.

3. Provide a recommended list of spare parts to be provided.

4. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

5. All submittals shall contain a statement that Sections 15500, 15505, 15509, 15555 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

6. Submit to the Engineer as provided in Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

a. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

b. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

c. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

d. Contents - Each volume shall contain the following minimum contents:

1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

e. Spare Parts List

f. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the Contract Documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME)

B. National Electrical Manufacturers Association (NEMA)

C. Factory Mutual (FM)

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this Section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup, commissioning, and final adjusting and start up of the boilers. Any required governmental inspectors, the Owner and Engineer, shall witness startup. The Contractor shall be responsible for scheduling the startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be dynamically balanced at the factory.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:

   a. One complete set of packing and rings for each pump using packing.
   b. One complete seal for each pump using a seal.
   c. One complete set of gaskets for each unit.

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Thermostats
   b. Thermometers
   c. Pressure gages
   d. Control relays
   e. Valve operators
   f. Control transmitters
   g. Control transformers

4. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Panel light bulbs
   b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.08 COORDINATION

A. The Contractor is responsible for the coordination of the connection of the flues and stacks specified in Section 15575. The Contractor shall insure that the flues and stacks do not impose any structural support loads on the boilers.

B. All ductwork, piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

PART 2 PRODUCTS

2.01 BOILER(S)

A. The boiler(s) shall be factory assembled complete with burner, prewired burner controls, fuel train, boiler trim, refractory and insulation.

B. The boiler(s) shall be designed, constructed and tested in accordance with the ASME Boiler and Pressure Code, Section IV and bear the ASME stamp. The gas burner and applicable controls shall be UL labeled.

C. Units shall be mounted on steel channels, insulated with 1-in minimum of fiberglass insulation and covered with sectional preformed sheet metal lagging.

D. Insulation jackets, base-frame and other components shall be factory painted with hard finish enamel.

E. Units shall have observation ports with shutters located at each end of boiler for inspection of flame.

F. Flue gas outlet shall have a cast iron collar with built-in damper. Damper shall be adjusted and locked in position during factory fire and combustion test.

G. The doors and heads shall be sealed with gaskets and fastened tightly using heavy duty cap screws threaded into replaceable brass nuts.

H. All boilers shall be provided with lugs, brackets or field supplied devices to allow the boiler to be firmly bolted to the structure. The lugs, brackets or filed supplied devices shall be sized to withstand the expected seismic loads for the area and type of application.

2.02 CAST IRON BOILERS

A. The boiler(s) will be a low pressure, cast-iron, sectional type with pressurized firebox(es) for forced draft venting. The burner(s) shall be capable of delivering the necessary air for proper combustion and to pressurize the firebox(es).

B. The boiler(s) sections shall be assembled with individual draw rods that distribute tension evenly on all boiler sections. The boiler sections shall be provided with accommodating sealing grooves and high temperature sealing rope shall be employed to assure a permanent gas-tight seal between the sections. The sealing rope shall be compressible and shall be impervious to heat and moisture. The boiler(s) shall be provided with a flexible elastomer sealing ring for each port opening to assure a permanent water-tight seal between the boiler(s) sections. Each section shall be provided with aligning lugs to assure positive alignment with the adjoining section(s).

C. The boiler(s) sections shall be of the Hydro-Wall design to provide a completely water-backed combustion area with water circulated around the entire firebox.

D. The boiler(s) sections shall be provided with integral, cast-on legs to maintain ample space between the bottom of the boiler sections and the floor for natural aeration.

E. The boiler(s) shall be furnished with (a) refractory insulated, steel burner mounting plate(s) provided with shutter type observation port(s). Each boiler shall have a firebox pressure relief door, which will open automatically in the event of excess firebox pressure. The burning mounting plate(s) shall be sealed with high temperature sealing rope in accommodating sealing grooves in the boiler front section(s) to provide a permanent gas-tight seal.

F. The boiler(s) shall be furnished with refractory insulated access panel(s) to be installed in the access opening(s) in back section(s) to permit access into the combustion area for cleaning. The access panel(s) shall be provided with (an) observation port(s). Cast-iron Cleanout Plates shall be provided for the cleanout openings at the front of the boiler(s). The cleanout plates and access panels shall have accommodating sealing grooves for high temperature sealing rope to ensure a permanent gas-tight seal. The cleanout plates shall be readily removable for the purpose of cleaning.

G. The boiler(s) shall be furnished with (a) cast-iron Smoke Collar(s) which shall have accommodating sealing groove(s) for high temperature sealing rope to provide a permanent gas-tight seal between the Smoke Collar(s) and the back section(s). The Smoke Collar(s) shall be provided with (a) built-in quadrant type breeching damper(s) which can be locked to assure positive pressure(s) in the firebox(es).

H. The boiler(s) shall be provided with (an) insulating heavy gauge steel jacket(s) with durable baked enamel finish. The jacket(s) shall be insulated with heavy density, fiberglass on the front, back, top and side panel(s). The jacket(s) shall be designed to permit installation after the connection of the supply and return piping.

I. The boiler(s) shall be completely factory packaged with jacket, burner, controls and trim mounted and wired. The packaged boiler-burner unit(s) shall be factory fire-tested before shipment to assure proper function. The boiler sections shall be held together with short individual draw rods and high temperature sealing rope shall be employed to provide a permanent gas-tight seal between the boiler sections. Each individual section and the complete section assembly shall be hydrostatically pressure tested before shipment in accordance with Section IV of the ASME Boiler and Pressure Vessel Code. Lifting lugs shall be cast onto intermediate sections and steel skids shall be secured to the bottom at each side of the section assembly to facilitate lifting and positioning the boiler.

2.03 HOT WATER BOILER FITTINGS

A. Dip tube or similar arrangement shall be an integral part of the hot water outlets with an air vent tapping in the boiler shell for removal of air. A McDonnell & Miller low-water cut-off switch to shut-off the fuel, stop burner and sound an alarm shall be factory installed and pre-wired for each boiler. Provide 4-in bell and transformer for alarm. Provide factory installed Honeywell switch type high limit aquastat. Pressure and temperature gauges shall be factory mounted on each boiler. Provide quick opening ASME relief set at 30 psig.

2.04 BURNER EQUIPMENT

A. Natural gas burners shall be provided with aluminized steel main burners which shall be of one-piece construction. The aluminized steel main burner shall feature high flame temperature, quiet ignition and extinction and flame retention qualities. The burners shall be designed so the proper amount of primary combustion air will be drawn into the burner throat entry over a wide range of burner manifold gas pressures. For all certified gases, primary combustion air control at the main

burner will not be required and air inlet adjustment shutters will not be necessary. The gas train shall include a main gas control group consisting of an automatic motorized gas valve, automatic safety gas valve, gas volume control valve with adjustable cam operator, gas pressure regulator, gas gauge and gas cock. The gas-electric ignition assembly shall consist of a pilot burner, 6,000 Volt ignition transformer, automatic gas valve, gas pressure regulator and gas cock; air flow safety switch; ultra-violet flame detector; flow fire interlock and all necessary controls and linkage for firing with proved fire start.

B. Gas burner shall be of the annular port flame retention type including a main gas control group consisting of an automatic motorized gas valve, automatic safety gas valve, gas volume control valve with adjustable cam operator, gas pressure regulator, gas gauge and gas cock; gas-electric ignition assembly consisting of a pilot burner, 6,000 Volt ignition transformer, automatic gas valve, gas pressure regulator and gas cock; air flow safety switch; ultra-violet flame detector; flow fire interlock; and all necessary controls and linkage for modulating firing with proved low fire start. Fuel-air control shall provide modulating regulation of the air damper and the gas volume control valve by means of a modulating motor.

2.05 CONTROLS

A. Boilers shall be controlled by a microprocessor based controller with system temperatures and operating status displayed on a LCD screen. The controller shall sequentially modulate boiler operation to optimize the system efficiency. The controller shall be capable of reset the supply water temperature based on return water temperature. All controls shall be located in a hinged metal cabinet with NEMA 1A enclosure and neoprene dust seal.

1. Controls shall conform to FM requirements.

2. Controls shall be Tekmar Boiler Control 265 or equal.

B. The sequence of burner operation shall be controlled by a programming relay of the electronic type providing pre-purge and/or post-purge cycles as scheduled and with full protection against flame failure during both ignition and normal burner operating periods. Operating of the programming relay shall be governed by the boiler controller, an excess pressure limit switch, an electronic flame failure protection device and the low water cut-off to shut-down the burner. After the safety shut-down manual reset shall be required. The burner blower controls shall be interlocked to prevent burner operation without mechanical draft. Means shall be provided for automatically delaying burner operation while allowing fan to scavenge boiler passes of combustion gases after flame or other burner stoppage.

C. The modulating controls shall be governed by the boiler water temperature for hot water boilers to automatically adjust the fuel firing rate and combustion air supply in response to changing demands, all at uniform 80 percent combustion efficiency across the entire range from 20 to 100 percent of rating. Provide manual override for flame magnitude control.

D. Burners Firing Gas

1. The gas burner(s) shall be arranged for full modulation operation with pre-purge, proven low fire start, high fire run and post-purge with modulating fire control.

2.06 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers shall be as listed or equal.

1. The H.B. Smith Co., Inc.

2. The Peerless Heater Company

3. Weil-McLain, a Division of Wylain, Inc.

4. Cleaver Brooks

5. Burnham Hydronics Division

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

B. Install boilers on concrete housekeeping pads.

C. Fuel train piping supply and return, fuel and other piping shall be assembled and installed. Wire fuel train and other required accessories.

D. All required gas train vent piping shall be furnished and installed under the Plumbing Section of Division 15.

E. Start up units and test operation.

F. Flue collar shall be connected to separate breeching and stack extended through the roof. Breeching and stacks shall be of the same size or larger than the flue collar.

G. Installation shall be in accordance with the published good practice requirements of the ASME Boiler and Pressure Vessel Code Section IV, state and local codes and be within the required parameters of the State Fire Marshal.

H. The installing contractor shall maintain all apparatus in satisfactory operating conditions and perform periodic burner tune-up and cleaning of the boiler fireside surfaces when dirty, provide preventative maintenance, perform turndown tests, conduct tests for flame safeguard, combustion efficiency, draft tests, limit control tests and safety valve tests, check the ignition system and adjust, repair or replace any as necessary while the heating system is under his ownership and control.

3.02 COMMISSIONING

A. An authorized representative of the boiler or burner manufacturer shall perform the initial start-up, final adjusting and testing of the burners and controls in the presence of the Owner's operating personnel.

B. Commissioning shall be in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code Section VII.

C. The final results of a Combination Efficiency Test with all pertinent combustion data shall be logged onto a check sheet which shall be submitted to the Engineer to prove compliance with this Section and for record purposes and shall certify, in writing, that the burner(s) have been properly tuned and set-up.

D. Factory authorized service representative shall provide the initial burner lightoff and one year of warranty burner service. This requirement shall not be waived, nor shall the responsibility for the service contract be assumed by any other party unless previously approved by the Engineer in writing.

END OF SECTION

SECTION 15575

FLUE STACKS, BREECHINGS AND VENTS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all flues, stacks, breechings and vents as shown on the Drawings, scheduled and as specified herein.

1.02 RELATED WORK

A. Thermal insulation is included in Section 15250.

B. This Section specifies the type and insulation thickness for the systems and equipment specified herein.

C. Section 15555 Boiler(s) specifies the equipment to be vented by this section.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Catalog cuts and assembly directions for each type of flue or stack.

2. Dimensional drawings of all flues, stacks and breaching. Drawings will show the building structure, adjacent and connected equipment and the location, magnitude and direction of all loads that will be transmitted to the building.

3. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

4. All submittals shall contain a statement that Sections 15500, 15575 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. Underwriters Laboratories (UL)

B. Where reference is made to the above standard, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this Section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 SCHEDULES

A. This Section is incomplete without the information contained in the schedules of fuel burning equipment. Flue connections are shown on individual fuel burning equipment schedules. Particular attention must be paid to the remarks and notes in these schedules.

PART 2 PRODUCTS

2.01 GENERAL

A. All equipment shall be provided with mounting brackets, legs, or clips suitable for required seismic loads. Where the equipment supplier does not provide such components, the Contractor shall provide them.

B. Type PS Factory Built Chimney - UL listed with use for industrial buildings for pressurized venting. The double wall metal chimney shall have an outer casing of aluminum coated steel (0.4 oz/sq ft), an inner casing of Type 304 or 316 or equal corrosion resistant - stainless steel and a minimum dead air space of 1/2-in. Chimney shall be complete with UL listed support plates, roof thimble and guy wires and other accessories as recommended by the manufacturer for a complete installation as manufactured by Metalbestos AMPCO, Model VS1-II or equal.

C. Single Wall Type B Gas Vent - UL listed for use with residential and commercial buildings when forced venting is not required. The single wall metal vent piping shall be minimum 0.018-in thickness galvanized steel as manufactured by Metalbestos or equal.

D. Double Wall Type B Gas Vent - UL listed for use with residential and commercial buildings when forced venting is not required. The double wall metal vent piping shall be an outer casing of 0.018-in thickness galvanized steel, an inner casing of 0.012-in thickness 1100 aluminum alloy as manufactured by Metalbestos or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all equipment per manufacturer's recommendations.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

3.02 INSULATION

A. Insulation for stacks and breeching (Type I-4). Insulation thickness all sizes 3-in.

END OF SECTION

SECTION 15620

CHILLERS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all chillers as shown on the Drawings, scheduled and as specified herein.

B. System Description

1. Microprocessor controlled, water-cooled liquid chiller utilizing scroll compressors.

1.02 RELATED WORK

A. Thermal insulation is included in Section 15250.

B. This Section specifies the type and insulation thickness for field applied insulation.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Catalog cuts for each unit and accessory.

2. Dimensional drawings of all equipment, entering, leaving temperatures and flow for the fluid being chilled, entering, leaving temperatures and flow for the condensing fluid, refrigerant type and total amount of refrigerant in the unit, electrical wiring diagrams, unit capacity at design conditions, energy efficiency at 50 percent, 75 percent, 100 percent and 110 percent for design load, power characteristics

3. Provide control descriptions, wiring and control diagrams.

4. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

5. All submittals shall contain a statement that Sections 15500, 15620 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

6. Submit to the Engineer as provided in Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

a. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

b. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

c. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

d. Contents - Each volume shall contain the following minimum contents:

1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

e. Spare Parts List

f. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the Contract Documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

B. Where reference is made to the above standard, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be dynamically balanced at the factory.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Thermostats
b. Thermometers
c. Pressure gages

d. Control relays
e. Valve operators
f. Control transmitters
g. Control transformers
h. Valve packing

3. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Panel light bulbs
b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.08 COORDINATION

A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the Drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.

1.09 SCHEDULES

A. This Section is incomplete without the information contained in the schedules. All liquid chillers shall be of the type, capacity and arrangement as listed on the schedules. Units shall consist of the components listed in the schedule and those components obviously required for the type of units supplied. Particular attention must be paid to the remarks and notes in the schedules.

PART 2 PRODUCTS

2.01 CHILLER UNITS

A. Chiller units shall consist of compressor, evaporator and condenser sections complete with refrigerant service valves, capacity control thermal expansion valves, filter dryers, sight glass, refrigerant charge and control panel. Packaged units shall be skid mounted, prepiped and wired requiring only water pipe and power wire connections.

B. All chillers shall be provided with lugs, brackets or field supplied devices to allow the chiller to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application.

2.02 COMPRESSOR AND DRIVE MOTOR

A. The unit shall have four direct drive, 3600 rpm, 60 HZ fixed compression scroll compressors. Each compressor shall have a centrifugal oil pump, oil level sightglass, oil charging valve, two

point lubrication for each motor bearing, flooded lubrication for the journal and thrust bearings and a check valve on the scroll discharge port. The motors shall be suction gas cooled, hermetically sealed, two pole squirrel cage induction type.

2.03 EVAPORATOR

A. Evaporators shall be direct expansion, one water pass with baffles, shell-and-tube type. Evaporator shall have removable heads on both ends and be designed for 300 psig working pressure on the both the refrigerant and water sides. Refrigerant side shall be designed, tested and stamped in accordance with ASME Code for Unfired Pressure Vessels. Evaporator shall include a water drain and entering and leaving temperature sensors. Evaporator shall be insulated to prevent condensation and protected with a steel jacket.

2.04 WATER COOLED CONDENSER

A. The water cooled condenser shall be two tubes in series of one pass construction and shell and tube design with seamless integral fin copper tubes. The condenser shall have removable heads at both ends and be designed, tested and stamped in accordance with ASME Code for Unfired Pressure Vessels for refrigerant-side working pressure of 450 psig. The condenser shall be designed for water-side working pressure of 300 psig.

2.05 CONTROLS

A. The chiller shall be supplied with a stand alone microprocessor based control panel that is factor installed and factory tested. The microprocessor shall operate the compressors to most efficiently meet the chilled water supply temperature. Other functions of the microprocessor shall be:

1. External auto-stop.
2. Chilled water flow interlock.
3. Emergency stop.
4. Chilled water pump control.
5. Chilled water temperature reset.
6. Condenser water pump control.
7. Condenser water flow protection.

B. Factory mounted to the control panel door shall be a LCD touch screen display for operator input and information output. The output screens shall include: evaporator report, condenser report, compressor report, ASHRAE Guideline 3 report, main, chiller, feature setting, manual setting and all display setting.

C. The capacity, operating and safety controls and control sequence shall be designed for completely fail-safe, automatic operation. The sequence shall prevent recycling of the unit prior to a predetermined safe time interval.

2.06 REFRIGERANT PIPING SYSTEM

A. A complete refrigerant piping system shall be factory fabricated and installed in the unit. Two complete and independent refrigerant piping systems shall be provided.

B. Piping shall be Type K copper tubing with joints silver brazed. Brazing shall be done with an inert gas purge. Suction lines shall be insulated with closed cell foam insulation. Hot gas piping shall be insulated to protect personnel as required.

C. Complete refrigerant system shall be cleaned, leak tested, and charged with refrigerant.

2.07 VALVING

A. Unit valving shall include: compressor and condenser pressure relief valves, condenser refrigerant liquid line service valve and refrigerant charging valve, condenser water side air bleed valve and drain tap, evaporator water drain tap and air bleed valve, compressor discharge and suction service valves and suction and discharge pressure taps, and liquid line solenoid valve.

2.08 ADDITIONAL FEATURES

A. Additional features shall be as follows: non-fused disconnect switch, short circuit rating, hot gas bypass function, sound attenuator, neoprene isolators, evaporator water regulating valve, and flow switches on condenser and evaporator.

2.09 PLATE AND FRAME HEAT EXCHANGER

A. The plate and frame heat exchanger shall consist of pressed Type 304 stainless steel plates to provide required heat transfer area to meet the operating conditions specified. Each plate shall have one piece molded nitrile gaskets.

B. Each plate shall have herringbone corrugations to optimize heat transfer with nominal pressure losses, and shall have a built-in self aligning system to accurately locate the plates in the frame assembly and prevent lateral plate movement and maintain maximum gasket contact under pressure.

C. The heat exchanger shall not use a welded frame assembly. All steel components shall be epoxy coated. Provide lifting lugs for rigging and removal of heat exchanger from chiller skid.

D. The heat exchanger shall be factory assembled and tested in accordance with the ASME code section VIII, Div. I, and furnished with ASME code stamp, Ul form for design pressure of 150 psig for both circuits. The plate and frame heat exchanger shall be manufactured by Bell & Gossett or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

B. Install chiller unit on vibration isolators on a housekeeping pad. Install and pipe field mounted accessories. During installation, proper location of the chiller shall be considered so that sufficient access for maintaining the chillers is provided. Also, space shall be provided to pull and clean tubes.

C. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

3.02 INSULATION

A. Insulation for Chillers (Type I-9). Insulation thickness shall be as follows or as provided by manufacturer:

1. Chiller condenser head, suction to compressor, float chamber and water boxes and covers, 2-in unless insulated by chiller vendor.

END OF SECTION

SECTION 15855

AIR HANDLING UNITS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all indoor mounted air handling units (AHU), makeup air units (MAU) and air conditioning units (ACU) with filters as shown on the Drawings, scheduled and as specified herein.

1.02 SCHEDULES

A. This Section is incomplete without the information contained in the schedules on the drawings. All air handling units shall be of the type, capacity and arrangement as listed on the schedules. Units shall consist of the components listed in the schedule and those components obviously required for the type of unit. The order of component assembly will be as called for on the schedule. Particular attention must be paid to the remarks and notes in these schedules.

1.03 SUBMITTALS

A. Submit, in accordance with Sections 01300 and 15500, the following:

1. Unit data sheets; to include catalog data, a description of the proposed unit, size, type, arrangement, and materials of construction.

2. For belt drive equipment, provide drive data indicating sheave sizes, belt size, number and length.

3. Each submittal shall include pertinent equipment dimensional data, heating and cooling coil operating data. Submit, in accordance with Sections 01300 and 15500, all data and the fan schedules. The submittal shall include fan data sheets with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, and frame size. Provide catalog data and selections for vibration isolators, include materials of construction. For belt drive equipment; provide drive data indicating the sheave sizes, belts size, number and length. Each submittal shall include pertinent equipment dimensional data, fan performance (operating data information, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the proposed equipment shall be noted on the equipment submittal. The Contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service.

4. For heating sections, provide information on type of heating, air entering and leaving conditions, air pressure drop, heating media entering and leaving conditions and flow or

consumption, and pressure drop. Provide size, type, arrangement, materials of construction, and operating weight.

5. For cooling sections, provide information on type of cooling, air entering and leaving conditions, air pressure drop, cooling media entering and leaving conditions, flow, and pressure drop. Provide size, type, arrangement, materials of construction, and operating weight.

6. For condensing sections provide information on number and type of compressors, type of refrigerant and refrigerant charge, and controls provided and operating weight. Provide electrical data for power and controls. For condensing coils, provide air entering and leaving conditions, air pressure drop, size, type, arrangement, and materials of construction.

7. List of accessories to be furnished shall be included on each submittal.

8. Provide a recommended list of spare parts to be provided.

9. Significant dimensional differences between the specified equipment versus the proposed equipment shall be noted on the equipment submitted.

10. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

11. All submittals shall contain a statement that Sections 15500, 15855, 15890 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

12. Submit to the Engineer as provided in Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

    a. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

    b. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

    c. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

    d. Contents - Each volume shall contain the following minimum contents:

        1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

e. Spare Parts List

f. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

1. ASHRAE 52 - Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

B. Air Movement and Control Association (AMCA)

C. National Fire Protection Association (NFPA)

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems

2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

D. American Society for Testing and Materials (ASTM)

1. ASTM C581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass- Fiber- Reinforced Structures Intended for Liquid Service.

2. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Materials).

E. Air-conditioning and Refrigeration Institute (ARI)

F. American Society of Mechanical Engineers (ASME)

G. National Electrical Code (NEC)

H. National Electrical Manufacturers Association (NEMA)

I. Association of Home Appliance Manufacturers (AHAM)

J. Factory Mutual (FM)

K. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be dynamically balanced at the factory.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:

a. One complete set of drive belts for each piece of belt driven equipment
b. One complete shaft seal for all fans with shaft seals.
c. One complete set of gaskets for each unit.
d. Three full sets of air filters if not otherwise specified

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Thermostats
b. Humidistat
c. Thermometers
d. Pressure gages
e. Control relays
f. Damper operators
g. Valve operators
h. Control transmitters
i. Control transformers
j. Valve packing

4. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Panel light bulbs
b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

PART 2 PRODUCTS

2.01 GENERAL

A. In general, units shall be factory assembled with cabinet fan, heating and/or cooling section, filters, dampers, access sections with hinged access doors, motor, motor base, drive, drive guard and vibration isolators.

B. Units shall be designed to provide an integrated assembly when all of the components are assembled. All transition sections and filler pieces required between sections are to be provided as part of the unit.

C. Support brackets or rails are to be provided with the unit. Type of support is to be as required by the schedules and as shown on the Drawings, e.g. hung, floor mounted, etc. All air handling units shall be provided with lugs, brackets or field supplied devices to allow the unit to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

D. Units not mounted on vibration isolators shall have all rotating components internally isolated from the main unit with vibration isolators.

2.02 CASINGS

A. Casings shall be sheet steel construction with structural framing members as required. Pressure class rating shall be for the total fan static pressure. All sections of the unit shall be of the same pressure class. Cabinet panels shall be easily removable for servicing.

B. Where specified on the schedules, and in all units with heating and/or cooling sections, the unit shall be insulated. All sections including, but not limited to, return plenum, coils, filter, spacers, access sections, fan cabinet, mixing box and by-pass sections, shall be insulated. Insulation shall be 1-in mat faced or neoprene coated fiberglass liner, 1-1/2 lb minimum density, installed with stick clips and adhesives to prevent erosion of the insulation.

C. Holes shall be provided in the base rails for rigging shackles to facilitate overhead rigging and forklift slots shall be provided to facilitate maneuvering.

D. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self tapping screws or other fastening methods that will damage the coating are not acceptable.

2.03 FAN SECTION

A. Fans shall be centrifugal cabinet fans with belt or direct drives as scheduled. Extended external lubrication fittings shall be provided.

B. Drives shall be adjustable V-belt type, with motor mounted on an adjustable slide base.

C. All bearings for fan and motor shall be as defined in Section 15500.

D. Backwardly curved wheels shall be air foil type.

E. All fans shall be statically and dynamically balanced before shipment.

F. All fans shall be AMCA rated for sound and air performance.

G. Where called for on the schedules, fans shall be of spark-proof construction. On spark-proof fans, bearings shall not be placed in the air stream. Construction shall conform to AMCA and NFPA requirements.

2.04 COOLING SECTION

A. Cooling coil section shall be insulated with drain pan, coil support slide rails and coil closure plate. Coil mounting shall minimize air by-pass around the coil. Drain pan shall be insulated, have a corrosion resistant lining and drain connections on both ends of the drain pan.

B. Chilled water cooling coils shall be cartridge type with copper tubes, aluminum fins, galvanized steel frame and non-ferrous headers. Fins shall be mechanically attached to the tubes. Vent and drain connections shall be provided with extension through the unit casing except outdoor mounted units where vent and drains shall be within the unit casing. Coils shall be proof tested at 300 psig and leak tested at 200 psig, with air under water and shall be suitable for 200 psig working pressure. Coils shall be certified per ARI Standards.

2.05 HEATING SECTION

A. Heating section shall be insulated. Where heating is provided by coils, coil support slide rails and closure plates shall be provided.

B. Location of heating sections, preheat and reheat shall be as shown on the schedules or Drawings.

C. Hot water heating coils shall be cartridge type with copper tubes, aluminum fins, galvanized steel frame and non-ferrous headers. Fins shall be mechanically attached to the tubes. Vents and drain connections shall be provided with extension through the unit casing except outdoor mounted units where vents and drains shall be within the unit. Coils shall be proof tested at 300 psig and leak tested at 200 psig with air under water and shall be suitable for 200 psig working pressure at 200 degrees F.

2.06 FILTERS

A. See schedule for filter types by unit.

B. Filter Box shall have tracks for the specified filter types, except roll filters, to allow filter replacement from either side. Sealing material shall be provided at tracks and ends to prevent air by-passing the filters.

C. Disposable Filters shall be framed filters, 1-in or 2-in thickness as scheduled. Filter pressure drop for clean filters at 300 fpm face velocity shall be 0.2-in WG for 1-in thickness and 0.15-in WG for 2-in thick filters. Filter shall have 30 to 35 percent efficiency on ASHRAE Test Standard 52. Manufacturers and type shall be American Air Filter Co., AmAir 300X; Farr Co., 30/30 Disposable; Cambridge, Aeroplate or equal.

D. A total of three complete sets of filter media shall be provided for each unit.

E. For all types of filters, each filter section shall be provided with a differential static pressure gage across the filter. Where more than one filter is used in series, each filter shall be provided with a separate gage. Each gage shall be provided with shut-off vent valves similar to Dwyer A-301A vent valves on each side of the gage to permit zeroing of the gage without disconnecting the gage. Tubing shall be aluminum. Static pressure sensors, valves and fittings shall be aluminum. Pressure range of gages shall be three times the clean pressure loss of the filters provided.

F. Remote indication of pressure differential shall be provided by a transmitter using a silicon strain gage transducer. Casing shall be cast aluminum. The unit shall be able to withstand an overpressure of 15 lbs/sq in. Unit shall have zero and span adjustment. The transmitters shall be provided with a LCD readout on the face of the transmitter. Transmitters shall be Dwyer Series 603A differential pressure transmitters.

2.07 ACCESSORY SECTIONS

A. Accessory sections shall be as called for on the Drawings and schedules and as required for the unit type.

B. Dampers shall be opposed blade type with blades mounted on 1/2-in minimum steel rods. Dampers shall be provided with low friction bushings and edge gaskets to reduce air leakage. Blades shall be sectionalized to limit unsupported blade length and warping at full system fan static pressures. Maximum damper blade width shall not exceed 6-in. Manual dampers shall be provided with an external position indicating handle with a positive locking device.

C. Mixing boxes shall be of the configuration shown on the Drawings. Deflection plates shall be provided if required to maintain even air flow over coils and prevent stratification.

D. The dampers for all units that require corrosion resistant coatings shall be supplied under Section 15950H. Materials and construction shall be as required for the ductwork materials to which the unit is connected.

E. Face and by-pass sections shall be of the type specified on the schedule. Where external face and by-pass is specified the external by-pass shall be provided. Deflection plates shall be provided if required to maintain even air flow over coils and prevention of stratification.

F. Spacer and access sections will be provided where specified or required. Access sections shall have hinged doors on each end except for filters.

2.08 ENERGY RECOVERY UNITS

A. The unit shall be of bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18 gauge galvanized steel, bolted to a minimum 16 gauge galvanized steel base with integral lifting lugs. Unit shall be provided with insulated top, side and interior panels utilizing 1" thick, three pound density foil faced insulation, manufactured and tested to meet NFPA 90A and UL 181 requirements. Insulation shall be fastened to the panels with weatherproof adhesive and weld pins. Energy recovery wheel shall be mounted in a slide track for easy inspection and cleaning. Separate blower and motor shall be provided for supply and exhaust airstream for independent system balancing. Blower and motor assemblies shall be mounted on rubber

vibration isolators. Two inch thick, 30 percent efficient pleated filters shall be provided for supply and exhaust airstreams. Removable side panels shall be provided for easy access to motors, blowers, filters and energy recovery wheel. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA certified transit tested packaging.

B. Energy recovery wheel constructed of fluted synthetic fiber-based media impregnated with a non-migrating water selective 4 angstrom molecular sieve desiccant. Energy transfer ratings shall be ARI certified in accordance with the ARI Air-to Air Energy Recovery Ventilation Equipment Certification Program, based on ARI Standard 1060-2000.

C. Fan Wheel shall be DWDI centrifugal forward curved type, constructed of painted steel. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

D. All internal electrical components shall be pre-wired for single point power connection. Internal control panel shall be UL listed with hinged access door and interlocking NEMA 3R disconnect switch. Each motor shall have a motor starter combination providing fuseless disconnect, over-current, overload and motor starting functions. A 24 volt circuit shall be provided to allow remote on/off control of ERV by building control system. Short circuit protection shall be provided on primary and secondary of control power transformer.

E. Bearings shall be permanently lubricated, sealed ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.

F. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150 percent of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

G. Ventilator shall be model ERV as manufactured by Loren Cook Company of Springfield, Missouri or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed in accordance with manufacturer's recommendation. Provide piping and ductwork connections in accordance with the requirements of the other related Sections.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. When units are shipped disassembled, field connect all sections together as shown on the Drawings to form single air handling unit. Seal all joints with gaskets and/or sealants.

D. Do not operate equipment without filters. Do not run equipment with dirty filter pressure drop more than twice clean filter pressure drop. A total of three complete sets of filters shall be provided. The first set is to be installed for start-up, test and balancing. The second set shall be

installed after final cleanup and acceptance by the Owner. The third set shall be turned over to the Owner as a spare.

E. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

END OF SECTION

SECTION 15860

FANS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all fans and fan accessories as shown on the Drawings, the attached schedules and as specified herein.

B. This HVAC specification is incomplete without the information contained on the Drawings and in the Schedules.

1.02 RELATED WORK

A. Odor control systems are included in Division 11.

B. HVAC is included in Section 15500.

C. Ductwork and accessories are included in Section 15890.

D. Fiberglass ductwork and accessories are included in Section 15891.

E. Remote disconnects are included in Division 16.

1.03 SUBMITTALS

A. Submit, in accordance with Sections 01300 and 15500, all data and the fan schedules. The submittal shall include fan data sheets with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, and frame size. Provide catalog data and selections for vibration isolators, include materials of construction. For belt drive equipment; provide drive data indicating the sheave sizes, belts size, number and length. Each submittal shall include pertinent equipment dimensional data, fan performance (operating data 0 information, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the proposed equipment shall be noted on the equipment submittal. The Contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service.

B. Where called for on the schedules, provide certified test data for the fan.

C. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

D. All submittals shall contain a statement that Sections 15500, 15250, 15860 and all other referenced Sections have been read and complied with. The certification statement shall be made

by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

E. Submit, in accordance with Section 01730, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.

1. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.

2. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

3. Provide information in three ring binders. All sheets shall have reinforced punches. Tabbed dividers shall separate all sections. Drawings will be bound in the manual, or contained in envelopes bound into the manual.

4. Contents - Each volume shall contain the following minimum contents:

   a. Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.

   b. Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.

   c. Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

5. Spare Parts List

6. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

F. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

G. Provide a recommended list of spare parts to be provided.

1.04 REFERENCE STANDARDS

A. These standards shall be considered as minimum requirements. This is a general list and not all standards listed are necessarily referenced elsewhere in this Section. Specific requirements of

this Section and/or Drawings shall have precedence. The Engineer shall resolve conflicts between published requirements.

B. Titles and abbreviation of Federal, State and industry standards, technical societies, associations and institutes and other organizations, which may be used, are as follows:

1. Air Diffusion Council (ADC)
2. American Bearing Manufacturers Association (ABMA)
3. Air Movement and Control Association (AMCA)
4. American National Standards Institute (ANSI)
5. Air Conditioning and Refrigeration Institute (ARI)
6. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
7. American Society of Mechanical Engineers (ASME)
8. American Society for Testing and Materials (ASTM)
9. Factory Mutual (FM)
10. Institute of Electrical and Electronic Engineers (IEEE)
11. National Institute of Standards and Technology (NIST)
12. National Electrical Code (NEC)
13. National Electrical Manufacturers Association (NEMA)
14. National Fire Protection Association (NFPA)
15. Occupational Safety and Health Administration (OSHA)
16. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
17. Underwriters Laboratories (UL)

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules

B. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

D. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

E. All rotating parts of equipment shall be statically and dynamically balanced at the factory.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instruction for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:

a. One complete set of drive belts for each piece of belt driven equipment
b. One complete set of gaskets for each unit.

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Control relays
   b. Damper operators
   c. Control transmitters
   d. Control transformers

4. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

   a. Panel light bulbs
   b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.08 SCHEDULES

A. Fans shall be belt or direct drive, of the type, materials of construction, capacity and arrangement as described herein and on the schedules. Particular attention must be paid to the remarks and notes in these schedules. This Section is incomplete without the schedules shown on the drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model of catalog number is for the purpose of establishing the standard quality, grade, type, size, physical arrangement, performance characteristics and availability.

B. Fans shall be factory assembled, complete with fan wheel, fan housing or cabinet, bearings, drives, drive guard, motor, motor base, unit base and vibration isolators, dampers and bird screens unless otherwise specified. All fans shall be provided with lugs, brackets or field supplied devices to allow the fan to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

C. All fans shall be statically and dynamically balanced prior to shipment from factory.

D. Where belt drives are used, motors shall be provided with adjustable slide bases. Adjustable sheaves and slide bases shall be selected so that the midpoint of the adjustable range matches the fan schedule data. Drives selected shall have a safety factor of 1.5 times motor horsepower.

E. All fans shall be AMCA certified for air performance and sound ratings tested in accordance with AMCA 300.

F. Motor shall be selected to be non overloading for the entire fan curve range and for the reasonable expected temperature and humidity. Schedule motor sizes are minimum. If a larger motor is required for the fan proposed, the larger motor shall be provided at no additional cost.

G. All bearings for the fan and motor shall be as defined in Section 15500.

H. Fans shall be assembled with OSHA shaft and motor guards. Provide access for greasing bearings, tachometer readings of fan and motor speed without removing the cover. Cover shall be properly ventilated to prevent motor overheating.

I. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self tapping screws or other fastening methods that will damage the coating are not acceptable.]

J. The noise level of the equipment operating in the field shall not exceed 85 dBA overall sound pressure level (referenced to 20 micro pascals) at a distance of 3-ft from equipment surfaces. Provide octave band sound data if another noise level is specified in the schedule or if sound data submission is specified in the schedules.

K. Additional requirements are contained in Paragraphs 2.03 through 2.11 for specific fan types and in the schedules.

L. Section 15500H contains general requirements for vibration isolators, bearings and motor drives. Adhere to those requirements and the specific requirements in this Section.

M. When bearings are not accessible, extended supply and relief fittings shall be supplied. Both supply and relief fittings shall terminate in the same location.

N. Provide inlet and outlet screens for fans that are not directly duct connected.

2.02 SPARK RESISTANT CONSTRUCTION

A. Where called for on the Drawings and Schedules, fans shall be of spark resistant construction. Bearings shall not be placed in the air stream. Construction shall conform to AMCA and NFPA requirements.

1. TYPE A - All parts in contact with the gas stream shall be non-ferrous material.

2. TYPE B - Aluminum wheel and non-ferrous ring around shaft openings.

3. TYPE C - Non-ferrous ring on inlet bell and shaft opening.

2.03 CENTRIFUGAL UTILITY FANS

A. Fans shall be centrifugal type. Unless spark resistant construction or other materials of construction are specified, fans shall be all welded steel construction with backward inclined airfoil blades continuously welded to the wheel flange and back plate. Fan housings are to be constructed of heavy gauge steel with sides and scroll continuously welded. Bearings shall be pillow block type rigidly mounted on steel structural members. Shaft shall be solid, ground and polished steel with keyways, keys and setcrews for attachment of both the fan wheel and drive

sheave and countersunk at drive end for tachometer readings. Manufacturers shall be Buffalo Forge Co.; Loren Cook Co.; New York Blower Co. or equal.

B. Fans shall be provided with the following accessories.

1. Scroll casing drain (1-in NPT with cap).

2. Factory drilled inlet and outlet flanges.

3. Paint requirement is one coat of rust inhibitive primer inside and out.

4. Scroll casing flush mounted and gasketed access door.

5. High temperature construction with oil lubricated bearings and heat slinger.

6. Split cover type shaft seal with thermosil or other non-asbestos seal mat fabric.

2.04 CENTRIFUGAL CABINET FANS

A. Centrifugal cabinet fans shall have external mounted bearings and drive. Drive shall be adjustable V-belt type. Backwardly inclined wheels shall be airfoil type. Unless spark resistant construction or other materials of construction are specified in the schedule, fans and cabinets shall be steel construction. Where specified as insulated on the schedule, cabinets shall be lined with 1-in mat faced neoprene coated fiberglass insulation, 1-1/2 lb density. Manufacturers shall be ILG Industries, Inc.; Loran Cook Co.; Penn Ventilators or equal.

2.05 TUBEAXIAL AND VANEAXIAL FANS

A. Axial fans shall have flanged inlet and discharge, access door in fan tube. Belt drive fans shall have shroud over the belt drive in the air stream. Mounting brackets shall be provided based on fan mounting orientation. Unless spark resistant construction or other materials of construction are specified on the schedule, fans shall be of welded steel construction with cast aluminum wheels. Manufacturers shall be Aerovent, Inc.; Buffalo Forge Co.; Hartzell Fan, Inc.; New York Blower Co.; Loran Cook Co.; Peerless-Winsmith, Inc. or equal.

2.06 INLINE CENTRIFUGAL FANS

A. Inline centrifugal fans shall have flanged inlet and discharge, wheel inspection door, and variable belt drives. Belt drive shall have a shroud over the belt in the air stream. Wheel shall be backward inclined airfoil type. Mounting brackets shall be provided per specific fan mounting orientation. Unless spark resistant construction or other materials are specified on the schedule, fan shall be of steel construction with steel or aluminum wheel. Manufacturers shall be Loren Cook Co.; Aerovent, Inc.; Buffalo Forge Co.; Hartzell Fan Inc.; New York Blower Co.; Clarage Fan Co. or equal.

2.07 PROPELLER FANS

A. Propeller fans shall be steel construction with cast aluminum, fabricated steel or aluminum propellers. Plastic fan propellers are not acceptable. Fans shall be provided with discharge safety screen if not directly connected to ductwork. Provide neoprene vibration isolation at metal contacts and permanently lubricated, sealed ball bearings. When spark resistant construction is

specified in the schedule, all electrical components shall be explosion proof. Unless spark resistant construction or other materials of construction are specified on the schedules housing shall be steel or aluminum. Manufacturers shall be Acme Eng. & Mfg. Corp.; Aerovent, Inc.; Hartzell Fan Inc.; New York Blower Co.; Loren Cook Co. or equal.

2.08 CENTRIFUGAL WALL AND ROOF EXHAUST FANS

A. Centrifugal wall and roof exhaust fans shall be furnished with removable discharge safety/bird screen and inlet safety screen if not directly connected to duct work. Motor and drive shall be located out of the exhaust air stream. Roof mounted fans shall be furnished with 12-in minimum height aluminum factory fabricated insulated curbs. Curbs shall provide level fan mounting surfaces regardless of roof pitch. Provide neoprene vibration isolation at metal contacts and permanently lubricated, sealed ball bearings. Bearings shall have an L-50 rating of 200,000 hours. Fan wheel shall be backward inclined. When spark resistant construction is specified in the schedule all electrical components shall be explosion proof. Fans shall be aluminum construction with spun aluminum drive housing and shroud unless other materials of construction are specified on the schedule. Manufacturers shall be Acme Eng. & Mfg. Corp.; Buffalo Forge Co.; New York Blower Co.; Hartzell Fan Inc.; Loren Cook Co. or equal.

2.09 PROPELLER ROOF EXHAUST FANS

A. Propeller roof exhaust fans shall be furnished with removable discharge safety/bird screen and inlet safety screen if not directly connected to duct work. Provide removable mushroom weather cap for access to the fan and drive. Roof mounted fans shall be furnished with 12-in minimum height aluminum factory fabricated insulated curbs. Curbs shall provide level fan mounting surfaces regardless of roof pitch. Provide neoprene vibration isolation at metal contacts and permanently lubricated, sealed ball bearings. When spark resistant construction is specified in the schedule all electrical components shall be explosion proof. Unless spark resistant construction or other materials of construction are specified on the schedules, the housing shall be of aluminum with cast or formed aluminum wheel. Manufacturers shall be ACME Eng. & Mfg. Co.; Buffalo Forge Co.; Hartzell Fan Inc.; Loren Cook Co. or equal.

2.10 PROPELLER ROOF INTAKE FANS

A. Propeller roof intake fans shall be furnished with discharge safety screen if not directly connected to ductwork. Provide removable mushroom weather cap for access to fan and drive. Roof mounted fans shall be furnished with 12-in minimum high aluminum factory fabricated insulated curbs. Curbs shall provide level fan mounting surfaces regardless of roof pitch. Provide neoprene vibration isolation at metal contacts and permanently lubricated, sealed ball bearings. Inlet shall be provided with 2-in throwaway filter serviceable without disassembly of the fan housing. Bird screen shall be provided downstream of the filters. Filter face velocity and inlet velocity shall not exceed 350 fpm. Bottom of filters shall be a minimum of 30-in from the roof with a maximum velocity at the perimeter of the mushroom weather cap of 350 fpm. When spark resistant construction is specified in the schedule, all electrical components shall be explosion proof. Unless spark resistant construction or other materials of construction are specified on the schedules, the housing shall be aluminum with cast or formed aluminum wheel. Manufacturers shall be ACME Eng. & Mfg. Co.; Buffalo Forge Co.; Hartzell Fan Inc.; Loren Cook Co. or equal.

2.11 CORROSION RESISTANT CENTRIFUGAL INLINE EXHAUST FANS

A. Corrosion resistant centrifugal inline exhaust fans shall be AMCA Type A construction with all parts in contact with the air stream constructed of FRP and a carbon steel blower shaft isolated from the air stream. The fans shall have flanged inlet and discharge, wheel inspection door, and variable belt drives. Belt drive shall have a shroud over the belt in the air stream. Wheel shall be backward inclined airfoil type. Mounting brackets shall be provided per specific fan mounting orientation. Manufacturers shall be M.K. Plastics Corporation; Buffalo Forge Co.; Hartzell Fan Inc.; New York Blower Co.; or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. The fans shall be installed in accordance with the instructions of the manufacturer and as shown on the Drawings.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Ensure that lubricating fluids and greases have been applied according to manufacturer's recommendations. Contractor shall be responsible for all start-up checks and adjustments and shall perform them unless they are done by the manufacturer's representative.

END OF SECTION

SECTION 15890

DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, fabricate and install all ductwork, including fittings, accessories, dampers, duct liner, hangers, diffusers, registers, grilles and any incidental work or components required to provide complete air supply, return and exhaust ductwork systems as shown on the Drawings and as specified herein.

B. Design, furnish and install seismic restraints and braces for all ductwork and accessories.

C. In general, ductwork shall consist of any passageway made of sheet metal or other material substantially air-tight, used for the conveying of air, gas or materials. Included are fittings, transitions, bracing, fasteners, sealers, supports and accessories such as access panels, access doors, turning vanes and manual air balancing dampers. All ductwork shall be of size and material as specified herein and as shown on the Drawings. All duct sizes indicated on the Drawings are clear, inside dimensions. Where ductwork is lined with fiberglass, duct sizes shown on the Drawings are clear, inside dimensions to the duct liner material.

D. Any change in duct sizes, offsets, transitions and fittings required to accommodate job conditions shall be submitted to the Engineer for approval.

E. All ductwork, piping, and equipment shown on the drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

1.02 RELATED WORK

A. Cutting and patching is included in Division 1 except for items specified herein.

B. Trenching, excavation and backfill is included in Division 2 except for items specified herein.

C. Concrete work is included in Division 3 except for required HVAC anchor bolts, sleeves and templates, which shall be furnished under this Section.

D. Structural steel and miscellaneous metal is included in Division 5 except for supplementary steel required for HVAC hangers, equipment supports, anchors and guides, which shall be furnished under this Section.

E. Flashing and counterflashing is included in Division 7 except for items specified herein.

F. Painting is included in Division 9 except for factory finished HVAC equipment, HVAC shop painting and HVAC identification labeling and as required in Paragraph 3.18 below.

G. Exterior louvers and louver blankoff panels are included in Division 10.

H. Thermal Insulation is included in Section 15250H. This Section specifies the insulation type and thickness for the systems specified herein.

I. Control dampers and duct mounted instruments are specified in Section 15950 and installed under this Section.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following Drawings and data.

1. Detailed equipment and ductwork drawings at a minimum scale of 1/4-in = 1-ft-0-in. Site layout drawings and roof plans may be submitted at scales smaller than 1/4-in = 1-ft-0-in, subject to Engineer's prior approval. Drawings shall locate ductwork accessories including manual, automatic and fire dampers. Ratings of fire dampers shall be shown. Drawings shall also show and dimension maintenance clear spaces for motors, drives, coils, filters and access doors or panels. Indicate ductwork pressure class used for fabrication.

2. Standard shop and field installation details for transitions, elbows, takeoffs, discharge nozzles, turning vanes, access panels and doors, volume control and splitter dampers, hangers and volume extractors. When SMACNA references are used, the specific methods for the project shall be clearly defined. Where SMACNA has more than one option, the option to be used shall be indicated.

3. Ductwork materials, joining methods, reinforcing and material gauges. Where options are allowed by SMACNA, the proposed option shall be clearly defined. Indicate proposed materials and methods for ductwork and equipment hangers.

4. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

5. All submittals shall contain a statement that Sections 15500, 15890 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. These standards shall be considered as minimum requirements. This is a general list and not all standards listed are necessarily referenced elsewhere in this Section. Specific requirements of this Section and/or Drawings shall have precedence. The Engineer shall resolve conflicts between published requirements.

B. Titles and abbreviations of Federal, State and industry standards, technical societies, associations and institutes and other organizations which may be used are as follows:

1. American Conference of Governmental Industrial Hygienists (ACGIH)

2. Air Movement and Control Association (AMCA)

3. American National Standards Institute (ANSI)

4. Air-conditioning and Refrigeration Institute (ARI)

5. Air Diffusion Council (ADC)

   a. ADC 1062-R4 - Certification, Rating and Testing Manual.

6. American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)

   a. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.

7. American Society of Mechanical Engineers (ASME)

8. American Society for Testing and Materials (ASTM)

   a. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron, Alloy-Coated (Galvannealed) by the Hot-Dip Process.

   b. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

   c. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

9. Factory Mutual (FM)

10. National Institute of Standards and Technology (NBS)

11. National Fire Protection Association (NFPA)

    a. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

    b. NFPA 102 - Standard for Grandstand, Folding and Telescopic Seating, Tents and Membrane Structures.

c. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.

d. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.

12. Occupational Safety and Health Administration (OSHA)

13. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

14. Underwriters Laboratories (UL)

a. UL 214 - UL Standard for Safety Tests for Flame-Propagation of Fabrics and Films.

b. UL 555 - UL Standard for Safety Fire Dampers.

c. UL 723 - UL Standard for Safety Test for Surface Burning Characteristics of Building Materials.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

B. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Fire damper fusible links
b. Thermostats
c. Thermometers
d. Pressure gages
e. Control relays
f. Damper operators
g. Control transmitters
h. Control transformers

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.07 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.08 DEFINITIONS

A. Particular terminology used under this Section is defined as follows:

1. Traffic Level and Personnel Level - Areas, including process areas, equipment rooms, boiler rooms and other areas where insulation may be damaged by normal activity and local personnel traffic. Area extends vertically to 8-ft above floor, walkways, platforms and stairs, and horizontally 3-ft beyond the edge of walkways, platforms, and stairs.

2. Exposed Piping and Ductwork - Piping and ductwork visible from the floor level and includes all piping and ductwork in equipment rooms, boiler rooms, etc.

3. Concealed Piping and Ductwork - Piping and ductwork not visible from the floor level and includes piping and ductwork above hung ceilings and in shaftways.

4. Supply Air Ductwork - Ductwork carrying air from a fan or air handling unit to the space or spaces to which it will be introduced. This air may have been heated or cooled or in the case of ventilation system the air would be neither heated nor cooled. Supply air ductwork extends from the fan or air handling unit to the registers, grills or diffusers at the end of the ductwork.

5. Return Air Ductwork - Ductwork carrying air from the space it was supplied to back to a fan or air handling unit. Return air ductwork extends from the registers or grills at the end of the ductwork to the air handling unit or connection with an outdoor air intake duct.

6. Exhaust Air Ductwork - Ductwork carrying air from a space to a fan and then to be discharged to the outdoors. Exhaust air ductwork extends from the registers or grills at the end of the ductwork to the fan. From the fan the exhaust ductwork extends to the discharge point, exhaust air damper, or exhaust air plenum, whichever comes first.

7. Relief Air Ductwork - Ductwork carrying air from a space without a fan to be discharged to the outdoors. Relief air ductwork extends from the registers or grills at the end of the ductwork, the discharge point, relief air damper, or relief air plenum, whichever comes first.

8. Outdoor Air Ductwork - Ductwork carrying untreated air from the outside to a fan or air handling unit. Outdoor air ductwork starts at the intake point, outdoor air damper, or outdoor air plenum, whichever comes last. The outdoor air ductwork extends to the fan, air handling unit, or connection with a return air duct, whichever comes first.

9. Mixed Air Ductwork - Ductwork that can carry either return air or outdoor air or a combination of both. Mixed air ductwork starts at the connection of the return air and outdoor air ducts and extends to the fan or air handling unit.

10. Outdoor Air Plenum - A plenum that extends from the opening in the skin of the structure to the outdoor air duct. If the outdoor air damper is directly at the intake or there is no outdoor air damper, the plenum will extend to the first size reduction. If the outdoor air damper is not at the intake, the plenum will extend to the outdoor air damper.

11. Exhaust Air Plenum - A plenum that extends from the opening in the skin of the structure to the exhaust air duct. If the exhaust air damper is directly at the discharge or there is no exhaust air damper, the plenum will extend from the last size reduction. If the exhaust air damper is not at the discharge, the plenum will extend to the exhaust air damper.

12. Relief Air Plenum - A plenum that extends from the opening in the skin of the structure to the relief air duct. If the relief air damper is directly at the discharge or there is no relief air damper, the plenum will extend from the last size reduction. If the relief air damper is not at the discharge, the plenum will extend to the relief air damper.

13. Ventilated Spaces - Areas supplied with outdoor air on a continuous or intermittent basis. The outdoor air may be heated and/or cooled or untreated.

14. Heated Spaces - Areas where heat is supplied to maintain a minimum temperature during the heating season.

15. Unheated Spaces - Areas where heat is not applied and there is no minimum temperature during the heating season.

16. Conditioned Spaces - Areas that are provided with heating and mechanical cooling.

17. Non-Conditioned Spaces - Areas that are not provided with mechanical cooling.

18. Thermal Conductivity - The rate of heat flow through unit area of a homogeneous substance under the influence of unit temperature gradient in the direction perpendicular to the area. Units-BTU per (hour)(sq ft)(degrees F temperature difference)(per inch thickness).

19. Indoor Ductwork - Ductwork within a building that is not exposed to the weather.

20. Outdoor Ductwork - Ductwork that is not within a building and is exposed to the weather.

21. Hot Ductwork - Ductwork carrying air with a temperature above the surrounding space temperature.

22. Cold Ductwork - Ductwork carrying air with a temperature below the surrounding space temperature.

23. Hot/Cold Ductwork - Ductwork carrying air with a temperature that can be either above or below the surrounding space temperature.

24. Flues/Stacks/Breeching - Ductwork carrying products of combustion to atmosphere.

1.09 COORDINATION

A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.

C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including; scheduling, and verification that all structures, ducts, piping and the mounting of equipment are compatible.

D. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

PART 2 PRODUCTS

2.01 VIBRATION ISOLATION FOR DUCTWORK

A. Flexible fabric connectors for vibration isolation shall be airtight, watertight, fire retardant, 6-in wide with 3-in metal edges. Metal edges and fasteners shall be the same material or greater corrosion resistance as the duct.

1. Flexible connections for conventional indoor HVAC systems shall be glass fabric coated with polychloroprene. Fabric must comply with Underwriters Laboratories Standard UL214 and NFPA Bulletin 90A. Connections shall be Ventglas by Ventfabrics or equal.

2. Flexible connections for makeup and exhaust systems in chemical rooms and spaces classified as class I, division I or II shall be fiberglass fabric coated with DuPont's teflon. Fabric must be resistant to sodium hypochlorite and hydrogen sulfide. Fabric must comply with Underwriters Laboratories Standard UL214 and NFPA Bulletin 102. Connections shall be Ventel by Vent Fabric or equal.

B. Manufacturer

1. Holz Rubber Company.

2. Mercer Rubber Company.

3. Proco Products Incorporated.

4. Or equal.

2.02 FLAME AND SMOKE RATINGS

A. All materials, including adhesives, surface coatings, sealers, assemblies of several materials, insulation, jacketing, finish, etc, shall have flame spread ratings not over 25 (fire resistive) and smoke development ratings not over 50 and fuel contributed rating not over 50, as established by tests conducted in accordance with the Federal Standard 00136B, National Bureau of Standards Radiant Energy Fire Test and the National Fire Code of the NFPA.

B. These requirements apply to all circumstances whether the materials are field applied or applied by a manufacturer in his/her shop, or elsewhere, prior to delivery to the project.

2.03 SOUND CONTROL

A. The selection of ductwork and accessories shall be such as not to create noise that will exceed the levels of permissible noise exposures for occupational areas as established by the OSHA and other Federal, State and local safety and health standards, codes and ordinances.

B. Acoustical Lining - Internal sound attenuation and insulation shall be 1-in thick bonded fiberglass mat coated with black pigmented fire resistive coating on the air stream side. Liner shall comply with NFPA 90A requirements. Flame spread and smoke development ratings shall be 25 and 50 respectively. Material shall be Owens Corning; Aeroflex or equal.

2.04 HANGERS, SUPPORTS AND ANCHORS

A. Furnish supports, hangers and other devices necessary to support firmly and substantially the equipment and ductwork described in this Section. Ductwork support systems shall include restrains as required by the applicable building codes to withstand seismic loading. All equipment, ductwork, and supports that are installed outdoors shall be designed and installed to meet wind loadings as required as required by the New York State Mechanical Code, the New York State Building Code, all other applicable codes, and the requirements specified herein. Design shall be provided by a professional engineer hired by the Contractor as specified in other sections of the specification. Signed and sealed calculations shall be submitted for record purposes.

B. Rectangular, Round and Flat-Oval Ductwork - Spacing and size of hangers shall be as called for in the SMACNA standards, except as limited below.

1. Rectangular ductwork 48-in wide and larger shall be supported by adjustable threaded rod hangers.

2. Round ductwork 37-in and larger shall be supported by two adjustable threaded rods at each support.

C. All hangers shall be of same material as ductwork which they serve, e.g., galvanized, aluminum, black steel, etc.

D. All hanger hardware and fasteners shall be of the same material as the duct they serve or shall be of a material with equal or greater corrosion resistance. Where materials other than the duct material are used, they must be approved by the Engineer before installation.

E. Perforated band iron or wire for supporting ducts shall not be permitted.

F. Where C-clamp type hangers are used, furnish with a retainer strap.

G. Support flexible duct with aluminum band hangers, 1-in wide minimum, attached so as not to crush the ductwork. The use of wire to hang flexible ductwork shall not be permitted.

H. The following methods of hanger attachment to the building structure are NOT allowed. The numbers and letters refer to hanger methods shown in Figure 4-1, 4-2 and 4-3 of the 1985 edition of the HVAC Duct Construction Standards Metal and Flexable as published by SMACNA.

"T"- wrap around strap on open web joist.

"W" - bent over band on open web joist.

"14" - friction clamps.

"17" - bent wire in metal deck.

I. Design of hangers shall include the effect of all loads applied to the duct as well as the load of the duct. These loads include, but are not limited to wind, snow and internal dirt or liquid buildup.

J. Hangers shall not be supported from roof decking or bulb tees. Where required, provide supplemental steel to span between the building structures.

2.05 DUCTWORK MATERIAL

A. Ductwork shall be constructed of the materials specified using the gauges or thicknesses, reinforcing and construction methods in accordance with SMACNA standards. Unless otherwise specified, all components of the duct systems shall be constructed of the same material as the ductwork. This is to include braces and turning vanes.

1. Galvanized steel ductwork shall be constructed of hot-dip galvanized sheet steel, per ASTM A653.

2. Aluminum ductwork shall be constructed of 3003H-14 alloy B&S Gauges.

3. Stainless steel ductwork shall be constructed of Type 316 stainless steel.

2.06 DUCTWORK CONSTRUCTION DETERMINANTS

A. Ductwork shall be constructed of the following materials and to the following standards:

System	Location	Static Pressure	Construction Material	SMACNA Standard
MAU-1,2	Filter Room	2" W.G.	AL	M&F
EF-1,2,3	Filter Room	2" W.G.	AL	M&F
ACU-2	Elec. Room 2	2" W.G.	AL	M&F
MAU-3	Chemical Room	2" W.G.	SS	M&F
EF-4	Chemical Room	2" W.G.	SS	M&F
AHU-1,2	HVAC Mezz.	2" W.G.	GS	M&F
MAU-7	HVAC Mezz.	2" W.G.	AL	M&F
EF-5,6,7	Garage Area	2" W.G.	AL	M&F

MAU-4	Garage Area	2" W.G.	AL	M&F
EF-11	HVAC Mezz.	2" W.G.	SS	M&F
EF-12	HVAC Mezz.	2" W.G.	AL	M&F
MAU-5	Sludge Handling	2" W.G.	SS	M&F
Exhaust	Sludge Handling	2" W.G.	SS	M&F
MAU-6	Headworks	2" W.G.	SS	M&F
Exhaust	Headworks	2" W.G.	SS	M&F
ERU-1	Blower Room	2" W.G.	SS	M&F
ACU-1	Blower Room	2" W.G.	AL	M&F
EF-8,9,10	Blower Room	2" W.G.	AL	M&F

Abbreviations

M&F - SMACNA HVAC Duct Construction Standards - 1st Edition.- Metal & Flexible
IRD - SMACNA Round Industrial Duct Construction Standards
IRT - SMACNA Rectangular Industrial Duct Construction Standards
AL - Aluminum
GS - Galvanized Steel
SS - Stainless Steel

B. Design of ductwork shall include all loads applied to the ductwork, in addition to the load of the duct. These loads include but are not limited to wind, snow and internal dirt or liquid build up.

2.07 DUCTWORK CONSTRUCTION

A. All ductwork shall be substantially built with joints and seams smooth on the inside and given a neat appearance on the outside. Inside surfaces and joints shall be smooth and free from pockets, burrs and projections. All joints shall be substantially airtight with laps made in the direction of air flow and no flanges projecting into the air stream.

B. Pressure Classes

1. Pressure classes for determination of sheet metal gauge and reinforcing shall be as defined by the latest issue of the SMACNA - Industrial Duct Construction Standards.

2. For systems with fans with a shut off static pressure higher than 2-in w.g., design pressure shall be as listed in Paragraph 2.06 above. For systems with fans a shut off static pressure 2-in w.g. or less design pressure shall be equal to the maximum pressure indicated for the fans or air handling units on the Schedules and the pressure class shall be the same for the entire length, including branches, of the specific duct system.

C. Rectangular Ductwork (Sheet Metal)

1. Ductwork shall be constructed as shown on the Drawings in accordance with the specified SMACNA - Construction Standard.

2. Cross-breaking shall conform to SMACNA standard. Cross-breaking shall be applied to the sheet metal between the standing seams or reinforcing angles. The center of the cross-break shall be of the required height to assure rigidity for each panel.

3. Alternate Construction - Factory fabricated joint systems may be offered as an alternate form of construction. The system offered shall meet all requirements of SMACNA. Alternate joint systems shall be "Ductmate System" as manufactured by Ductmate Industries, Inc., installed in accordance with the manufacturer's recommendations. The system shall be sealed for zero leakage and angle attachment to the main duct section shall be by tack welding. The use of screws is not allowed.

D. Round Ductwork (Sheet Metal)

1. Ductwork shall be constructed as shown on the Drawings in accordance with the specified SMACNA - Construction Standard.

2. Round ductwork longitudinal seams shall be either lock type or continuous welded construction.

3. Slip joints shall be used on ductwork and fittings up to 36-in in diameter and Vanstone flanges shall be used on ducts over 36-in in diameter.

4. Fittings shall be fabricated with continuous welds. 90 degree elbows shall have a turning radius of 1.5 times the fitting diameter. 90 degree elbows shall be mitered construction with five segments.

5. All fittings in the round duct system shall be of the male and female type. Mechanically fasten the conduits together using sheet metal screws not less than four per fitting 6-in on centers maximum and equally spaced around the circumference of fitting.

6. Round ductwork and fittings shall be manufactured by United Sheet Metal; SEMCO or equal.

E. Round Flexible Ductwork

1. Aluminum flexible ductwork shall be self supporting, suitable for both high and low velocity systems. Attachment shall be by means of stainless steel worm drive band clamps. Duct shall be "United Flex" as manufactured by United Sheet Metal or equal.

2. Stainless steel flexible ductwork shall be self supporting, suitable for both high and low velocity systems. Attachment shall be by means of stainless steel worm drive band clamps. Duct shall be "United Flex" as manufactured by United Sheet Metal or equal.

3. Fabric flexible ductwork shall be vinyl coated glass fabric with cold rolled flat steel spiral support. Duct shall be suitable for both high and low velocity systems. Attachment shall be by means of stainless steel worm drive band clamps. Duct shall be Type 57 as manufactured by Wiremold Co. or equal.

4. Maximum length shall be 10-ft. The remainder shall be sheet metal. Duct run shall be as short and straight as possible to minimize static pressure loss.

F. Insulated Round Flexible Ducts

1. Round flexible ducts shall comply with specified SMACNA - Construction Standards and be constructed of corrugated ductile aluminum that can be bent and rebent by hand and is self-supporting. 1-in insulation shall be applied around the outside and be finished with a vinyl cover.

2. Thermal conductivity of the insulation shall not exceed 0.27 BTU/hr/sq ft/1 degree F at 75 degree mean temperature. Duct shall be Class I, per UL 181.

3. Maximum length shall be 5-ft. The remainder shall be galvanized sheet metal. Duct run shall be as short and straight as possible to minimize static resistance.

4. Ducts shall be Bendway as manufactured by Flexaust Company or equal.

G. Acoustical Lined Ductwork – Round and Oval

1. Where indicated on the Drawings, both duct and fittings shall be lined with fiberglass with a thermal conductivity of 0.27 BTU/hr/sq ft at 75 degrees F mean temperature.

2. The lining shall be covered with a perforated zinc coated steel liner with an open area of 25 percent minimum.

3. Lining adhesives, cloth and coatings, shall have a fire and smoke hazard rating conforming to ASTM E84, NFPA 255 and UL 723 not exceeding a flame spread of 25, flue contributed of 50 and smoked developed of 50.

4. Lining shall be odorless, shall not shed or dust and shall not support mold growth.

5. Duct shall be similar to United Sheet Metal K-27 type lined duct, or equal.

2.08 VOLUME AND SHUT OFF DAMPERS

A. Rectangular dampers shall be multiple blade type with channel frame, exterior linkage and position indicator and locking device. Blades shall not exceed 6-in in width.

B. Round or oval dampers and splitters shall be shop fabricated, single blade type with position indicators and locking device. For galvanized sheet metal systems, material shall be two gauges heavier than ductwork or 18 gauge, whichever is heavier.

C. Dampers shall be constructed of the same material as the ductwork.

D. Shut off dampers shall have replaceable neoprene seals. Leakage rates shall not exceed 7 cfm/sq ft at 4-in w.g. for rectangular dampers and 0.15 cfm/in of perimeter at 4-in w.g. for round or oval dampers.

E. Dampers shall be supplied with locking quadrants. Quadrants in galvanized steel and black steel ductwork shall be galvanized steel. All other duct systems shall have stainless steel locking quadrants. Locking quadrants shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable.

F. All dampers shall be flanged connections unless otherwise noted.

G. All dampers shall be selected for a rating that equals or exceeds the specified system pressure and velocity. Manufacturer shall be Ruskin or equal.

H. Balancing and balancing/shut off dampers shall be opposed blade. Shut off dampers shall be parallel blade.

2.09 ACCESS DOORS

A. Access doors shall be minimum 24-in by 24-in in ducts 26-in and larger. Where the duct size is less than 26-in, the largest door that can be accommodated shall be used. Access doors shall be of the same material as the duct, pan type construction for metal ductwork, with smooth edges and fitted seals, constructed and installed for air-tight fit with ease of opening and closing. Doors shall be substantially butt hinged, with heavy sash locks and substantial door pulls. Door openings and door frames shall be reinforced with bar stock or angle. Where ductwork is installed with duct liner or exterior duct insulation, the access door shall be of the insulated type. Access doors shall be factory fabricated. Where ductwork is constructed of aluminum or stainless steel, access door and hardware shall be of similar material.

B. Hand hole access panels shall be 12-in by 12-in, constructed of the same material as the ductwork, with peripheral gaskets and sash locks. Provide hinges or chain for attachment to duct.

2.10 FASTENERS

A. Sheet metal screws, drive cleats, cinch bands and other fasteners shall be fabricated from materials with an equal or greater corrosion resistance than the ductwork in which they are installed. Where a material other than the duct material is used, it shall be approved by the Engineer before installation

2.11 FIRE DAMPERS

A. Fire dampers shall meet local codes and the requirements of the NFPA Pamphlet No. 90A. Dampers in systems constructed of materials other than galvanized steel shall be constructed of Type 316 stainless steel.

B. Dampers shall be sized so that the free air space is not less than the connected duct free area. Location shall be as shown on the Drawings and required by code. Dampers shall have a minimum 1-1/2 hour standard fire protection rating in accordance with NFPA Pamphlet No. 252 and UL 555. Where the fire protection rating of the partition exceeds 2 hours, multiple dampers in series may be used to provide a rating equal to the partition.

C. Fusible Links - Dampers shall be arranged to close automatically and remain tightly closed upon the operation of a UL approved fusible link or other approved heat actuated device, located where readily affected by an abnormal rise of temperature in the duct. Fusible links shall have a temperature rating of 50 degrees F above the maximum normal duct operating temperature, but not less than 165 degrees F.

D. Workmanship - Install dampers in sleeve unless noted otherwise on the Drawings or in the case of dampers listed for installation without sleeves after specific approval from the Engineer. Fire

dampers shall be installed to provide a positive barrier to passage of air when in a closed position. Dampers shall be installed so they will be self-supporting in case of duct destruction due to heat. Care shall be exercised that the frame be set so that the closing device will not bind.

E. Factory fabricated, steel-curtain type, UL approved fire dampers, with damper blades out of the air stream, are acceptable. These fire dampers shall be installed in accordance with the manufacturer's instructions and UL 555.

F. Access Doors - Tight fitting access doors shall be provided for accessibility to dampers and fusible links for inspection and maintenance.

G. All fire dampers shall have written approval from local authorities.

2.12 RELIEF DAMPERS

A. Relief dampers shall be manually operated or automatic gravity-type used for exhaust of air. Dampers shall be constructed of the same material as the ductwork with flanged connection and blades set in parallel-bladed position and gang operated by exterior linkage. Dampers shall have a shop coat of primer or aluminum finish as specified. Relief dampers shall be of size, type and capacity as specified on the Drawings. Adjustable counter-balanced gravity dampers shall be provided where indicated on the Drawings. Manufacturer shall be Ruskin or equal.

2.13 LABELS

A. The service of each duct along with and arrow indicating direction of flow shall be provided on each duct system. Labels shall be located not more than 26 linear feet apart and shall also be provided at both sides of wall penetrations, at each damper, and each equipment connection.

B. Labels shall contain the service spelled out, the duct size, and the equipment number of the equipment served. Label locations shall have unobstructed view from normal viewing locations.

C. Numbers and letters shall be die-cut from 3.5 mil vinyl film and pre-spaced on carrier film. Adhesive and finish shall be protected with one piece removable liners. Colors shall be white letters on black backgrounds.

D. The system for preparation and application of letters shall be Type B a.s.i./2 by ASI Sign Systems; Architectural Graphics Inc. or equal. Letters shall be 3-in high Optima Bold, upper case using Grid 2 spacing. Direction arrows are to match. The instructions of the manufacturer shall be followed in respect to storage, surface preparation and application of letters.

E. Each piece of equipment is to be provided with an identification label listing the unit number and the areas served. Labels shall be as specified above.

F. Service identifications are to be as follows:

SUPPLY AIR – ??x??
UNIT -----

RETURN AIR – ??x??
UNIT ----

EXHAUST AIR – ??x??
UNIT ----

RELIEF AIR – ??x??
UNIT ----

OUTDOOR AIR – ??x??
UNIT ----

MIXED AIR – ??x??
UNIT ----

2.14 DIFFUSERS, REGISTERS AND GRILLES

A. General

1. All diffusers, registers and grilles shall be of the shape, sizes, capacity and type as shown on the Drawings.

2. On all duct openings that do not have a specific diffuser, register, grill or mesh cover provide a wire mesh cover.

3. Finish - Unless otherwise specified, diffusers, registers and grilles shall have the following finish. All diffusers, registers and grilles located in ceilings shall have a baked white enamel finish except where the ceiling system has an exposed aluminum support grid. Where the ceiling has an exposed aluminum support grid the diffusers, registers and grilles shall have a baked aluminum enamel finish. All diffusers, registers and grilles not located in ceilings shall have baked aluminum enamel finish.

B. Supply Air Diffusers

1. General - Diffusers shall be a factory-assembled unit of welded steel construction consisting of a housing with built-in louvers, cones, vanes or other means of directing discharge of air in a particular pattern principally for overhead or ceiling air diffusion. All diffusers shall be equipped with a volume control device. Distribution of air may be adjustable if so specified.

2. Exposed Duct Mounted Diffusers

a. Diffusers shall be of the adjustable type for ease of horizontal and vertical adjustment of air pattern. Refer to Drawings for direction of air throw. Each diffuser shall be equipped with an equalizing grid, baffles as required and extended bottom plate flange designed specifically for air diffusion from diffusers mounted on exposed ductwork.

b. Acceptable manufacturers shall be as listed or equal.

1) Square and Rectangular: Model TDCA - Titus Manufacturing Corp.; Carnes, Model SK Adjustable Series; Air Devices Inc.

2) Round: Model TMA - Titus Manufacturing Corp.; Carnes; Air Devices, Inc.

3. Ceiling Mounted Diffusers

a. Diffusers shall be of type suitable for installation in the particular ceiling system as shown on the Reflected Ceiling Plans and Architectural Drawings. Special attention shall be given to the exact location of these ceiling diffusers for best air diffusing characteristics as well as architectural aesthetics. Diffusers shall have removable core with vanes to diffuse supply air in the various directional patterns as shown on the Drawings. Equalizing grid control devices, baffles as required, and throw reducing vanes as required shall be furnished with each diffuser. Throw reducing vanes shall be furnished loose for field installation.

b. Acceptable manufacturers shall be as listed or equal.

1) Square and Rectangular: Model TDC - Titus Manufacturing Corp.

2) Square and Rectangular: Model SK Series - Carnes Corp.

3) Square and Rectangular: Model SH-4-22 - Krueger Mfg. Co., Inc.

4) Round: Model TMA - Titus Manufacturing Corp.

4. Plenum Slot Diffusers

a. Plenum slot diffusers shall be of the sizes and mounting type shown on the plans. Diffusers shall have 1-inch slot widths with 4 parallel slots. Standard nominal lengths shall be 2, 3, 4, or 5 feet. Units shall be constructed of 24-gauge steel. The standard finish will be black on the face of the diff user and pattern controllers and white on factory provided T-bars. Each supply slot of the diffuser shall have an extruded aluminum pattern controller with a tight sealing gasket edge at the top of the blade, which seats against the plenum wall or slot divider and provides full horizontal flow. The pattern controller must be field adjustable from the face of the diffuser to change the discharge pattern from horizontal to vertical. The plenum inlet on supply models must be drawn from the plenum wall to eliminate leakage. Welded-in inlets or mechanically fastened inlets are not acceptable. The inlet must have at least 1⅛-inch depth for duct connection. The slot face must be constructed of a double metal thickness for rigidity. Factory furnished T-bars and inlet dampers shall also be provided as optional accessories. The manufacturer shall provide published performance data for the plenum slot diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

b. Plenum slot diffusers shall be TITUS Model TBD-80 or equal.

C. Supply Air Grilles

1. In general, grilles shall be a factory-assembled unit consisting of a grille with double deflecting adjustable airfoil vanes to diffuse supply air in the various directional patterns as shown on the Drawings. Grilles shall be of aluminum frame and border with aluminum louver blades. All grilles shall be furnished with a sponge rubber gasket to prevent streaking. Front and rear louver blades shall be individually adjustable. Where wall mounted, front blades shall be vertical and rear blades shall be horizontal. Where ceiling mounted, front blades shall be parallel to long dimension.

2. Grilles shall be Series 272F by Titus Manufacturing Corp.; Carnes Model RAFA Series; Air Devices Inc. or equal.

D. Supply Air Registers

1. General - Registers shall be a factory-assembled unit consisting of a grille with adjustable vanes to diffuse supply air in the various directional patterns as shown on the Drawings and a damper. Grilles shall be of aluminum frame and border with aluminum louver blades. All registers shall be furnished with a sponge rubber gasket to prevent streaking. Supply air registers shall have aluminum opposed-blade dampers. Front and rear louver blades shall be individually adjustable. Where wall mounted, front blades shall be vertical and rear blades shall be horizontal. Where ceiling mounted, front blades shall be parallel to the long dimension.

2. Acceptable manufacturer shall be Series 272F by Titus Manufacturing Corp.; Carnes Model RNFA Series or equal.

E. Return Air Grilles

1. Louver-Faced Return Air Grilles

a. In general, grilles shall be a factory-fabricated unit of aluminum frame border and louver blades. All grilles shall be furnished with a sponge rubber gasket to prevent streaking.

b. Acceptable manufacturer shall be Model 4F by Titus Manufacturing Corp.; Carnes Model RAHA & RAJA Series; Air Devices, Inc. or equal.

F. Return Air Registers

1. Louver-Faced Return Air Registers

a. In general, registers shall be a factory-assembled unit consisting of a grille and damper. Grille shall be of aluminum frame border with aluminum louver blades. Dampers shall be aluminum, opposed blade type. All registers shall be furnished with a sponge rubber gasket to prevent streaking.

b. Acceptable manufacturer shall be Model 4F, Titus Manufacturing Corp.; Carnes, Model RNHA and RNJA Series; Air Devices, Inc. or equal.

G. Wire Mesh Covers

1. Where wire mesh covers are called for on the Drawings, the wire mesh and support frame shall be the same material as the duct where the cover is installed. Unless otherwise noted the wire mesh shall be 0.5-in mesh.

2. The wire mesh shall be contained in a metal frame. The mesh shall be firmly attached to the frame to prevent it being pulled out of the frame by casual contact. The frame shall be a minimum of 16 gauge sheet metal or the minimum gauge for a flange based on SMACNA, whichever is greater. The frame shall be on both sides of the mesh creating a sandwich with the mesh in the middle. Fastenings shall go through the frame on both sides of the cover.

2.15 WEATHER HOODS

A. Weather hoods shall be factory-fabricated and assembled sheet metal housing. Hoods shall have a pleasing contour. Intake hoods shall have a free area for the handling of outdoor air at a maximum velocity of 500 fpm. Weather hoods shall consist of a "dome" or "mushroom" head, a stack section and a base for mounting of the entire unit over a curbed roof opening. Weather hoods shall be of substantial construction with rigid framing, bracing and supports. Weather hoods shall be of all aluminum construction, low silhouette. All hoods shall be provided with bird screens of 1/2-in mesh, welded wire, galvanized. Hoods shall be of type, size and capacity as shown on the Drawings. Provide anti-condensation coating on internal surfaces.

B. Roof Hoods - Acceptable equipment shall be Trim Line-Skymaster by Acme Engineering & Manufacturing Corp.; Carnes or equal.

2.16 ROOF CURBS

A. Roof curbs shall be furnished for all roof mounted HVAC equipment including fans and relief or intake vents.

B. Roof curbs shall be pre-fabricated type, minimum 12-in height and sized to match the dimensions of the equipment base supported.

C. Roof curbs for fans are specified under Section 15860.

D. Curbs shall be straight sided type of all aluminum welded construction with nominal 2-in thick acoustical/thermal insulation in curb walls. A perforated metal liner shall be provided to protect the insulation. Curbs shall provide a flat top surface regardless of the roof slope.

E. Curb interiors shall be provided with protective coatings when a coating is specified.

F. Roof curbs shall be "Sonotrol" type as manufactured by Penn Ventilator Co. or equal.

2.17 VARIABLE AIR VOLUME COMPONENTS

A. Variable Air Volume Boxes (VAVB)

1. Unit casing shall be 22-gage galvanized steel. Hanger brackets and side access shall be provided with the unit.

2. The unit shall have 1" double wall insulation. The interior surface of the unit casing is acoustically and thermally lined with a 1-inch, 1.0 lb./ft composite density glass fiber with high-density facing. The insulation R- value is 3.8. The insulation is covered by an interior liner made of 26-gage galvanized steel. All wire penetrations are covered by grommets. There are no exposed edges of insulation (complete metal encapsulation).

3. The primary air inlet connection is a galvanized steel cylinder sized to fit standard round duct. A multiple-point, averaging flow sensing ring is provided with balancing taps for measuring +/-5% of unit airflow. The shaft shall be cast with a damper position indicator. The valve assembly includes a mechanical stop to prevent over-stroking. At 4 in. wg, air valve leakage does not exceed 1% of designed airflow.

4. Units shall be provided with hot water coils factory installed on the discharge outlet where scheduled. The coils shall be one or two row copper tubes with aluminum plated fins. Coils shall be proof tested at 450 psig and leak tested at 300 psig air pressure under water. Coil connections shall be left or right-hand as shown on the drawings.

5. Each unit shall be provided with a DDC controller, DDC actuator and a DDC room thermostat.

   a. The DDC terminal controller shall be a microprocessor-based terminal unit controller that shall provide accurate, pressure independent control through the use of a proportional integral control algorithm and direct digital control technology. It shall monitor zone temperature setpoints, zone temperature and its rate of change, and valve airflow using a differential pressure signal from the pressure transducer. Additionally, the controller can monitor either supply duct air temperature or CO2 concentration via appropriate sensors as specified.

   b. The DDC actuator shall be a 24-VAC floating-point control actuator with linkage release button. Torque shall be 35 in-lb minimum and is non-spring return with a 90-second drive time. Travel is terminated by end stops at fully-opened and -closed positions.

   c. The DDC room thermostat shall sense zone temperature through a sensing element located in the zone sensor and shall include an externally-adjustable setpoint, and an override button to change the individual controller from unoccupied to occupied mode. The override button has a cancel feature that will return the system to unoccupied. All temperatures sensed and temperature setpoints shall be displayed on a liquid crystal display screen on the DDC room thermostat. Additionally all temperature setpoints shall be adjustable through push buttons on the DDC room thermostat. The zone sensors shall utilize a thermistor to vary the voltage output in response to changes in the zone temperature. The setpoint adjustment range is 50–88°F.

6. All units scheduled with reheat shall have a two position control valve and actuator. The valve body shall be forged brass with a stainless steel stem and return spring. All connections shall be National Pipe Thread (NPT). Upon demand, the actuator motor strokes the valve. When the actuator drive stops, a spring returns the valve to its fail-safe position.

7. The following additional accessories shall be provided: transformer and disconnect switch.

B. Variable Air Volume Terminals (VAVT)

1. Unit casing shall be 22-gage galvanized steel. Hanger brackets, side access, and plenum filter shall be provided with the unit.

2. The unit shall have 1" double wall insulation. The interior surface of the unit casing is acoustically and thermally lined with a 1-inch, 1.0 lb./ft composite density glass fiber with high-density facing. The insulation R- value is 3.8. The insulation is covered by an interior liner made of 26-gage galvanized steel. All wire penetrations are covered by grommets. There are no exposed edges of insulation (complete metal encapsulation).

3. The primary air inlet connection is a galvanized steel cylinder sized to fit standard round duct. A multiple-point, averaging flow sensing ring is provided with balancing taps for measuring +/-5% of unit airflow. The shaft shall be cast with a damper position indicator. The valve assembly includes a mechanical stop to prevent over-stroking. At 4 in. wg, air valve leakage does not exceed 1% of designed airflow.

4. The unit shall be provided with a direct drive, single-speed, permanent split capacitor type motor. Thermal overload protection shall be provided. The motor shall be provided with a variable speed control switch capable of adjusting the motor speed.

5. Units shall be provided with hot water coils factory installed on the plenum inlet where scheduled. The coil shall be one or two row copper tubes with aluminum plated fins. Coils shall be proof tested at 450 psig and leak tested at 300 psig air pressure under water. Coil connections shall be left or right-hand as shown on the drawings.

6. Each unit shall be provided with a DDC controller, DDC actuator and a DDC room thermostat.

   a. The DDC terminal controller shall be a microprocessor-based terminal unit controller that shall provide accurate, pressure independent control through the use of a proportional integral control algorithm and direct digital control technology. It shall monitor zone temperature setpoints, zone temperature and its rate of change, and valve airflow using a differential pressure signal from the pressure transducer. Additionally, the controller can monitor either supply duct air temperature or CO2 concentration via appropriate sensors as specified.

   b. The DDC actuator shall be a 24-VAC floating-point control actuator with linkage release button. Torque shall be 35 in-lb minimum and is non-spring return with a 90-second drive time. Travel is terminated by end stops at fully-opened and -closed positions.

   c. The DDC room thermostat shall sense zone temperature through a sensing element located in the zone sensor and shall include an externally-adjustable setpoint, and an override button to change the individual controller from unoccupied to occupied mode. The override button has a cancel feature that will return the system to unoccupied. All temperatures sensed and temperature setpoints shall be displayed on a liquid crystal display screen on the DDC room thermostat. Additionally all temperature setpoints shall be adjustable through push buttons on the DDC room thermostat. The zone sensors shall utilize a thermistor to vary the voltage output in response to changes in the zone temperature. The setpoint adjustment range is 50–88°F.

7. All units scheduled with reheat shall have a two position control valve and actuator. The valve body shall be forged brass with a stainless steel stem and return spring. All connections shall be National Pipe Thread (NPT). Upon demand, the actuator motor strokes the valve. When the actuator drive stops, a spring returns the valve to its fail-safe position.

8. The following additional accessories shall be provided: transformer, disconnect switch, and a flanged outlet connection.

2.18 TURNING VANES

A. Turning vanes shall be shop fabricated and installed in all abrupt rectangular elbows. Single thickness or airfoil type double thickness blades shall be chosen based on SMACNA recommendations.

B. Vanes shall be fabricated from the same material as the ductwork and manufactured by Elgen; Duro-Dyne; Aero/Dyne or equal.

PART 3 EXECUTION

3.01 INSTALLATION OF DUCTWORK

A. Fabricate and erect all ductwork where shown on the Drawings, as specified herein, and in accordance with SMACNA standards. Rigidly support and secure ductwork.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Wherever ducts are divided, maintain the cross-sectional area. All such changes must be approved and installed as directed by the Engineer or as approved on shop or erection drawings.

D. During installation, temporarily close the open ends of ducts to prevent debris and dirt from entering. Install work in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.

E. Install louver blank off panels provided by the louver manufacturer as specified under Section 10200. Provide louver manufacturer the louver blank off panel dimension requirements. Secure blank off panels to the building structure using aluminum angles and rustproof fasteners. Caulk perimeter completely to eliminate water penetration.

F. Cross-break sheet metal in accordance with SMACNA duct construction standard. Apply cross-breaking to the sheet metal between the standing seams or reinforcing angles. The center of the cross-break shall be of the required height to assure each panel section being rigid.

G. Cross-break streamlined ducts on top only and adequately brace internally.

H. Beading as specified in SMACNA will be acceptable in lieu of cross-breaking.

I. The Drawings of the air ducts and air risers show the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.

J. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, maintain the cross-sectional area. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.

K. The taper of all transformations shall be not more than 15 degrees.

L. Secure casing to curbs according to SMACNA "Duct Construction Standards."

M. Provide baffle plates as required to prevent stratification and to provide proper operation of controls.

N. Where ducts are constructed of materials other than galvanized steel the reinforcing members shall be of the same material as the ductwork.

O. For PVC ductwork where reinforcing members of material other than PVC are required, totally encase the reinforcing member in PVC.

P. The use of button punching or snap locks on ductwork constructed of aluminum shall not be permitted.

Q. Ducts carrying moist air that pass through areas that could cause condensation shall be pitched to facilitate condensate removal. Low points of such ducts shall be provided with drains.

R. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self tapping screws or other fastening methods that will damage the coating are not acceptable.

3.02 HANGERS

A. Rectangular, Round and Flat-Oval Ductwork - Spacing and size of hangers shall be as recommended in the SMACNA standards except as noted in PART 2.

B. Install hangers plumb and securely suspended from supplementary steel or inserts in concrete slabs. Sufficiently thread lower ends of hanger rods to allow adequate vertical adjustment. Do not use building siding or metal decking to hang ductwork.

C. Ducts shall not be supported from furring, hung ceilings or from another duct or pipe.

D. C-clamp type hangers shall be supplied with a retainer strap.

E. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.

F. Duct support at flexible connections shall be adjustable for ease of aligning the duct to the piece of equipment

3.03 SEALING OF DUCTWORK

A. General - Unless otherwise indicated, seal all ductwork joints and seams using sealant in accordance with the instructions of the sealant manufacturer and this Section. All transverse seams, joints and fitting connections, both shop and field assembled, shall be sealed in accordance with this Section. Longitudinal seams shall be sealed on all duct systems with a design operating pressure greater than 2-in w.g.

B. Application of Sealant - Thoroughly clean all seams, joints, etc, of dirt, oil, grease, or other coatings which might interfere with the adhesion of the duct sealant before the sealant is applied.

C. Uncured sealant may be forced into the slotted side of the seam or joint before shop or field assembly and the joint or seam completed while the sealant is still uncured. Excess sealant shall be removed from both the inside and outside of the duct before it sets.

D. Duct Tape - The use of duct tape alone for sealing ductwork is prohibited. Duct tape may be used primarily for the purpose of retaining the uncured duct sealant in seams and joints until it has cured. Duct tape shall not be applied to the inside of any duct nor shall it be applied to standing type joints at any time. All duct tape used shall be compatible with the sealant. The use of sealant saturated tape is acceptable when part of an integrated sealing system.

E. Sealant shall be either in liquid form or a mastic with a maximum flame spread of 25 and a maximum rate of fuel contributed and smoke developed of 50 when tested in accordance with ASTM E84, NFPA 255 and UL 723.

F. Sealing systems shall be suitable for the environment. The following schedule is to be used to select the sealant.

1. Indoor, dry galvanized round and rectangular duct is to be sealed with Iron Grip 601 or equal.

2. Indoor, dry, stainless steel, aluminum and PVC coated is to be sealed with FTA 20 adhesive and DT-Tape gypsum or equal.

3. All other areas unless otherwise noted are to be sealed with FTA 50 adhesive and DT-Tape gypsum or equal.

4. All sealers listed are manufactured by Hardcast Inc and are to define the type of sealer. Other equal sealants are acceptable.

G. The following ductwork systems do not require sealing of joints and seams. Gaskets at flanged joints are still required.

1. Ventilation supply air systems down stream of the supply fan or air handling unit and located in the area being served by the system.

2. Return air systems upstream of the return fan or air handling unit and located in the area being served by the system.

3. Return air systems upstream of the return fan or air handling unit and located in a return air plenum for the system being served.

3.04 DUCTWORK FITTINGS AND ACCESSORY ITEMS

A. Duct Elbows - Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air. All elbows shall have a centerline radius of not less than 1-1/2 times the width of the duct in the plane of the elbow. For rectangular ductwork where full radius elbows cannot be installed, provide abrupt elbows equipped with shop-installed turning vanes unless noted otherwise on the Drawings.

B. Flexible Fabric Connectors

1. Install flexible connectors for vibration isolation at all duct connections to fans, fan units or blowers, air handling units and air conditioning units. Make connections substantially airtight at all seams and joints.

2. Where the construction of the flexible connection or vibration isolator results in a cross sectional area of the connection which is less than 90 percent of the adjacent ductwork, the size of the connection shall be increased to provide a cross sectional area equal to or greater than 90 percent of the adjacent duct.

3. Provide flexible duct connections at both the intake and discharge connections for all fans and air handling units except as noted below.

   a. Wall and roof fans that have integral motor/fan wheel isolation.

   b. Air handling units where the fan is isolated from the intake and discharge connections by internal flexible connections or separations, and the unit is mounted without vibration isolators between the unit and the support structure.

4. Ductwork spacing and alignment for flexible connections shall be aligned to the tolerances of the flexible connection manufacturer, or plus/minus 1/4-in whichever is less. Bolts shall be torqued to the manufacturer's recommendations. Do not over tighten.

5. Where flexible connections are used as expansion joints, the manufacturer's precompression recommendations must be followed. When the temperature at installation differs from the temperature in the precompression recommendation, a correction shall be made.

C. Dampers

1. Install manual volume control dampers wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings.

2. Install splitter dampers, where shown on the Drawings, to regulate air volume for system air balancing.

3. Install motorized and pneumatic actuated dampers when supplied by other trades.

D. Access Doors

1. Hinged access doors shall be installed where listed below, wherever shown on the Drawings and wherever access may be required for service, maintenance and adjustment.

2. Provide access doors at the following locations (minimum requirements):

   a. Coils in ducts - both entering and leaving side.

   b. Motorized or pneumatic actuated dampers - linkage side.

   c. Duct mounted temperature controllers.

   d. Freeze-stats.

e. Smoke detectors.

f. Plenums.

g. Fire dampers.

h. Smoke dampers.

i. Electric duct heaters.

j. Filter banks.

k. Manual dampers and splitters.

l. Inlet side of centrifugal fans.

m. Volume extractors.

n. As necessary or required.

o. Inlet and outlet ducts to fans and air handlers.

3. Where access doors are required in ductwork located above ceilings, coordinate the location of the access doors to clear the ceiling support system and to be accessible through the ceiling grid.

4. 12-in by 12-in handhole access panels may be substituted for access doors when indicated on the Drawings.

E. Duct Liner - Duct liner shall be shop installed on the interior surfaces of ductwork, where shown on the Drawings or as specified herein. Installation shall be made using a single thickness of duct liner and shall be in accordance with Duct Liner Application Standard by SMACNA. Liner shall be adhered with adhesive having a minimum of 90 percent coverage. Fasteners shall be spaced in accordance with SMACNA. After the duct has been formed the leading edges of the insulation that will be abutting another lined duct shall be spray-coated with fire-resistive adhesive. For ductwork with velocities exceeding 4000 fpm a metal nosing shall be installed at all transverse edges to secure the duct liner.

F. Blast Gates – Blast Gates shall be installed where shown on the Drawings. After final balancing of the system, drill a hole through both the frame and gate and insert a positive locking device, such as a pop rivet, to prevent moving the gate.

3.05 GRILLES, REGISTERS AND DIFFUSERS

A. The location of diffusers, registers and grilles shall be as shown on the Reflected Ceiling Plans and as shown on the ductwork drawings. The exact location of these devices shall be determined in the field in cooperation with the other trades.

B. Install all devices in an approved manner in accordance with the manufacturer's recommendation.

3.06 FLEXIBLE DUCTWORK

A. Make connections, joints and terminations air tight as recommended by the manufacturer. Where joints are made to rigid sheet metal ductwork, apply 3M Company EC-800 sealer and the joint shall be drawn tight with a drawband. Collars shall be 2-in long minimum and sleeves shall be 4-in long minimum.

B. Install flexible ducts with one duct diameter-radius elbows and cut as short as possible. Duct shall not be compressed and the length shall be kept short so minimum hangers or supports are required and static pressure losses are kept to a minimum. Sag in flexible duct shall not exceed 1/2-in/ft between duct supports.

3.07 FILLING IN SPACE AROUND DUCTWORK

A. To prevent sound passing through the area between the duct and the framed or cut opening in the floors, walls or partitions, pack mineral wool to completely fill the space the full depth of the opening. Whenever a fire-rated wall or floor is penetrated and a fire damper is not required, fill the space around the duct with a locally approved fireproof rope.

B. At penetration, apply escutcheon plates on both faces of the wall to close the gap between the structure and the sides of the insulated or bare duct. Escutcheon plates shall be the same material as the duct for metal ducts and stainless steel for PVC ducts.

3.08 DUCT SUPPORTS AT FLOOR PENETRATION

A. Where vertical ducts pass through floor openings and a fire damper is not required, rigidly attach supporting angles to the ducts and anchor with expansion bolts to the floor or curb. Angles shall be of the same material as the duct for metal duct and stainless steel for PVC ducts, placed on the two long sides of the duct extending 3-in over edge of opening and shall not be less than the sizes recommended by SMACNA.

B. Remaining open area in the floor opening shall be sealed with a plate of the same material as the angle.

3.09 DUCTWORK TERMINATIONS AT MASONRY OR CONCRETE

A. Where ducts terminate at masonry or concrete openings, place a continuous 2-1/2-in by 2-1/2-in by 3/16-in angle of the same material as the duct around the ductwork. Use stainless steel angles for PVC ductwork. Bolt the angle to the construction and make airtight by applying caulking compound on the angle before it is drawn down tight to construction.

B. Fasten plenums to concrete curbs with 3-in by 3-in by 1/4-in continuous angle. Concrete curbs are provided under another Division. Mount angle on a continuous bead of caulking compound and anchor to the curb on 16-in centers. Terminate duct at the curb and bolt to the angle. Seal the duct to the curb with a continuous bead of caulking compound. Apply neoprene filler strip to level curb surface as necessary

3.10 DUCTWORK GENERATED NOISE

A. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear, correct by removing, replacing or reinforcing the work. No discreet tones will be allowed.

3.11 PLENUMS

A. Seal fresh air inlet and exhaust air plenums watertight at louvers or otherwise subject to water entrainment at all bottom joints and seams and up all vertical seams for a minimum of 12-in.

Remove excess sealant before it sets hard. Where possible, pitch fresh air inlet and exhaust air plenums down towards the louver. Where it is not possible to pitch the plenum, provide a 1-in capped drain connection at the low point of the plenum.

3.12 TEST PORTS

A. Where shown on the Drawings and where required for testing and balancing, provide instrument insertion ports. Size and location of ports shall be coordinated with the Contractor performing air balancing. Seal ports with plastic snap lock plugs. When the ductwork will be insulated, extend the port to the face of the insulation and seal the vapor barrier to the port. When the ductwork is lined, extend the port into the duct to the inner surface of the duct liner.

B. In round ductwork provide 2 ports 90 degrees on centers. In rectangular ductwork provide ports as required by AABC or NEBB for a full traverse measurement.

C. As a minimum, ports shall be provided in the following connections:

1. All duct mains.

2. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.

3. All connections to tanks or hoods where there is no other access for taking a measurement.

D. A main duct is defined as one of the following:

1. A duct serving five or more outlets.

2. A duct serving two or more branch ducts.

3. A duct emanating from a fan or plenum.

4. All remaining ducts are considered branch ducts.

3.13 VAV BOXES, DIFFUSERS AND TERMINALS

A. Perforated metal straps for support of VAV boxes, diffusers and terminal units will not be permitted.

B. Supporting VAV boxes, diffusers or terminal units from ducts, pipes or furring will not be permitted.

3.14 SOUND TESTS - VAV BOXES

A. Sound power levels shall be measured in accordance with the ASHRAE Standards 68.

B. When measured at the unit outlet terminals, the maximum permissible power level for each octave band shall be according to the following schedule:

Octave Band	Frequency (CPS)	Max PWL (db Re 10-12W)
1	63	62
2	125	56
3	150	49
4	500	46
5	1000	43
6	2000	42
7	4000	41
8	8000	42

C. Units located in ceiling plenums over occupied spaces, the maximum permissible radiated sound power level for each octave band, for installed and operating conditions shall be in accordance with the following schedule:

Octave Band	Frequency (CPS)	Max PWL (db Re 10-12W)
1	63	72
2	125	70
3	250	61
4	500	60
5	1000	57
6	2000	56
7	4000	66
8	8000	65

D. Manufacturer shall submit to the Engineer for approval, guaranteed soundpower level ratings by octave bands. These ratings shall list the sound power generation of each unit within the test chamber. Sound power generation shall be specified for upstream pressures of 3-in w.g., 2-in w.g. and minimum pressure w.g. Until such data is submitted, neither the manufacturer nor the specific unit selected will be approved.

3.15 ADJUSTMENT

A. Start-Up and Temporary Operation

1. Properly maintain and service all equipment and systems until the particular equipment or the system has been accepted by the Owner.

3.16 PAINTING

A. Paint the outside face of all louver blank off panels and the interiors of unlined plenums and ductwork where connected to louvers. Prime and paint with two coats of flat black exterior paint. Painting shall be performed under this Section and shall be as specified in Division 9.

3.17 CLEANING OF DUCTWORK

A. Maintain all ductwork, fans, coils, air filters, outlets and other parts of the ductwork systems in a clean condition during installation.

B. Clean complete ductwork systems prior to testing and air balancing. Secure cheese cloth over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

3.18 INSTALLATION OF DUCTWORK INSULATION

A. Provide ductwork insulation as specified under Section 15250 and with thickness as specified under this Section.

B. Ductwork Insulation - Blanket Type (Type I-5)

1. Hot Ductwork

a. Insulation Thickness - Concealed round and rectangular hot ductwork and exposed round hot ductwork.

1)	Supply ducts in heated spaces	1-1/2-in
2)	Supply ducts in unheated spaces	2-in
3)	Return ducts	1-1/2-in
4)	Mixed air ducts	1-1/2-in

2. Cold and Hot/Cold Ductwork

a. Insulation Thickness - Concealed round and rectangular cold and hot/cold ductwork and exposed round cold and hot/cold ductwork.

1)	All ducts in non-conditioned spaces	2-in
2)	All ducts in conditioned spaces	1-1/2-in
3)	Outdoor air ducts and plenums	2-in
4)	Exhaust air ducts and plenums between shut-off damper and outdoors	1-1/2-in
5)	Ventilation supply air ducts and plenums between shut-off damper and outdoors	2-in

C. Ductwork Insulation - Fiberglass Board Type (Type I-6)

1. Hot Ductwork

a. Insulation Thickness - Exposed rectangular hot ductwork.

1)	Supply ducts in heated spaces	1-1/2-in
2)	Supply ducts in unheated spaces	2-in

3)	Return ducts	1-1/2-in
4)	Mixed air ducts	1-1/2-in

2. Cold and Hot/Cold Ductwork

   a. Insulation Thickness - Exposed rectangular cold and hot/cold ductwork.

1)	All ducts in non-conditioned spaces	2-in
2)	All ducts in conditioned spaces	1-1/2-in
3)	Outdoor air ducts and plenums	2-in
4)	Exhaust air ducts and plenums between shut-off damper and outdoors	1-1/2-in
5)	Ventilation supply air ducts and plenums between shut-off damper and outdoors	2-in

D. All ductwork, except as specifically noted below, shall be insulated unless approved in writing by the Engineer.

1. Exposed supply and return air ductwork located in the area it serves.
2. Exposed ventilation exhaust and relief ductwork located in the area it serves.
3. Exposed ventilation and relief ductwork located in areas that are neither heated nor cooled.
4. Exposed outdoor air intake ductwork and plenums located in areas that are neither heated nor cooled.
5. Return air ductwork located in return air ceiling spaces above the area it serves, except where the return ductwork is installed in ceiling spaces with a roof above.
6. Toilet exhaust from toilets without showers, up to the exhaust air plenum if applicable.
7. Toilet exhaust from toilets with showers in heated spaces, up to the exhaust air plenum if applicable.
8. Process exhaust ductwork when the exhaust air temperature is within plus/minus 10 degrees F of the surrounding space, up to the exhaust air plenum if applicable.

END OF SECTION

SECTION 15891

FIBERGLASS DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, fabricate and install all fiberglass reinforced plastic (FRP) ductwork including fittings, accessories, dampers, hangers and any incidental work or components required and provide complete air supply, return and exhaust ductwork systems as shown on the HVAC and Mechanical Drawings and as specified herein.

B. Design, furnish and install seismic restraints and braces for all ductwork and accessories.

C. In general, ductwork shall consist of any passageway made of FRP substantially air-tight, used for the conveying of air, gas or materials. Included are fittings, transitions, bracing, fasteners, sealers, supports and accessories such as access panels, access doors, turning vanes and manual air balancing dampers. All ductwork shall be of size and material as specified herein and as shown on the Drawings. All duct sizes indicated on the Drawings are clear, inside dimensions.

D. Any change in duct sizes, offsets, transitions and fittings required to accommodate job conditions shall be submitted to Engineer for approval.

1.02 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, the following drawings and data. Ductwork shop drawings shall include typical details of discharge nozzles, transitions, elbows, fittings, accessory items such as access panels or access doors, turning vanes, volume control and splitter dampers, volume extractors, hangers, joining methods, bracing and material gauges. Drawings of general layouts of individual systems shall be submitted, scale shall be 1/4-in = 1-ft-0-in minimum.

B. The following additional data shall be submitted.

1. Manufacturer's qualification and experience data, specifications and installation instructions, factory and field quality control procedures catalog data, brochures, descriptive matter, illustrations, diagrams and color charts of ductwork to be selected.

2. Specific handling and storage requirements for ductwork, joint kits and resin systems.

3. Sample coupons of laminate not less than 1-ft square. Provide sample laminate coupons for each method of manufacture and for both round and rectangular duct manufacturing methods.

4. Resin system data, including chemical environment service test data, case history data of similar installations (with contact addresses), resin pot life and time versus temperature data required for complete resin cure for laminate thicknesses actually proposed.

5. Submit design calculations signed and sealed by a professional engineer and fabrication procedures for record purposes only. Also submit a letter certifying that the laminates fabricated with the proposed resin system will give satisfactory performance under the specified service conditions and stating the service conditions for which certification is provided and indicating compliance with specified pressure and vacuum design criteria.

6. Submit construction details for flexible connectors, expansion joints, elbows, transitions, junctions and flanged fittings including dimensioned laminate cross sections and flange fabrication and assembly details.

7. Submit results of factory readings taken with "Barcol Hardness Impressor" and provide procedure to field check for complete cure of resin.

8. Certified service tables for the resins being used and the expected contaminants showing satisfactory services for the required design conditions.

9. Detailed instructions for field joining of the ductwork to include quality control procedures.

10. Submit shop test reports for fiberglass reinforced plastic dampers.

1.03 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM C581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.

B. National Fire Protection Association (NFPA)

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.

2. NFPA 91 - Standard for Exhaust Systems for Air Conveying of Materials.

3. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.

C. Underwriters Laboratories (UL)

1. UL 555 - UL Standard for Safety Fire Dampers.

D. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

E. American National Standards Institute (ANSI)

1. ANSI RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. All FRP duct and fittings shall be from a single manufacturer.

B. All materials shall be supplied by a manufacturer experienced in the fabrication of materials similar to those specified. Design and engineering shall be performed by personnel regularly employed by the manufacturer who are experienced in the design of FRP systems similar to those specified.

C. The manufacturer shall provide factory trained personnel for training of installers and for supervision and inspection of the installation. The use of local sales representatives for this service is not acceptable.

D. Corrosion resistance data shall be based on ASTM C581.

1.05 DELIVERY, STORAGE AND HANDLING

A. Equipment, material and spare parts are to be shipped complete except where partial disassembly is required by transportation regulations or for protection of components. No ductwork or components shall be shipped prior to complete resin cure.

B. Inspection of the duct and components will be made by the Engineer or other representative of the Owner after delivery. Materials shall be subject to rejection at any time on account of failure to meet any of the specified requirements. Material rejected after delivery shall be marked for identification and shall be immediately removed from the jobsite.

1.06 STANDARDS OF CONSTRUCTION AND INSTALLATION

A. All ductwork construction and installation details shown on the Drawings and specified herein are based on acceptable methods of construction and installation and are intended to define the quality of construction and installation to be furnished. Alternate details may be submitted for approval.

1.07 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents.

1.08 DEFINITIONS

A. Refer to Section 15890 for definitions.

PART 2 PRODUCTS

2.01 MATERIAL

A. Design Conditions

1. Temperature: minus 10 to 125 degrees F

2. Pressure: 20-in H_2O w.g. positive; 20-in H_2O w.g. negative

3. Flow medium and velocity: air at 2500 fpm

4. Wall thickness: refer to SMACHA Standard

a. Up to 36-in diameter - 0.187-in struct. wall plus 0.10-in liner

b. 38 to 60-in diameter - 0.250-in struct. wall plus 0.10-in liner

B. The following materials are expected to be in the air stream or surrounding area. The resins used shall be suitable for all of the following level of compounds:

1. H_2SO_2 (Sulfuric Acid) up 2000 ppm.

2. H_2S (Hydrogen Sulfide) up 2 ppm

3. CL_2 (Chlorine from Sodium Hypochlorite, up 10 ppm)

2.02 CLASSES OF CONSTRUCTION

A. Ductwork shall be designed and constructed for the following services and in accordance with ANSI RTP-1.

Systems	Location	Static Pressure	Material Conveyed	Construction Material
Odor Controls	See Mech Dwgs	± 20	Air	SMACHA Standard FRP Manual latest edition

B. Design of ductwork shall include all loads applied to the ductwork, in addition to the load of the duct. These loads include but are not limited to wind, snow and internal dirt or liquid buildup.

2.03 FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK

A. FRP ductwork shall be of contact molded or filament wound construction, or a combination of these methods, to meet design criteria.

B. FRP ductwork shall have a flame spread rating of 25 or less inside and outside and a smoke developed rating of not more than 50 in accordance with NFPA 91. Sprinklers shall not be used for internal fire suppression.

C. Laminates shall consist of a 20 mil (finished thickness) minimum chemical resistant interior liner with an apertured synthetic surface veil embedded in a resin rich surface. The corrosion barrier shall be a minimum of 100 mils thick and include not less than two layers of 1-1/2 oz mat with 25 percent glass and 75 percent resin content. The structural layer shall be of sufficient thickness to meet the minimum thickness requirements specified. The exterior surface layer shall be resin rich "C" - glass or apertured nexus veil not less than 20 mils thick. Outside finish shall be a pigmented, parrafinated gel coat with an ultra violet inhibitor. The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8-in in diameter and not over 1/32-in deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits.

D. Resins used in the laminate shall be premium corrosion resistant and fire retardant vinylester resins and shall contain 3 percent NYACOL as a fire retardant. The duct exterior should be a low flame spread low smoke surface equal.

E. Fittings and Joints: All fittings such as elbows, laterals, tees and reducers shall be of the same resin as and equal or superior in strength to the adjacent duct section and shall have the same internal dimensions as the adjacent duct. Non-flanged duct joints shall be butt wrapped or bell and spigot joints. Bell and spigot joints shall be sealed with a standard butt joint overlay as per PS 15-69. The interior opening between the bell and spigot shall be sealed with a resin paste so that no glass fibers are exposed and all voids are filled. Field cut duct ends and exposed glass fibers shall be resin coated prior to joint assembly to maintain a continuous interior corrosion barrier. Coat all exterior surfaces of joints with a paraffinated resin-rich gel coat with UV inhibitors.

F. Total width of overlay for butt-wrap joints shall be not less than 6-in for diameters from 6-in up to and including 30-in, 36-in and larger shall be not less than 10-in.

G. Round Standard Elbows

1. Standard elbow centerline radius shall be equal to one times the diameter.

2. Standard elbows up to 24-in diameter shall be smooth radius molded elbows. Standard elbows 30-in diameter and greater may be mitered sections as specified below.

3. 0 to 44 degree elbows shall contain one mitered joint and two sections. 45 to 80 degree elbows shall have a minimum of two mitered joints and three sections. Elbows greater than 80 degrees shall have a minimum of four mitered joints and five sections.

H. Rectangular Fittings

1. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required to meet the specified

deflection requirements and to provide a system free from pulsing, warpage, sagging and undue vibration.

2. Provide forming vanes in all mitered rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.

I. Reinforcing

1. Round duct reinforcing shall be factory installed with spacing between reinforcing located to avoid all hangers and support saddles.

2. Rectangular duct and fitting reinforcing shall be factory located and installed to avoid duct hangers, support saddles, bracing, branch take offs and entries, and plenum connections. Routine field cutting and field relocation of factory installed reinforcing is not acceptable.

J. Tolerances

1. Out-of-roundness of duct shall be limited to plus or minus 1/8-in or plus or minus 1 percent of duct inside diameter, whichever is greater for duct sizes 6-in diameter and greater.

2. Rectangular duct tolerances shall be 3/16-in for duct diameter up to 18-in and plus or minus 1 percent for dimensions of over 18-in.

3. All unflanged duct shall be square on the ends in relation to the pipe axis and plus or minus 1/8-in up to and including 24-in diameter and plus or minus 3/16-in for all diameters greater than 24-in.

4. Fittings

   a. The tolerance on angles of all fittings shall be plus or minus 1 degree, up to and including 24-in diameter and plus or minus 1/2 degree for 30-in diameter and above.

5. Flanges

   a. Flange faces shall be perpendicular to the axis of the duct within 1/2 degree.

   b. Flange faces shall be flat to within plus or minus 1/32-in, up to and including 18-in diameter and flat within plus or minus 1/16-in for 20-in diameter and larger.

   c. Provide custom filler pieces as required to mate flanges squarely.

K. Calculations for wall thickness determination shall be based on the structural fiberglass reinforced wall only. Long term deflection shall not exceed 1 percent of duct diameter or duct width for rectangular ducts. Round and rectangular FRP ductwork shall be designed using a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service. Round duct shall be designed by manufacturer to resist specified loadings but in no case shall FRP duct be less than the thickness as required in Chapter 5 of FRP Duct Construction Manual at specified conditions.

Where rectangular duct is used the longest dimension shall be considered equivalent to diameter.

Rectangular duct may be reinforced with angles or tees as required to meet the required pressure/vacuum service.

L. All connections to expansion joints, butterfly dampers, fire dampers, tanks, or other equipment shall be flanged. Gaskets shall be chlorobutyl. Flanges shall be hand laid up to thickness specified in PS 15-69 except that minimum thickness shall be 3/4-in. Each flange face shall be ground flat, and a new 100 mil corrosion barrier shall be applied. The flange shall be anchored to a waxed table to ensure the flatness tolerance outlined above. The face shall be textured for use with full face chlorobutyl gaskets, 1/8-in minimum thickness. Flange drilling shall be as per PS 15-69. All bolt holes shall be back spot faced for a washer seat. All flange bolts shall be torqued to values as recommended by manufacturer.

M. Fasteners: Furnish all bolts, nuts, washers and other fasteners required. Material of metallic fasteners shall be Type 316 stainless steel.

N. There shall be not less than a 1/4-in buildup of FRP over the duct at each support and as shown on the Drawings.

O. Provide 1-in minimum PVC pipe and PVC ball valve duct drains in the bottom of all main, branch and riser ducts to allow removal of condensate.

2.04 FLEXIBLE CONNECTORS

A. Furnish flexible connectors at each inlet and outlet of fan and in the duct runs where required for expansion, contraction and movement. Flexible connections shall be integral flange molded arch type units constructed of EPDM rubber 1/4-in thick, reinforced with a strong synthetic asbestos-free fabric suitable for corrosive service. The flexible connections shall be designed to minimize the transmission of vibration from the fans to the ductwork at the suction and discharge connections. Expansion or contraction flexible connections shall be designed to allow 1-in movement. Working length or "live" length shall be as designed by the manufacturer to allow up to 1-in of movement. Ends shall be flanged, with flanges matching duct connection flanges. Corners on rectangular expansion joints shall be molded and free of patches or splices. The flexible connections shall be suitable for outdoor service and temperature ranges from minus 10 up to 125 degrees F, and pressure to 5 psig. Specially fabricated split Type 316 stainless steel retaining back-up bars shall be supplied to prevent damage to the EPDM rubber flanges when Type 316 stainless steel bolts are tightened.

B. Where the construction of the flexible connections or vibration isolator results in a cross sectional area of the connection which is less than 90 percent of the adjacent ductwork, the size of the connection shall be increased to provide a cross sectional area equal to or greater than 90 percent of the adjacent duct.

C. Provide flexible duct connections at both the intake and discharge connections for all fans and air handling units except as noted below.

1. Wall and roof fans that have integral motor/fan wheel isolation.

2. Air handling units where the fan is isolated from the intake and discharge connections by internal flexible connections or separations, and the unit is mounted without vibration isolators between the unit and the support structure.

D. Ductwork spacing and alignment for flexible connections shall be aligned to the tolerances of the flexible connection manufacturer, or plus/minus 1/4-in whichever is less. Bolts shall be torqued to the manufacturer's recommendations. Do not over tighten.

E. Where flexible connections are used as expansion joints, the manufacturer's precompression recommendations must be followed. When the temperature at installation differs from the temperature in the precompression recommendation, a correction shall be made.

F. Manufacturer:

1. Holz Rubber Company.

2. Mercer Rubber Company.

3. Proco Products, Incorporated.

4. Or equal.

2.05 TOOLS, SPARE PARTS AND MAINTENANCE MATERIALS

A. The duct system shall be furnished with the following:

1. One set of special tools required to maintain and repair the system.

2. All materials in kit form to make or repair joints. Additional kits shall be supplied sufficient to repair 10 percent of the joints. Materials shall be packaged for long term storage.

3. Names and addresses of all manufacturers of: Fiberglass reinforcements, resins, hardeners and components used to repair and maintain the FRP duct system.

B. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location, until transferred to the Owner at the conclusion of the project.

C. Material safety data sheets for all components must be furnished.

2.06 FIBERGLASS REINFORCED PLASTIC DAMPERS

A. Furnish and install where indicated on the Drawings manually operated butterfly or parallel blade dampers, with handle for manual operation and positive locking quadrant for balancing purposes. Dampers shall be flanged connection and fabricated from materials similar to those specified in Paragraph 2.03 above.

B. Locking quadrants shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable.

C. Rating Conditions

1. Velocity Through Damper: 4000 fpm.

2. Pressure Rating: ±20-in water column.

3. Allowable Leakage: With a differential pressure of 12-in wg.

Size (in Dia.)	Maximum Allowable Leakage (cfm)
72	200
66	186
60	172
54	158
42	130
36	50
24	25
18	20

4. One damper of each size shall be shop tested at 12-in wg differential and shall meet the above leakage. Submit damper test report to the Engineer. Damper shall not be shipped until approved by the Engineer.

D. Materials

1. Bearings, Teflon.

2. Blade: FRP, angle reinforced.

3. Frame: FRP.

4. Axles: FRP rods, full length of damper size as shown on the Drawings.

5. Finish: FRP.

6. Handle: Type 316 stainless steel, or FRP.

7. Pins: Type 316 stainless steel.

8. Blade Stops: FRP angles with elastomer seals suitable for use at the design conditions.

9. Bushings: Teflon.

10. Hardware: Type 316 stainless steel.

11. Angles: FRP.

E. Dimensions: As detailed on the Drawings.

F. Manufacturer: Provide products of one of the following:

1. Ershigs Incorporated.

2. Bionomic Industries, Interchem Systems Division.

3. Heil Process Equipment, Xerxes Corporation.

4. Swartwout, Phillips Industries.

5. Calgon Corporation.

6. Or equal.

2.07 FRP TRANSITION PIECES:

A. Provide transition pieces as shown on Drawings and specified herein.

B. Construction:

1. Thickness of transition pieces shall be designed using a safety factory of 10 to 1 for pressure and 5 to 1 for vacuum service with the pressure classification listed below.

2. Custom flanges shall be designed as required to connect to fans, coils, dampers and duct work. Coordinate flange sizes to match approved equipment dimensions.

C. Pressure Classification: Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warpage and sagging at design pressures.

PART 3 EXECUTION

3.01 INSTALLATION

A. All ductwork shall be fabricated and erected where shown on the Drawings or as specified herein. Ductwork shall be rigidly supported and secured in an approved manner. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment. Building siding and metal decking shall not be used to hang ductwork.

B. Wherever ducts are divided, the cross-sectional area shall be maintained. All such changes must be approved and installed as directed by the Engineer or as approved on shop or erection drawings.

C. During installation the open ends of ducts shall be closed to prevent debris and dirt from entering. Work shall be installed in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.

D. The unused portion of external louvers (where it is not as a fresh air intake or exhaust) shall be provided with a blank-off constructed of 0.0625-in aluminum. Blank-off panels shall be provided with aluminum reinforcing angles to prevent buckling and secured to the exterior wall with aluminum angles and rustproof fasteners on not more than 12-in centers. Caulking shall be provided completely around the outside edge of the angle and the aluminum.

E. Install automatic dampers when supplied by other trades.

F. The Drawings of the air ducts and air risers indicate the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.

G. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, the cross-sectional area shall be maintained. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.

H. The taper of all transformations shall be not more than 15 degrees.

I. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions. Notify the Owners representative prior to starting any field modifications involving ductwork structural reinforcing members. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.

J. No ductwork or components shall be shipped prior to complete resin cure.

K. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self tapping screws or other fastening methods that will damage the coating are not acceptable.

3.02 HANGERS

A. Rectangular Ductwork, Round and Flat-Oval Ductwork - Spacing and size of hangers shall be as required by the ductwork manufacturer. Ductwork support systems shall include restraints as required by the applicable building codes to withstand seismic loading. Design shall be provided by a professional engineer hired by the Contractor as specified in other sections of the specification.

B. All hanger materials shall be galvanized steel aluminum Type 316 stainless steel.

C. Perforated band iron or wire for supporting ducts will not be permitted. Ducts shall not be supported from furring, hung ceilings or from another duct or pipe.

D. C-clamp type hangers shall be supplied with a retainer strap.

E. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.

F. Fiberglass ductwork shall be properly anchored and supported from building structure where indicated on the Drawings. Support anchoring for horizontal ducts shall be 10-ft-0-in on center, maximum spacing or as required by FRP Manual. Each anchor shall consist of two semi-circular stainless steel bands around the duct bolted together vertically and horizontally. The structural supports or wall securement shall be stainless steel and furnished and installed under this Section.

G. All fittings expansion joints and similar items shall be supported within 18-in of the joint unless otherwise noted.

H. Hanger system shall use threaded rod for adjustability for ductwork over 24-in in diameter or width.

I. The following methods of hanger attachment to the building structure are NOT allowed. The numbers and letters refer to hanger methods shown in Figure 4-1, 4-2 and 4-3 of the 1985 edition of the HVAC Duct Construction Standards Metal and Flexible as published by SMACNA.

"T"- wrap around strap on open web joist.

"W" - bent over band on open web joist.

"14" - friction clamps.

"17" - bent wire in metal deck.

J. Design of hangers shall include the effect of all loads applied to the duct as well as the load of the duct. These loads include, but are not limited to wind, snow and internal dirt or liquid buildup.

3.03 DUCTWORK FITTINGS AND ACCESSORY ITEMS

A. Duct Elbows - Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air. All elbows shall have a centerline radius of not less than 1-1/2 times the width of the duct in the plane of the elbow. For rectangular ductwork where full radius elbows cannot be installed or abrupt elbows are shown, provide abrupt elbows equipped with shop-installed hollow, fiberglass air foil turning vanes. An access door shall be installed at each abrupt elbow, so located for easy access to turning vanes.

B. Dampers

1. Manual volume control dampers shall be installed wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings. Dampers shall be standard butterfly or parallel blade type on channel frame with external damper position indicator, manual adjustment and position locking arrangement.

2. An access door, of ample size to permit maintenance and resetting of damper blades, shall be installed at each damper, so located for easy access to the damper blades.

C. Access Doors

1. Hinged access doors shall be installed where listed below, wherever shown on the Drawings and wherever access may be required for service, maintenance and adjustment. Access doors shall be 24-in by 24-in minimum, except where the duct size is less than 26-in, where the largest door that will fit the duct will be used. Unhinged access panels are not acceptable, except where so specified on the Drawings. Access doors shall be of the same material as the duct. Doors shall be substantially butt hinged, with heavy sash locks and substantial door pulls. Door openings and door frames shall be reinforced with bar stock or angle. Access doors may be factory fabricated. Access door hardware shall be Type 316 stainless steel.

2. Provide access doors at the following locations (minimum requirements):

   a. Automatic dampers - linkage side.

   b. Duct mounted temperature controllers.

   c. Freeze-stats.

   d. Manual balancing dampers.

   e. Turning vanes.

   f. Fire dampers.

   g. Smoke dampers.

   h. Inlet side of centrifugal fans.

   i. Inlet and outlet sides of tubular axial-flow fans.

   j. As necessary or required.

3. Where access doors are required in ductwork located above ceilings the location of the access doors shall be coordinated to clear the ceiling support system and to be accessible through the ceiling grid.

3.04 FILLING IN SPACE AROUND DUCTS

A. To prevent sound passing through the area between the duct and the framed or cut opening in the floors, walls or partitions, mineral wool shall be packed to completely fill the space the full depth of the opening. Whenever a fire-rated wall or floor is penetrated the space around the duct shall be filled with a locally approved type of fireproof rope.

B. At fire walls, apply Type 316 stainless steel sheet metal escutcheon plates on both faces of the wall in order to close the gap between the structure and the sides of the insulated or bare duct.

3.05 DUCT SUPPORTS THROUGH FLOORS

A. Where vertical ducts pass through floor openings, supporting angles shall be rigidly attached to the ducts and anchored with expansion bolts to the floor or curb. Angles shall be Type 316 stainless steel placed on the two long sides of the duct extending 3-in over edge of opening,.

B. Remaining open area in the floor opening shall be sealed with a Type 316 stainless steel plate.

3.06 SUPPORTING OUTDOOR DUCTS

A. All ductwork supports to structural frames, guides shall be the complete responsibility of the Duct Supplier. As a minimum, duct supports and guides shall consist of a clamp which will clamp around the duct for mounting on the systems supplier's structural frame. An elastomer shall be provided between the clamp and duct to prevent chaffing. Provide all pads, bolts, clamps, and kits for installing field applied stainless steel collars and straps required for the supports and guides. Supports shall be used to anchor the duct inplace, preventing all longitudinal and lateral motion of the duct. Guides shall allow longitudinal movement to provide for thermal expansion, and restrict lateral motion. The duct supplier shall determine the location of supports and guides to allow thermal expansion. Locations of supports, anchors joints shown on drawing are to be used as guide. All duct supports shall be provided with restraints to withstand to seismic and wind loading as per Section 17500-2.03.

B. Ducts shall be sloped to shed water.

3.07 DUCTWORK AT MASONRY

A. Where ducts connect to or terminate at masonry openings or along the edges of floors where concrete curbs are not being provided, there shall be placed around the ductwork a continuous 2-1/2-in by 2-1/2-in by 3/16-in angle of the same material as the duct which shall be bolted to the construction and made air tight to same by applying caulking compound on the angle before it is drawn down tight to construction.

B. Plenums connected to concrete curbs shall be fastened with 3-in by 3-in by 1/4-in thick continuous angle of the same material as the duct. Concrete curbs will be provided under another Division. This angle shall sit on a continuous bead of caulking compound and be anchored to the curb at 16-in centers. The duct shall terminate at the curb and be fastened to the angle. A continuous bead of caulking compound shall seal the plenum to the curb.

C. When exposed ducts pass through finished floors, walls or ceilings, provide angle collars completely covering space around duct.

3.08 QUALITY

A. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear they shall be corrected by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum requirement as specified in ASHRAE - Systems Volume. No discreet tones will be allowed.

B. The maximum allowable leakage of low pressure system shall be 5 percent of air volume.

C. The maximum allowable leakage of high pressure systems shall be one percent of air volume when tested at 100 percent of the operating static pressure.

D. The Engineer reserves the right to reject acceptance of delivery of any or all pieces of equipment found upon inspection to have any or all of the following defects in the laminate:

1. Blisters
2. Chips
3. Crazing
4. Exposed glass
5. Cracks
6. Burned areas
7. Dry spots
8. Foreign matter
9. Surface porosity
10. Sharp discontinuity
11. Trapped air
12. Any item which does not satisfy the tolerances as specified.

3.09 CLEANING OF DUCTWORK

A. All ductwork, fans, outlets and other parts of the ductwork systems shall be maintained in a clean condition during installation.

B. Complete ductwork systems shall be cleaned prior to testing and air balancing. Cheese cloth shall be secured over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

3.10 PAINTING

A. Louver blank-off panels and ductwork visible through louvers in exterior walls are to be painted black. Painting shall be performed under this Section and shall be as specified in Division 9.

3.11 PLENUMS

A. Fresh air inlet and exhaust air plenums at louvers or otherwise subject to weather entrainment shall be sealed water tight at all bottom joints and seams and up all vertical seams for a minimum

of 12-in. After application excess sealant shall be removed before setting hard. Where possible fresh air inlet and exhaust air plenums shall pitch down towards the louver. Where it is not possible to pitch the plenum a 1-in capped drain connection shall be provided at the low point of the plenum.

3.12 TEST PORTS

A. Where shown on the Drawings and where required for testing and balancing instrument insertion ports shall be provided. Size and location of ports shall be coordinated with the contractor performing air balancing. Ports shall be sealed with plastic snap lock plugs. When the ductwork will be insulated the port shall be extended to the face of the insulation and the vapor barrier sealed to the port.

B. In round ductwork provide 2 ports 90 degrees on centers. In rectangular ductwork provide ports as required by AABC or NEBB for a full traverse measurement.

C. As a minimum, ports shall be provided in the following connections:

1. All duct mains.

2. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.

3. All connections to tanks or hoods where there is no other access for taking a measurement.

D. A main duct is defined as one of the following:

1. A duct serving five or more outlets.

2. A duct serving two or more branch ducts.

3. A duct emanating from a fan or plenum.

4. All remaining ducts are considered branch ducts.

3.13 INSULATION

A. Refer to Section 17890 for insulation thickness.

END OF SECTION

SECTION 15950

ELECTRIC AUTOMATIC TEMPERATURE CONTROL SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install a complete electric automatic temperature control system as manufactured by Honeywell, Inc.; Johnson Controls or Andover Controls.

B. The automatic temperature control (ATC) shall be as specified herein and shall perform the functions specified and shown on the Drawings.

C. The control system shall be installed by competent mechanics, technicians and electricians in the direct employ of the automatic temperature control manufacturer.

D. The manufacturer shall be fully licensed at the time of bid to do business in the job site area for each type of subsystem. Wholesalers, contractors, franchisers, dealers, or any firm whose principle business is not that of manufacturing and installing DDC controls will not be acceptable.

E. The manufacturer shall provide a system to meet requirements of NFPA-72A, 72B, 72C and 72D, and shall be listed by UL. Each component of the system shall be, where applicable, UL listed for the intended service.

F. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems, and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use.

G. The control system shall consist of all thermostats, temperature transmitters, flow switches, flow elements, flow transmitters, local flow controllers, ionization type smoke detectors, automatic valves and dampers, damper operators, control panels, electric relays, and other accessory equipment along with a complete system of electrical wiring to fill the intent of the specification and provide for a complete and operable system. All control equipment shall be fully proportioning, except as noted otherwise.

H. Control sequences shall be as shown on the Drawings.

1.02 RELATED WORK

A. The following shall be furnished and/or installed, under other sections:

1. Separable thermometer wells are included under Division 15.

2. All necessary valve pressure taps, water drain and overflow connections and piping are included under Division 15.

3. On magnetic starters the necessary auxiliary contacts, with buttons and switches in the required configurations are included under Division 15 and Division 16.

4. The necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified is included under Division 15. Locate baffles by experimentation and affix and seal permanently in place only after stratification problem has been eliminated.

5. Access doors or other approved means of access through ducts for service to control equipment is included under other Sections.

B. The installation of the following shall be under Division 15:

1. Automatic valves. Section 15505

2. Automatic dampers. Section 15890

C. The following are to be furnished and installed under other sections of Division 15, but will be integrated with the work of this Section:

1. Boilers Section 15555

2. Chillers Section 15620

3. Air Handling Units Section 15855

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, shop drawings and product data for the following:

1. Control drawings with composite wiring diagrams, including bill of material and description of operation for all systems.

2. Panel layouts and nameplates lists for all local and central panels.

3. Where a computer interface is used, submittals must include the screen graphics and displays. Submittals shall be on 8.5 by 11-in paper in color, and shall be, as they will be seen on the screen. Submittals shall indicate links from screen to screen. A basic template indicating the screen formats shall be submitted and approved prior to preparing the actual displays. This early submittal shall also include a listing of expected screens. All screens are to be approved prior to system installation

4. Valve and damper schedules showing size, configuration, sizing, pressure vs. flow diagrams for the fluid used, capacity, and location of all equipment.

5. Data sheets for all control system components.

6. Provide a recommended list of spare parts to be provided.

7. Software licensing and user agreements will be submitted for approval with the shop drawings for the equipment using the software. The submittal shall be a copy of the final agreement document that is to be signed.

8. Technical specification data sheets of each system component and device with indication of its use.

9. Complete listing of deviations from the system as specified.

10. Training manuals for each of the subjects required to be covered in training to include teaching plans, duration of each class, and maximum size of each class are to be submitted for review a minimum of three months prior to starting training. The manuals are to be broken down into the material required for each of the various courses. The submittal shall also include supplemental materials that will be used in the class and copies of overheads or slides if they are not in the preceding material.

11. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

12. All submittals shall contain a statement that Sections 15500, 15505, 15890, 15950 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. The manufacturer shall provide a system to meet requirements of NFPA-72A, 72B, 72C and 72D, and shall be listed by Underwriters Laboratories. Each component of the system shall be, where applicable, UL listed for the intended service and meet the safety requirements.

1.05 QUALITY ASSURANCE

A. The manufacturer must have a branch office facility with 25 miles of the project for at least 5 years, with technical staff and complete spare parts inventory and test and diagnostic equipment to keep systems in operation 24 hours per day 7 days per week. He/She shall have emergency service available in the local area for temperature control systems for which he/she is currently performing on-call emergency service 24 hours per day 7 days per week with a maximum response time of 4 hours.

B. The automatic temperature control contractor shall have in his/her direct employ the personnel capable of detailed engineering, coordination, drafting, procurement, and expediting, scheduling construction, testing, inspection, installation, startup, calibration, and commissioning.

C. The equipment to be furnished under this Section shall be essentially the standard product of the manufacturer. Where two or more units of the same class of equipment are required, they shall

be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

D. Several manufacturers are indicated as acceptable for some items of equipment in these specifications. The HVAC Subcontractor shall be responsible for determining that all equipment supplied for this project is suitable for installation and proper operation in the space provided with fully adequate operating and maintenance access space.

E. The equipment furnished for installation under this Section shall be tested at the factory as standard with the manufacturer of the equipment.

F. Unless otherwise indicated, the controls shall maintain space temperatures within plus or minus 0.5 degrees F, and space relative humidity within plus or minus 5 percent of their set points.

G. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

H. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.07 COORDINATION

A. The HVAC Subcontractor shall assume full responsibility for the coordination of the work of this Section with that of the Refrigeration, Heating and Air Distribution Systems sections to accomplish the requirements of space conditioning as indicated on the construction drawings and as specified. The control manufacturer shall furnish, install, supervise and test the field wiring associated with the work of this Section and shall be responsible to coordinate the installation of controls with the HVAC Subcontractor.

B. The Automatic Temperature Control System manufacturer shall coordinate the locations of desired items such as access doors, size of instrument holes, conduits/wiring, or other devices in the ductwork, piping and plenums with the HVAC Subcontractor.

1.08 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved Shop Drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flat bed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for servicing and startup of equipment in long term or prolonged storage shall accompany each item

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.09 ENVIRONMENT

A. All components, including data processing equipment, shall be suitable for operating in a normal plant environment without requirements for special temperature and humidity control.

1.10 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:

a. One complete set of gaskets for each sealed unit.

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components:

a. Thermostats
b. Humidistat
c. Thermometers
d. Pressure gages
e. Control relays
f. Damper operators
g. Valve operators
h. Control transmitters

i. Control transformers
j. Photo-electric type smoke detectors
k. Ionization type smoke detectors

4. Provide a minimum of 4 or 10% of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.

a. Panel light bulbs
b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

PART 2 PRODUCTS

2.01 MATERIALS

A. All products and materials used in this project shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved in writing. Spare parts shall be guaranteed to be available for a minimum of five years after the completion of the project.

2.02 ATC EQUIPMENT

A. Area Classification

1. Where specific area classifications are called for or shown on the electrical drawings, all equipment and wiring shall be in conformance with the requirements for that classification. Special attention shall be given to hazardous areas specifically "Class I, Group D, Div. 1" and "Class I, Group D, Div. 2" to comply with code requirements for equipment selection and installation procedures.

2. The type of enclosure shall be as specified in Division 16.

B. Room Thermostats

1. Temperature sensors for office areas with night setback shall be of the wire-wound resistive element type (RTD) using either nickel or platinum alloy as the resistive element. Temperature sensors shall be provided with concealed adjustment, exposed thermometer for displaying room temperature and override switch to allow occupant to reset setting from unoccupied to occupied mode during unoccupied mode. All temperature sensors shall have an end to end (element to readout display) accuracy of plus or minus 0.5 degrees F.

2. Temperature sensors shall be of the wire-wound resistive element type (RTD) using either nickel or platinum alloy as the resistive element. All temperature sensors shall have an end to end (element to readout display) accuracy of plus or minus 0.5 degree F.

3. Electric room thermostats shall be of the heavy duty all metal type, provided with concealed adjustment and exposed thermometer.

4. Room thermostat and temperature sensors mounted on exterior walls shall be provided with insulated mounting plates.

5. All room thermostats and sensors shall be mounted 4-ft-0-in above finish floor except where otherwise indicated on the Drawings or specified herein or as required by code.

6. Electric thermostats in corrosive areas shall be installed in electric boxes with remote stainless steel bulbs.

C. Low Temperature Non-averaging Safety Thermostat - Electric low temperature thermostats shall have 20-ft low point sensitivity elements, non-averaging type, installed to cover the entire duct or coil area. Location of thermostats shall be as shown on the Drawings. These thermostats shall be two-position with manual reset. Where coils are two banks high, two low temperature thermostats wired in series shall be provided. Provide additional contacts as required. Low temperature safety thermostats shall be provided with a timed bypass to permit cold weather start up. The thermostat shall only be bypassed when the timer is timing. The timer shall be adjustable from 0 to 5 minutes.

D. High Temperature Safety Thermostat - Electric high temperature thermostats shall have a bimetal type sensing element with at least a 10-in insertion length. These thermostats shall be two-position manual reset type.

E. Static Pressure Sensors - Shall be adjustable, set point proportional type, with adjustable range in inches of water to meet the performance or function specified.

F. Ionization Type Smoke Detectors (Four Wire Type)

1. Furnish and install ionization type smoke duct detectors downstream of the air filters and ahead of any branch connections in air supply systems wastewater process areas as shown on the Drawings and having a capacity greater than 2,000 cfm. In addition, furnish and install ionization type smoke detectors all exhaust systems serving wastewater process areas as shown on the Drawings and having a capacity greater than 2,000 cfm. Smoke detectors shall also be installed where shown on the Drawings and where called for on the control sequences.

2. Duct smoke detector shall be suitable for expected air velocity range, temperature range, humidity range, and contaminant range in the airstream as indicated on the associated HVAC Equipment Unit Schedules.

3. The detector housing shall be listed per UL 268A specifically for use in air handling systems. The detector housing shall be equipped with an integral mounting base capable of accommodating either photo electronic or ionization detector heads. It shall be capable of local testing via remote testing station. The duct detector housing shall incorporate an airtight smoke chamber in compliance with UL 268A, Standard for Smoke Detectors for Duct Applications. The housing shall be capable of mounting to either rectangular or round ducts without brackets. An integral filter system shall be included to reduce dust and residue effects on detector and housing, thereby reducing maintenance and service.

4. Detectors shall be provided with two sets of DPDT 10 amp dry contacts in the smoke detector housing to provide smoke alarm signals. One contact is to be used by the ATC systems, and the second is for use by Division 16 for interface to the fire alarm systems.

5. Remote test switch and alarm indicator stations shall be furnished for all duct smoke detectors as specified above. The installation and wiring of the remote stations will be provided under this Section. The remote test stations shall be wall mounted within the visible location of the smoke detector and easily accessible from the floor.

G. Automatic Control Valves

1. All automatic control valves including butterfly type shall be fully proportioning with modulating plug or V-port inner guides, unless otherwise specified. The valves shall be quiet in operation and fail safe in either normally open or normally closed position as specified in the event of control failure. All valves shall be capable of operating in sequence when required by the sequence of operation. Flow data shall coordinate with the shop drawings for equipment controlled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressure involved.

2. Valve construction shall conform to the requirements specified for the piping for the system.

3. Valve actuator and trim shall be furnished to provide the following minimum close-off pressure rating:

   a. Water Valves:

      1) Two-way: 150 percent of total system (pump) head.

      2) Three-way: 300 percent of pressure differential between ports A and B at design flow or 100 percent of total system (pump) head.

4. Water Valves Sizing Criteria

   a. Two-position service: Line size.

   b. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50 percent of the pressure difference between supply and return mains or 5 psi, whichever is greater.

   c. Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 5psi maximum.

5. Steam Valves Sizing Criteria

   a. Two-position service: Pressure drop 10 percent to 20 percent of inlet psig.

   b. Modulating service: 15 psig or less; pressure drop 80 percent of inlet psig.

   c. Modulating service: 16 to 50 psig; pressure drop 50 percent of inlet psig.

   d. Modulating service: over 50 psig; pressure drop as scheduled on the Drawings.

6. Cold water valves shall be single seated type, except where pressure and flow combination exceeds rating for commercial valve operators, double seated valves may be used.]

H. Electronic Valve Actuators

1. Electronic actuators, less than 600 in-lb of rated torque, shall have ISO 9001 quality certification and be UL listed under standard 873, CSA C22.2 No. 24 and have CE certification. Electronic actuators used on valves shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V-clamp creating a cold weld, positive grip effect. Single point, bolt or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.

2. Actuators shall be fully modulating/proportional, pulse width, floating/tri-state, or two position as required and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required. Proportional actuators shall be capable of digital communication, as built.

3. Two sets of DPDT switches with fully adjustable set points shall be provided to activate panel indicators and provide signals for equipment operation.

4. Actuator shall have an operating range of minus 22 to 122 degrees F.

5. Proportional actuators shall accept a 0 to 10 VDC or 0-20 mA input signal and provide a 2 to 10 VDC or 4-20 mA (with a load resistor) operating range.

6. Actuators shall be capable of operating on 24, 120 or 230 VAC or 24 VDC and Class 2 wiring as directed by the application. Power consumption shall not exceed 10 VA for AC, including 120 VAC actuators and 8 watts per actuator for applications

7. NEMA 2 rated actuators shall be provided with a three foot (minimum), prewired, electrical cable. Actuators requiring removal of the actuator cover for access to wiring terminals, exposing electronics, printed circuit boards to damage, are unacceptable.

8. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end of rotation or magnetic clutches are not acceptable.

9. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models >60 in-lb will be capable of mounting on shafts up to 1.05-in diameter. Spring return actuators with more than 60 in-lb of torque shall have a manual override metal crank. Upon loss of control signal, a proportional actuator shall fail open or closed based on the minimum control signal. Upon loss of power, a non-spring return actuator shall maintain the last position.

10. Actuators using "on-board" chemical storage systems, capacitors or other "on-board" non-mechanical forms of fail-safe operation are unacceptable.

11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Valves requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages, or special factory wiring to function are not acceptable. Actuators in a tandem pair must be "off the shelf" standard actuators ready for field wiring.

12. Valve actuators will not produce more than 62 dbA when furnished with a mechanical fail-safe spring. Non-spring return actuators shall conform to a maximum noise rating of 45 dbA with power on or in the running or driving mode.

13. Proportional actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable. Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload, mechanical travel and mechanical load limit. The actuators shall also provide actuator service data, at a minimum, number of hours powered and number of hours in motion.

14. Actuators shall not be manufactured by a control manufacturer.

15. Where special classifications are shown on the electrical drawings valve actuators shall be provided with suitable enclosures.

16. NEMA 4X enclosures shall be as specified in Division 16 and shall have a shaft seal and all electrical connections shall be suitable for the space classification. Enclosure shall be UL listed.

17. Explosion-proof enclosure shall be suitable for Class I, II and III as specified in Division 16. A suitable shaft seal must be provided. Housing shall be cast copper fill aluminum with stainless steel fasteners and shall be UL listed. Housing shall be suitable for NEMA 4, 7 and 9.

I. Dampers

1. Automatic dampers shall be parallel or opposed blade as specified under "Sequence of Operation."

2. All damper frames are to be constructed of the same material as the duct or a material with greater corrosion resistance sheet metal and shall have flanges for duct mounting. Damper blades shall not exceed 6-in in width. All blades are to be of corrugated type construction, fabricated from two sheets metal spot welded together. Blades are to be suitable for high velocity performance. Maximum blade length in any section shall be 48-in. Additional stiffening or bracing shall be provided for sections exceeding 48-in in height. Multi-section dampers shall be provided with sufficient interconnecting hardware to provide unison operation of blades in the entire assembly.

3. All damper bearings are to be made of nylon.

4. Replaceable butyl rubber or bulb vinyl seals are to be provided with the damper. Seals are to be installed along the top, bottom and sides of the frame and along each blade edge. Seals shall provide a tight closing, low (1 percent) maximum leakage damper. Leakage and flow characteristics shall be submitted to the Engineer prior to approval of dampers.

5. Dampers shall be selected for the velocity and pressure differential required without excessive deflections.

6. Modulating dampers shall be of opposed blade construction. Dampers for two position operation may be single direction multiple-leaf type.

7. Dampers shall have flanged connections.

J. Electronic Damper Actuators

1. Electronic actuators, less than 600 in-lb of rated torque, shall have ISO 9001 quality certification and be UL listed under standard 873, CSA C22.2 No. 24 and have CE certification. Electronic actuators used on valves shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V-clamp creating a cold weld, positive grip effect. Single point, bolt or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.

2. Actuators shall be fully modulating/proportional, pulse width, floating/tri-state, or two position as required and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required. Proportional actuators shall be capable of digital communication, as built.

3. Two sets of DPDT switches with fully adjustable set points shall be provided to activate panel indicators and provide signals for equipment operation.

4. Actuator shall have an operating range of minus 22 to 122 degrees F.

5. Proportional actuators shall accept a 0 to 10 VDC or 0-20 mA input signal and provide a 2 to 10 VDC or 4-20 mA (with a load resistor) operating range.

6. Actuators shall be capable of operating on 24, 120 or 230 VAC or 24 VDC and Class 2 wiring as directed by the application. Power consumption shall not exceed 10 VA for AC, including 120 VAC actuators and 8 watts per actuator for applications

7. NEMA 2 rated actuators shall be provided with a three foot (minimum), prewired, electrical cable. Actuators requiring removal of the actuator cover for access to wiring terminals, exposing electronics, printed circuit boards to damage, are unacceptable.

8. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end of rotation or magnetic clutches are not acceptable.

9. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models >60 in-lb will be capable of mounting on shafts up to 1.05-in diameter. Spring return actuators with more than 60 in-lb of torque shall have a manual override metal crank. Upon loss of control signal, a proportional actuator shall fail open or closed based on the minimum control signal. Upon loss of power, a non-spring return actuator shall maintain the last position.

10. Actuators using "on-board" chemical storage systems, capacitors or other "on-board" non-mechanical forms of fail-safe operation are unacceptable.

11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Dampers requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages, or special factory wiring to function are not acceptable. Actuators in a tandem pair must be "off the shelf" standard actuators ready for field wiring.

12. Damper actuators will not produce more than 62 dbA when furnished with a mechanical fail-safe spring. Non-spring return actuators shall conform to a maximum noise rating of 45 dbA with power on or in the running or driving mode.

13. Proportional actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable. Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload, mechanical travel and mechanical load limit. The actuators shall also provide actuator service data, at a minimum, number of hours powered and number of hours in motion.

14. Actuators shall not be manufactured by a control manufacturer.

15. Where special classifications are shown on the electrical drawings damper actuators shall be provided with suitable enclosures.

16. NEMA 4X enclosures shall be as specified in Division 16 and shall have a shaft seal and all electrical connections shall be suitable for the space classification. Enclosure shall be UL listed.

17. Explosion-proof enclosure shall be suitable for Class I, II and III as specified in Division 16. A suitable shaft seal must be provided. Housing shall be cast copper fill aluminum with stainless steel fasteners and shall be UL listed. Housing shall be suitable for NEMA 4, 7 and 9.

K. Local ATC Panels

1. Where required on the Drawings or the control sequence local ATC panels shall be provided.

2. Electrical power supplied to automatic temperature control panels shall be 120V, single phase, 60Hz. Where 24V power is required, a 120/24 transformer shall be provided. The transformers shall be sized for their control system electrical loads. Transformers shall be mounted in the local control panel.

3. All controllers, relays, switches, etc, for equipment shall be mounted within ATC cabinets with hinge lock type doors where shown on the Drawings. All temperature settings, adjustments and calibrations shall be made at the system control panel.

4. Provide on the local ATC panels a readout of all remote thermometers and sensors as shown on the control drawings. Temperature indications shall be provided for each point of temperature measurement for control and additionally for those points outlined in this Section or shown on the Drawings. Readout shall be provided by dial indicators with a minimum of

3-in diameter, or by digital display using LEDs or LCDs. Readout may be integral with the electronic controller.

5. Details of each ATC panel shall be submitted for approval prior to fabrication. Locations of each panel are to be convenient for adjustment and service. Provide engraved nameplates beneath each panel mounted control device clearly describing the function of said device and range of operation. All manual switches digital readouts and dial thermometers shall be flush mounted on the hinged door, with permanent labels showing the function of each item. All other devices shall be located within the cabinet mounted to a sub panel.

6. All electrical devices within the panels shall be factory pre-wired to a numbered terminal strip. All wiring within the panel shall be in accordance with NEMA and UL standards and shall meet all local codes.

7. All panels shall be provided with lugs or brackets to allow the panel to be firmly fastened to the structure. The lugs and brackets shall be sized to withstand the expected seismic loads for the area and type of application.

8. Provide a 110V power receptacle in each panel.

9. Provide a copy of the wiring and control diagram for all work in each panel. The diagram is to be stored in a pocket on the door.

10. Provide a swing down or slide out shelf to support a lap top computer or other portable interface devices.

L. Local DDC Panels

1. General: Local DDC panels shall be standalone microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each local DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the control functions.

2. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:

   - Control processes
   - Energy Management Applications
   - Alarm Management
   - Historical/Trend Data for all points
   - Maintenance Support Applications
   - Custom Processes
   - Operator I/O
   - Dial-Up Communications
   - Manual Override Monitoring

3. Point types: Each DDC panel shall support the following types of point inputs and outputs:

   - Digital Inputs for status/alarm contacts
   - Digital Outputs for on/off equipment control

- Analog Inputs for temperature, pressure, humidity, flow, and position measurements
- Analog Outputs for valve and damper position control, and capacity control of primary equipment
- Pulse Inputs for pulsed contact monitoring

4. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators. The system architecture shall support 15% expansion capacity of all types of DDC panels, and all point types included in the initial installation.

5. Hardware Override Switches: As indicated in the control sequences, the operator shall have the ability to manually override automatic or centrally executed commands and reset alarms at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

6. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

7. Network Alarm: Provide an audible and visual network connection lost alarm on all local panels to indicate when they are disconnected from network.

8. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Indicator lights called for on the control sequence shall be on the face of the panel.

9. Integrated On-line Diagnostics: Each DDC panel shall continuously perform self- diagnostics, communication diagnosis and diagnosis of subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

10. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980.

11. Power Failure Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

12. All panels shall be provided with lugs, brackets or field supplied devices to allow the panel to be firmly fastened to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application.

M. Miscellaneous Devices - Provide all the necessary relays, limit switches, positioners, valves, clocks, transformers, etc, to make a complete and operable system. Locate these devices on local ATC panel unless specified otherwise.

N. Humidistats - The room humidistat shall have adjustable sensitivity and a range of at least 20 percent R.H. The humidistat shall be fully proportioning and shall be capable of returning to original calibration after being subject to saturated air for an extended period of time. Humidistat shall be sensitive to plus or minus 5 percent R.H. throughout its range of operation.

O. Identification of Hardware and Wiring

1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2-in of termination with the address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

3. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

4. Identify room sensors relating to terminal box or valves with nameplates.

5. Manufacturers' nameplate and UL labels are to be visible and legible after equipment is installed.

6. Identifiers shall match record documents.

P. Set points on thermostats, temperature controllers, humidistats, humidity controllers and static pressure controllers shown on the Drawings are indicative only and devices shall be adjustable above and below such set points. If a set point is not stated, the control range of devices shall be suitable for the intended service. Range of devices shall be approximately 50 percent greater in both directions than span of variable, with a minimum of 25 degrees and a maximum of 100 degrees F for air systems.

Q. Thermometers - Thermometers shall be flush mounted on local panels. These thermometers shall be of the dial type, minimum 3-in diameter.

R. Flow Switches and Sensors

1. Duct air flow elements for modulating control shall be of the multipoint, self-averaging pitot tube, differential pressure type. Each element shall have air straightening vanes. These elements shall be fabricated of heavy-gauge, galvanized steel welded casing with 90 degree connecting flanges in a configuration and size equal to that of the duct it is mounted into. The maximum allowable unrecovered pressure loss through the element shall not exceed 0.065-in w.c. at 1000 fpm. Element accuracy shall be plus or minus 1 percent of actual flow rate over the flow range. Repeatability shall be plus or minus 0.1 percent of the actual flow rate over the flow range. Rangeability shall be guaranteed to meet flows as specified. Air monitor or equal.

2. Flow switches for clean air applications to include supply and makeup air systems shall be adjustable differential pressure type with an adjustment range suitable for the application

including pressure range, temperature range, humidity range and expected containment range. Switches shall be arranged for sensing system velocity pressure through the use of a pitot tube arrangement. Pitot tubes shall be accessible and removable for inspection and maintenance without disturbing wiring connections or transmitters. Tube shall be aluminum.

3. Flow switches for general HVAC exhaust applications shall be vane (paddle) type switches suitably selected for the expected duct velocity, pressure range, temperature range, humidity range, and expected contaminants in the air stream. Positioned in the ductwork to be accessible and located so as to avoid nuisance tripping and unreliable operation due to flow turbulence. Vane and vane blocks shall be Type 316 stainless steel. Switches and control wiring shall be arranged so switch is easily removable from ductwork to permit vane inspection, without disconnecting the wiring.

4. Flow switches for spaces classified wet, corrosive or explosive shall be thermal dispersion type sensors using a heater and a heated and unheated RTD sensor to define flow based on temperature differential between the two sensor RTDs. Housing shall be aluminum construction NEMA 4X and all parts of the sensor in contact with the measured air stream shall be Type 316 stainless steel. Units shall be powered by 120 Volt, single phase, 60 Hz. The unit set point shall be field adjustable. Flow switches shall be Model 12-64 Insertion Flow Switch manufactured by Fluid Components, Inc San Marcos, CA or equal. Each duct airflow switch for system status shall activate two DPDT 10 amp dry contacts located in its local housing for status indication. One contact is to be used by the ATC system and the second is to be used by Division 16. Provide panel indicator lights for system "normal" and "failure" status indication and provide "failure" annunciation. Provide a portable monitor/calibrator or equivalent service for testing and calibrating the flow sensors. The monitor calibrator shall be manufactured by the same manufacturer as the flow switch. Switch shall be set after the system has been balanced.

5. Flow sensors for spaces classified wet; corrosive or explosive shall be thermal dispersion type sensors using a heated and RTD sensor probe to define flow. Housing shall be aluminum construction NEMA 4X and all parts of the sensor in contact with the measured air stream shall be Type 316 stainless steel. Units shall be powered by 120 Volt, single phase, 60 Hz. The unit set point shall be field adjustable and shall provide a 24 Volt DC signal. Flow sensors shall be Model FLT 9 3B manufactured by Fluid Components, Inc San Marcos, CA or equal. Each duct airflow sensor for system status shall provide flow indication by LED and activate two DPDT 10 amp dry contacts located in its local housing for status indication. One contact is to be used by the ATC system and the second is to be used by Division 16. Provide panel flow rate readout and indicator lights for system "normal" and "failure" status indication and provide "failure" annunciation. Provide a portable monitor/calibrator or equivalent service for testing and calibrating the flow sensors. The monitor calibrator shall be manufactured by the same manufacturer as the flow switch. Sensor alarm points shall be set after the system has been balanced.

6. Thermal dispersion flow sensors shall be set and calibrated after air balancing has been completed. Unless otherwise noted, the set points for high or low shall be plus/minus 10 percent. For high high, or low low shall be plus/minus 15 percent. When the sensor has a varying speed response for start up and shut down, the shorter time response shall be used for the system alarm or shut down signal.

7. Where specifically called for on the drawings or in the control sequences, ON-OFF current sensing devices that sense motor current are acceptable. ON-OFF current sensing devices are only to be used where specifically allowed.

8. Flow switches for glycol/water circulating pumps shall be vane type with snap acting switches.

S. Electronic Sensors

1. All mixed air and coil discharge sensors shall utilize industry standard 4-20 mA sensors with averaging elements. Sensing elements shall be a minimum of 25-ft and temperature sensed shall be averaged over the entire length of the element. Thermistor type sensors will not be acceptable for this application.

2. Space type sensors shall have an accuracy of plus/minus .5 degrees over sensed temperature range (20 to 120 degrees F).

3. Well type sensors used for liquid immersion shall have stainless steel removable wells. Sensing element shall have an accuracy of plus/minus .5 degrees over range (70 to 220 degrees F or 20 to 120 degrees F) of the sensor. Each sensor shall have a suitable electrical box to enclose all wiring connections.

4. Temperature control wells shall be installed by the HVAC Contractor under supervision of the temperature control contractor.

T. Short Cycle Timers - Timers shall be electric operated with two sets of normally open, normally closed contacts with manual time adjustment from 1 to 15 minutes.

U. Time Clocks - Time clocks shall be electric operated, 24-hour, 7 day type with provision for 15 minute time increments. Unit shall have two sets of N.O. and N.C. contacts. Provision shall be provided for 10 hours of operation minimum during a power failure with automatic recharge when power is returned.

V. Software licensing and user agreements shall be based on a one time fee. Agreements that remove all responsibility for the software and its performance are not acceptable.

W. All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:

1. Project graphic images

2. Record Drawings

3. Project database

4. Project-specific application programming code

5. All documentation

2.03 ELECTRIC WIRING

A. All field wiring (other than power wiring) between control cabinets (A.T.C. control), control devices, unitary control panel and control terminals in motor control centers shall be furnished under this Section and shall conform to the requirements of Division 16. Wiring to suspended and cabinet unit heaters and their thermostats shall be considered power wiring. All interlocking wiring within MCC shall be done by Division 16.

B. Refer to the electrical drawings for NEMA enclosure types, other than NEMA 1, by room or location designation such as "Damp," "Wet," "Corrosive," "Class.__, Div.__, Group__."

C. Installation of all conduit, wire, sleeves, outlet boxes, insulating bushings, system cabinets, terminal boxes, pull boxes, junction boxes, inserts, anchors, system devices, etc, shall be in accordance with the appropriate requirements of Division 16, and in accordance with sections of the current edition of the local codes for signal systems and electrical systems.

D. Wiring shall be run in rigid steel conduit except in dry locations above ceilings and wood or metal stud framed partition walls, where EMT may be used. Conduit, boxes and fittings and their installation and testing shall be as specified in Section 16110.

E. Wire with the exception of DDC cable and thermostat wire shall be stranded copper type THHN/THWN insulated for 600 Volts. Wire and its installation and testing shall be as specified in Section 16120.

F. In the event of any conflict among referenced codes, current editions of the applicable local codes shall take precedence for interpretation of "Signal System" installation requirements.

G. Installation of sensor wiring in finished areas shall be concealed whenever possible. Where concealed wiring is not possible, written approval for exposed work must be obtained from the Engineer prior to installation.

H. A power supply 115V, single phase, 60 Hz, 20 Amp circuit for ATC, requirements will be available at each local control panel. Power shall not be taken from the control power transformers of the motor control center.

I. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.)

J. All wiring in mechanical, electrical or service rooms or where subject to mechanical damage shall be installed in conduit at levels below 10-ft.

K. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

L. All wire to device connections shall be made at a screw type terminal block or screw type terminal strip. All wire to wire connections shall be at a screw type terminal block.

M. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

N. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

O. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

P. Size of conduit and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendations and code requirements, except as noted elsewhere.

Q. Include one pull string in each conduit (1-in) or larger

R. Use coded conductors throughout with conductors of different colors.

S. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment and control panel enclosures unless they also contain Class 1 starters.

T. Conceal all conduits, except within mechanical, electrical or service rooms. Install conduits to maintain a clearance of 6-in from high temperature equipment.

U. Secure conduits with conduit clamps fastened to the structure and spaced accordingly to code requirements. Conduits and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.

V. Comply with Division 16 requirements where conduit crosses building expansion joints.

W. Install insulated bushings on all conduit ends and openings to enclosures. Seal top end of all vertical conduits.

X. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

Y. Flexible metal conduits and liquid tight, flexible metal conduits shall not exceed 3-ft in length and shall be supported at each end. Flexible metal conduits less than 1/2-in electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid tight, flexible metal conduits shall be used.

Z. Conduits must be rigidly installed, adequately supported, properly reamed at both ends and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes.

AA. Coordination Issues

1. When motors are manually or automatically controlled from the HVAC ATC panels, the panels shall include a set of normally dry (non-powered) contacts (for connection to the motor starter) which close when the motor is to operate. The ATC contractor will wire these contacts to the motor starter and make connections to the terminals provided. Contacts shall be rated 120 Volts, 10 Amps, 60 Hz for inductive and resistive loads.

2. A set of normally open dry (non-powered) contacts (for connection to the HVAC ATC panel) which close when the motor starter has pulled in, shall be provided under Section 16000. The

ATC contractor will make connections to the terminals provided and wire these contacts from the motor starter to the HVAC ATC panel to signal the motor is operating.

3. Line voltage thermostats for unit heaters will be furnished under this Section and installed and wired under Division 16.

4. The electrical contractor will provide a 120V circuit to all control panels shown on the Drawings. Power for the control systems is to be taken from the panels and no other source.

5. Alarms from the HVAC systems that provide a signal to the plant SCADA system will be furnished and installed under this Section. The alarms shall be provided with two sets of contacts. One set will be wired by the electrical contractor for the SCADA system. The second contact will be used to provide an HVAC signal, which will be wired under the Section.

6. The electrical contractor will provide an NO contact input to all ATC panels to indicate operation of the generator for use in the control sequences.

7. The wiring to be done under this Section shall consist of but not limited to the following:

   a. Between ATC panels and MCCs.

   b. Between ATC panels and all sensors and switches

   c. Between ATC panels and all operators and controllers.

   d. Between ATC panels and control panels on equipment provided by the HVAC contractor.

   e. Between alarm devices provided by the other trades and ATC panels.

   f. Power wiring from the ATC panels to smoke detectors.

   g. Power wiring from ATC panels to flow switches and sensors.

8. Wiring from smoke detectors provided under this Section to building fire alarm systems will be provided under Division 16.

9. Wiring from flow alarms provided under this Section to plant SCADA system will be provided under Division 16.

10. Refer to electrical drawings for details of wiring at motor control panels. Provide all interconnecting wiring to start and stop motors.

2.04 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.

   1. Labels shall use white lettering (12-point type of larger) on a red background.

2. Warning labels shall read as follows:

CAUTION

THIS EQUIPMENT IS OPERATING UNDER AUTOMATIC CONTROL AND MAY START OR STOP AT ANY TIME WITHOUT WARNING. SWITCH DISCONNECT TO "OFF" POSITION BEFORE SERVICING.

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type of larger) on a red background.

2. Warning labels shall read as follows:

CAUTION

THIS EQUIPMENT IS FED FROM MORE THAN ONE POWER SOURCE WITH SEPARATE DISCONNECTS. DISCONNECT ALL POWER SOURCES BEFORE SERVICING.

2.05 SYSTEM PROTOCOL

A. The control system is to be based on the use of ANSI / ASHRAE STANDARD 135-1995 (BACnet).

2.06 OPERATOR INTERFACE

A. Basic Interface Description:

1. Furnish IBM compatible PCs as shown. The CPU shall be a minimum of an Intel Pentium IV processor and operate at a minimum of 2.8 GHz. A minimum of 512 megabytes of RAM, with one 3.5-in diskette drive, one read/write CD drive and a 40 gigabyte hard disk with a minimum access time of 12 milliseconds shall be provided. A two button mouse will also be provided. Furnish all required serial, parallel and network communication ports and all cables for proper system operation. The PC shall have a minimum of a 14-in VGA monitor

2. Furnish one auto dial telephone modem per workstation and associated cables for communications to remote buildings and workstations. The modem shall transmit at a minimum of 28,800 baud and communicate over voice grade telephone lines.

3. Each workstation shall have one printer with associated cables. Each printer shall be capable of a minimum 160 characters per second operation and be compatible with standard parallel or serial communication. Supply one box of 2000 sheets minimum of printer paper and two printer cartridges.

4. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

a. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. For example, users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

b. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, shall also be provided by the Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operation. Use the appropriate technique based on the following programming types:

1) Text based:

a) Must provide actions for all possible situations

b) Must be modular and structured

c) Must be commented

2) Graphic based:

a) Must provide actions for all possible situations

b) Must be documented

3) Parameter based

a) Must provide actions for all possible situations

b) Must be documented

5. Displays shall be graphical, indicating the various components of the system. Displays shall be in a hierarchy, with an overall systems display. Displays for the next level down shall be accessed by clicking on the specific system. This hierarchy shall be continued down to the unit level for air handlers, and the system level for pumping systems. Each display shall be labeled. Individual components of each display shall also be labeled. Status and measurements for each unit shall be located in an appropriate location on the schematic. All indications and measurements are to be identified to include engineering units.

6. Provide a specific visual flashing "Network Connection Lost" alarm on the central control system screen and audible alarm if any network connection is lost. The flashing "Network Connection Lost" shall also identify the specific connection lost.

7. System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Use the following naming convention in conjunction with the equipment numbers on the Drawings and in the schedules.

a. AA.BBB.CCDDE where

AA is used to designate the location of the point within the building, such as mechanical room, wing, or level, or the building itself in a multi-building environment.

BBB is used to designate the mechanical system with which the point is associated (e.g., A01, HTG, CLG, LTG).

CC represents the equipment or material referenced. Refer to equipment schedule.

D or DD may be used to clarification or for identification if more than one CC exists. Refer to equipment schedule.

E represents the action or state of the equipment or medium (e.g., T for temperature, H for humidity, C for control, S for status, D for damper control, I for current).

8. All graphic displays will use consistent symbols, fonts, colors and units of measurement and line sizes, for all displays. Each graphic shall follow the Windows style motif (three-dimensional look with shading.

a. There will be three types of displays

1) Pictorial/flow diagram system and equipment displays. For example, these could include heating hot water systems. Equipment could include boilers, or air handling units.

2) Data displays in alphanumeric format. These would include sensors and operators.

3) Alarm/Event summaries

b. Pictorial displays will provide an overview of a system or unit. In general, displays will follow a flow diagram format. The diagram will illustrate the components and flows for the system or unit. Basic information such as status and set points and sensor data shall be included. Clicking on an item in a system diagram will go to a pictorial display of the specific unit. Clicking on an item in an equipment diagram will go to a further level of units or the data display for that item.

c. Data displays will provide alphanumeric information on the specific sensor or operator. Information shall include as a minimum:

1) Specific identification of the item
2) Address of the item
3) Function of the item
4) Range
5) Set point
6) Reading
7) Other related information

d. Alarm/Event summaries will present information on current alarms and operator changes of set point or status. The summary will also include the time the alarm or event took place.

e. All display screens shall include:

1) Title bar with applicable equipment identification
2) Menu bar
3) Buttons to link to other related screens
4) Applicable Alarm/Event summary field

f. All screens shall share a common appearance. Titles will have a constant location. All colors, font sizes, symbols and symbol sizes will be consistent from screen to screen.

g. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.

h. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils and unit ventilators. This library shall also include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

i. Displays are to use basic colors. The use of various shades is not allowed, to prevent confusion for visual impaired operators.

j. Font shall be Arial Bold, or similar approved font.

9. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in a windowing environment to speed facility operation and analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance. If the interface is unable to display several different types of displays at the same time, the FMS contractor shall provide at least two operator stations.

10. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

a. Passwords shall be exactly the same for all operator devices, including DDC panel portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.

b. A minimum of five levels of access shall be supported:

c. A minimum of 50 passwords shall be supported at each DDC panel.

d. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, shall be limited to only those items defined for the access level of the password used to log-on.

e. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

11. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files.

a. Dynamic Graphic Displays: 1) Graphic Floor Plan display and 2) system schematics for each piece of mechanical equipment including air handling units, chilled water system and hot water boiler systems shall be provided.

b. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

c. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

B. Performance Standards

1. The system shall display a graphic with 20 dynamic points with all current data within 10 seconds.

2. The system shall update a graphic with 20 dynamic points with all current data within 8 seconds.

3. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 2 seconds. Analog objects should start to adjust within 2 seconds.

4. All changes of state and change of analog values will be transmitted over the high speed network such that any data used or displayed at a controller or workstation will have been current within the previous 6 seconds.

5. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds.

6. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

7. Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

8. All workstations on the network must receive alarms within 5 seconds of each other.

9. The system shall report all values with an end to end accuracy as specified:

Measured Variable	Reported Accuracy
Space Temperature	Plus/minus 1 degree F
Ducted Air	Plus/minus 1 degree F
Outside Air	Plus/minus 2 degree F
Dew Point	Plus/minus 3 degree F
Water Temperature	Plus/minus 1 degree F
Delta – T	Plus/minus 0.25 degree F
Relative Humidity	Plus/minus 5 percent RH
Water Flow	Plus/minus 5 percent of full scale
Airflow (terminal)	Plus/minus 10 percent of full scale (See Note 1)
Airflow (measuring stations)	Plus/minus 5 percent of full scale
Airflow (pressurized spaces)	Plus/minus 3 percent of full scale
Air Pressure (ducts)	Plus/minus 0.1 in. w.g.
Air Pressure (space)	Plus/minus 0.1 in. w.g.
Water Pressure	Plus/minus 2 percent of full scale (See Note 2)
Electrical (A, V, W, Power Factor)	5 percent of reading (See Note 3)
Carbon Monoxide (CO)	Plus/minus 5 percent of reading
Carbon Dioxide (CO2)	Plus/minus 50 ppm
Note 1: 10 percent to 100 percent of scale	
Note 2: For both absolute and differential pressure	
Note 3: Not including utility-supplied meters	

10. Control loops shall maintain measured variable at set point within the tolerances specified:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	Plus/minus 0.2 in. w.g. Plus/minus 0.1 in. w.g.	0 to 6 in. w.g. 0.1 to 0.1 in. w.g.
Airflow	Plus/minus 10 percent of full scale	
Space Temperature	Plus/minus 2.0 degrees F	
Duct Temperature	Plus/minus 3.0 degrees F	
Humidity	Plus/minus 5 percent RH	
Fluid Pressure	Plus/minus 1.5 psi Plus/minus 1.0 in. w.g.	1 to 150 psi 0 to 50 in. w.g. differential

11. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states and reactions for each object in the system.

12. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location and nature of the alarm without relying upon acronyms or other mnemonics.

13. Alarm Reactions. The operator shall be able to determine (by object) what, if any, actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day.

14. Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include interval, start time and stop time. Trend data shall be sampled and stored on the building controller panel, be archivable on the hard disk and be retrievable for use in spreadsheets and standard database programs.

15. Alarm and Event Log. The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.

16. Reports and Logs. Provide a reporting package that allows the operator to select, modify or create reports. Each report shall be definable as to data content, format, interval and date. Report data shall be archivable on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer and shall be set to be printed either on operator command or at a specific time each day.

17. Standard Reports. The following standard system reports shall be provided for this project. Provide ability for the Owner to readily customize these reports for this project.

    a. All Objects: All system (or subsystems) objects and their current values.

    b. Alarm Summary: All current alarms (except those in alarm lockout).

    c. Disabled Objects: All objects that are disabled.

    d. Alarm Lockout Objects: All objects in alarm lockout (whether manual or automatic).

    e. Alarm Lockout Objects in Alarm: All objects in alarm lockout that are currently in alarm.

    f. Logs

        1) Alarm History

        2) System Messages

        3) System Events

        4) Trends

18. Custom Reports. Provide the capability for the operator to easily define any system data to a daily, weekly, monthly or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.

19. Weather Data Report. Provide a monthly report showing the daily minimum, maximum and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month.

20. Scheduling: An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and month. This shall consist of a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The start and stop times for each object shall be adjustable from the master schedule. Schedules shall be easy to copy to other objects and/or dates.

C. Laptop PC Workstation Description

1. Laptop Personal Computer Operator Workstations shall be provided for command entry, alarm management, information management, and data base management functions. Laptop PCS may be directly connected to Standalone DDC panels on a temporary basis. All real-time control functions shall be resident in the Standalone DDC panels to facilitate greater fault tolerance and reliability.

   a. Laptop PC Operator Workstations shall be general purpose, commercially available, personal computers with sufficient memory and processor capacity to perform all functions described in this Section.

   b. The Laptop display shall have a diagonal screen measurement of no less than 9-in and a minimum display resolution of no less than 640 x 480 pixels. The screen shall be non-reflective.

   c. The manufacturer shall supply two lap top computers. The computers are to be programmed with the operating systems for the controls. The programming shall include all revisions and modifications made in the system up to the date of final acceptance.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

3.02 INSTRUCTION AND ADJUSTMENT

A. Upon completion of the project:

1. Completely adjust and calibrate, ready for use, all thermostats, valves, damper operators, relays, thermometers and recorders, etc, provided under this Section.

B. The system contractor shall provide complete system documentation at acceptance time, as specified herein. Documentation shall be provided in four sets, unless otherwise elsewhere in this Section. Documentation shall include the following:

1. All data specified in the Paragraph 1.03 above, in its final as-built approved form.

2. As-built interconnection wiring diagrams, or wire lists, or list of the complete field installed system with complete, properly identified, ordering number of each system component and device.

C. Training

1. The manufacturer shall provide training for the operation and maintenance of the automatic control systems. Each trainee shall be provided with a full set of instructional materials and operating manuals for each of the various courses in which he is trained. In addition, two complete additional sets of the training manuals are to be provided.

2. All training sessions are to be scheduled with the Owner to maintain required plant operating coverage. If required to maintain coverage, the classes shall be split into multiple sessions.

3. The use of on site facilities for training is to be approved by and scheduled with the Owner.

4. The manufacturer shall provide all terminals required for hands-on laboratories.

   a. The manufacturer shall provide a one week course for personnel that will be operating the system. The course shall include six persons. The material covered will include basic instruction in the computer operating system, system operations that do not require programming or set point changes, and generation of data files and reports. The course shall be a combination of classroom and hands-on work with the computer terminals.

   b. The manufacturer shall provide a one week course for personnel that will be operating the system and will also be taking additional training courses. The course shall include six persons. The material covered will include basic instruction in the computer operating system, system operations that do not require programming or set point changes, and generation of data files and reports. This course is to be more detailed to provide a base for the remaining courses. The course shall be a combination of classroom and hands-on work with the computer terminals.

   c. The manufacturer shall provide a one week course for personnel that will be maintaining the mechanical portions of the system. The course shall include six persons. The material covered will include instruction in trouble shooting and repair of the mechanical components. The course shall be a combination of classroom and hands-on laboratories. Where possible the actual equipment in the plant will be used for the hands-on laboratories.

   d. The manufacturer shall provide a one week course for personnel that will be maintaining the electrical and digital parts of the system. The course shall include six persons. The material covered will include instruction in trouble shooting and repair of the electrical and digital components. The course shall be a combination of classroom and hands-on laboratories. Where possible the actual equipment in the plant will be used for the hands-on laboratories.

e. The manufacturer shall provide a one week course for personnel that will be responsible for reprogramming the system for changes in control sequences, and additions and deletions of equipment. The course shall include six persons. The material covered will include instruction in the basic programming for the system, and the function and effects of the various operating parameters. The course shall be a combination of classroom and hands-on laboratories using computer terminals.

f. The manufacturer shall provide a one day course for personnel that will be responsible for access codes and levels of access for various personnel. The course shall include six persons. The material covered will include instruction in adding, deleting and changing access codes, and defining the various allowed levels of access for each code. The course shall be a combination of classroom and hands-on laboratories using computer terminals.

3.03 ACCEPTANCE PROCEDURE

A. Upon successful completion of the system, the Engineer shall be requested, in writing, to inspect and approve the satisfactory operation of the ATC system, sub-system(s) and accessories.

B. Upon receipt of a detailed punch list from the Engineer, an installation inspection report shall be prepared showing, by system, each outstanding item on the punch list. After all items appearing on the installation inspection report are completed, a second written request for system approval shall be made to the Engineer. As each or all items are approved, an appropriate notation shall be entered at the time of joint inspection on the system report, with counter signature of the Engineer and date. A copy of this report shall be made for the Engineer.

C. Problems, which occur within approved hardware, shall be corrected in an appropriate fashion under guarantee. Any such occurrence shall not void previous approval; however, the system contractor shall be responsible to attend to and remedy such items within a reasonable amount of time. Appropriate logs, schedules, and reports shall be maintained to reflect these items and their redress.

D. During the acceptance inspections, the System Supplier shall provide the required personnel to operate the system and show complete functionality. The System Supplier will also provide the required communication devices to allow simultaneous observations at multiple points. In general each system will be run through its complete operating sequence.

E. Functional acceptance testing will be halted for systems that are found to be operating incorrectly. Corrections will not be made during the inspection. If multiple systems are found to have operating deficiencies, the acceptance testing will be canceled and rescheduled at the System Supplier's expense.

3.04 CONTROL SEQUENCES

A. HVAC equipment will operate with the sequences of operation as shown on the drawings.

1. The following will apply to all sequences.

a. All sequences are reversible unless otherwise noted.

b. Manual reset of control functions with manual reset will be at the local control panel unless otherwise noted.

c. Where required to prevent nuisance shut downs of systems, provide time delay of sensors to allow system start up before the sensors are activated. This would include, but not be limited to low temperature freeze protection on 100 percent outdoor air units.

d. For fan systems with shut off dampers and air flows greater than 2000 cfm and fan operating static pressure greater than 1-in water gauge, fans shall be stopped and started by damper end switches. When the sequence calls for the fan to run, the control system shall open the respective damper. When the damper is open as indicated by an end switch on the damper the fan shall start.

e. Where control sequences refer to activation of an alarm indicator, it will be understood to mean activation of a labeled pilot light at the local ATC panel. A dedicated pilot light will be provided for each alarm unless a common alarm light is specified.

f. The ATC contractor shall provide all connections, relays and other devices required to operate the system under the control of the firefighter control panel.

END OF SECTION

SECTION 15990

TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish the necessary labor, materials, instruments, transportation and devices required and test, adjust and balance the total heating-ventilating-cooling systems, both water and air systems. Each as specified and detailed herein, or as required to cause the systems to perform in accordance with the intent of the Drawings and this Section. Systems to be tested, adjusted and balanced include air and hydronic systems installed by the HVAC Contractor; and include the interconnecting heating and cooling glycol yard piping installed by the Contractor.

B. Testing, balancing and operation of the systems shall be performed by competent and experienced personnel, having formerly done similar work and whose qualifications and performance shall be subject to the approval of the Engineer. Test and balance air and water system and submit testing and balancing reports to the Engineer for review and approval. Re-balance when required by the Engineer, incorporating all changes and certify the systems have been tested and balanced to meet specified requirements.

C. The tests shall demonstrate the specified capacities and operation of equipment and materials comprising the systems. Such tests other than as described herein, which are deemed necessary by the Engineer to indicate the fulfillment of the Contract, shall be made.

D. Data required by this Section shall receive complete approval before final payment is made.

E. If, in the opinion of the Engineer, the Contractor has not, will not, or cannot comply with the testing, balancing and adjusting requirements of this Section, he may advise the Owner to employ a qualified firm to perform such work at Contractor's sole expense.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Qualifications and experience information and data as detailed under Paragraph 1.04 below.

2. Proposed testing schedules and procedures.

3. Results of periodic field inspections as specified under Paragraph 3.01 below.

4. Preliminary draft "system" balancing reports as systems are completed and tested.

5. Final systems and Project balancing reports as final system adjustments are made as systems are accepted by the Owner.

6. All submittals shall contain a statement that Sections 15500, 15990 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The

statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

B. In general, corrections or comments or lack there of, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.03 QUALITY ASSURANCE

A. Qualifications standards for this work - Affiliation with manufacturers, installing contractors or engineering firms will not preclude acceptability. Submit qualifications within 60 days after Contract award. Membership in the AABC or NEBB for air and water testing is required. The testing balancing contractor shall not be affiliated with the on-site contractors.

B. The balancing contractor shall be prepared to submit credentials and other evidence of qualifications, and work experience, following receipt of, but prior to award of filed subbids.

C. To perform required professional services, the balancing agency shall have one test-and-balance engineer certified by the AABC or NEBB.

D. This certified test-and-balance engineer shall be responsible for supervision and certification for the total work specified herein.

E. The balancing agency shall submit records of experience in the field of air and hydronic system balancing or any other data as requested by the Engineer. The supervisory personnel for the firm shall have at least 5 years experience and all the employees used in this project shall be qualified technicians in this specific field.

F. The balancing agency shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the balancing agency may be required by the Engineer to determine the balancing agency's performance capability.

1.04 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.05 SCHEDULE AND PROCEDURES

A. A complete schedule of balancing procedures for each of the buildings or systems shall be submitted in sufficient time in advance so that the Engineer might arrange to observe these procedures as they progress. Before commencing with the balancing of the systems submit the methods and instruments proposed to be used to adjust and balance the air and water systems.

B. Submit proposed testing programs at least 2 weeks prior to the scheduled test to assure agreement as to personnel and instrumentation required and scope of each testing program.

1.06 DRAWING REVIEW

A. The balancing organization shall thoroughly review the location of all fresh air dampers, return dampers, spill dampers, quadrant dampers, splitter dampers, bypass dampers, face dampers, fire dampers, registers, grilles, diffusers, VAV boxes, troffers, etc. The purpose of the review is to finalize the optimum locations for dampers, test ports and balancing valves shown on the Drawings.

1.07 EQUIPMENT CURVES

A. Fan Characteristics Charts: The HVAC and General Contractors shall provide to the Balancing Organization any required characteristic curve charts for all fans to include air conditioning units and air handling units. Characteristic curve charts shall be not less than 8-1/2-in by 11-in and shall show the static pressure, capacity horsepower and overall efficiency for operating conditions from no load to 130 percent of specified load. The minimum size of the actual fan curve shall be no less than 6-in by 8-in. The use of faxed copies of curves is not acceptable.

B. Pump Characteristic Charts: The HVAC Contractor shall provide to the Balancing Organization any required characteristic curve charts for each water or water/glycol system pump. Charts shall be not less than 8-1/2-in by 11-in showing head developed, efficiency and power required for varying capacities at the operating speeds of the equipment. The minimum size of the actual pump curve shall be no less than 6-in by 8-in. The use of faxed copies of curves is not acceptable

1.08 GUARANTEE

A. The balancing work shall be guaranteed to be accurate and factual data, based on readings in the field. All typewritten data shall be submitted within 14 working days of the performance of the test. Test data shall not be held until final completion, but shall be submitted on an interim basis as soon as the test or appropriate groups of tests are finished.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish gaskets, lubricants and other expendable materials required to be replaced during the execution of this work.

B. Fixed-pitched pulleys required for fan adjustments shall be furnished on an exchange basis by the party responsible for the fan installation.

C. Where test results indicate that air quantities at any system fan are below or in excess of the specified amount, the HVAC and General Contractors, at their own expense, shall change driving pulley ratio or shall make approved changes to obtain the specified or scheduled air quantities.

D. Testing apparatus: Furnish plugs, caps, stops, valves, pumps, compressors, blowers and similar devices required to perform this work.

1. Furnish anemometers, thermometers, gauges, voltmeters, ammeters, lachometers and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems.

2. Testing apparatus, not part of the permanent installation, shall remain the property of the Contractor, but made available to the Engineer.

3. Instruments used for testing shall be certified accurate to within plus or minus 0.10 degrees F for temperature or plus or minus 0.10-in wc for pressure. Calibration of the instruments shall be done within 7 days of testing for this project and henceforth every 30 days thereafter for the duration of the testing period. Certification of calibration shall be submitted to the engineer prior to starting the work.

2.02 TESTING REPORTS

A. Forms: Furnish test report data on 8-1/2-in by 11-in bond AABC or NEBB form paper in accordance with Section 01300. Submit format for recording data and receive approval prior to use.

B. Reports shall be excel spread sheets format and shall be submitted in both hard copy and as a data file.

C. The report shall contain the following general data in a format selected by the balancing agency:

1. Project number

2. Contract number

3. Project title

4. Project location

5. Project architect

6. Project mechanical engineer

7. Test and balance agency

8. Test and balance engineer

9. General contractor

10. Mechanical subcontractor

11. Dates tests were performed

12. Certification

D. At a minimum, the report shall include:

1. Preface. A general discussion of the systems, any abnormalities and problems encountered.

2. Instrumentation list. The list of instruments including type, model, manufacturer, serial number and calibration dates.

3. System Identification. In each report, the VAV boxes, zones, supply, return and exhaust openings and traverse points shall be numbered and/or lettered to correspond to the numbers and letters used on the report data sheets and on the report diagrams.

E. Prepare 11-in by 17-in single line diagrams or 12-in by 18-in half size drawings showing all duct systems indicating all terminal air outlets including diffusers, grilles and registers, perforated plates, nozzles and other types of air supply, exhaust or return outlets. The minimum scale for diagrams showing the measurement points shall be 1/8-in=1-ft-0-in in the final form as submitted. The use of faxed copies of diagrams is not acceptable. Location of test points shown on the diagrams shall be clear and easy to locate on the diagram. The identification mark of the test points shall be the same as is shown on the test report showing the test data. The identification for test points shall include indication of the units served, and shall not have a duplicate in the project. All supply outlets shall be adjusted so that there are no drafts. Grille and register readings may be made by a vane anemometer, but diffuser readings shall be made by a flow hood or a velometer, using the tip recommended by the diffuser manufacturer. Each test sheet shall include the following data:

1. Job name and address.

2. Name of HVAC Contractor.

3. Name of balancing organization.

4. Instruments used to perform the test.

5. Name of test technician or test engineer.

6. Fan system and/or zone number.

7. Room number or area name.

8. Size of outlet.

9. Type outlet.

10. Manufacturer of outlet.

11. The cfm at each outlet on system and corresponding cfm at each outlet as noted on the plans.

12. Percent deviation of the measured flow versus the design flow.

13. Indication of the branch and terminal that are the open/low that are the basis for balancing the remainder of the system

PART 3 EXECUTION

3.01 INSPECTIONS

A. During construction, the balancing agency shall inspect the installation of pipe systems, sheet metal work, temperature controls, and other component parts of the heating, ventilating and air conditioning systems. The inspections shall be performed periodically as the work progresses. A minimum of two inspections are required as follows: (1) when 60 percent of the duct work is installed: (2) when 90 percent of the equipment is installed. The balancing agency shall submit a brief written report of each inspection to the Engineer.

3.02 START OF BALANCING

A. The General Contractor shall notify the Balancing Organization and Engineer when systems become operational and ready for preliminary and final testing, adjusting and balancing.

B. Final balancing shall not begin until system has been installed complete and is capable of normal operation. Provide personnel to assist in rough balance and calibration.

C. All grilles, dampers, fans, coils, pumps, valves and linkages shall be verified to be installed and operating.

D. System shall be capable of operating under control as specified on Drawings and/or contained herein.

E. Visually inspect all fire dampers on branch take-offs to each floor to ensure that they are fully open.

F. Verify with straight edge that fan/pump and motor shafts are parallel and that sheaves are in proper alignment.

G. Verify that belts are properly tensioned when unit is operating with no excessive squeal at startup. If not correct, adjust sheaves or motor base accordingly.

H. Start fans and pumps, verify that rotation is correct. If rotation is incorrect coordinate with electrical contractor to switch power leads such that the motor rotates correctly.

I. Check nameplate voltage on motor, compare to scheduled voltage. Notify the Engineer immediately of any discrepancies. Measure and record actual voltage across all power leads. Notify the Engineer of discrepancies immediately.

J. Check motor nameplates full load amps, measure and record amperage across all power leads. If there are marked discrepancies in amperage draws between legs, notify the Engineer immediately.

K. Measure and record fan/pump and motor rpm. Check that motor rpm agrees with nameplate and scheduled rpm.

L. If, upon commencing the work, the balancing contractor finds that the systems are not ready, or if a dispute occurs as to the readiness of the systems, the balancing agency shall request an inspection to be made by the Engineer. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for testing and balancing. Should the inspection reveal the notification to have been premature, all costs for the inspection and work previously accomplished by the balancing agency shall be paid for by the General Contractor. Furthermore, such items that are not ready for testing and balancing shall be completed and placed in operational readiness before testing and balancing services shall be recommenced.

M. Leaks, damage and defects discovered or resulting from startup, testing and balancing shall be repaired or replaced to like-new condition with acceptable materials. Tests shall be continued until system operates without adjustments or repairs.

3.03 REQUIRED ACCURACY

A. Systems shall be balanced to be within the following limits of the capacity shown on the Drawings. Limits shall be applied to both individual components and to the system totals.

1. General Systems (plus/minus 10 percent)

2. Laboratory Hoods (plus/minus 5 percent)

3. Odorous Exhaust Systems (plus/minus 5 percent)

3.04 TESTING

A. HVAC Air Systems

1. Balance the supply return and exhaust air systems in accordance with AABC or NEBB Standards by the use of direct reading instruments such as an "anemotherm" or velometer which has been properly calibrated.

2. Temporarily add static pressure to the system, to simulate the effect of dirty filters, by blanking off portions of the filter section, covering filter section with cheesecloth or other suitable means. Confirm static has been added with new static pressure reading across fan. Remove cheesecloth, etc, after traverses are complete.

3. If so instructed by the Engineer, further balancing of temperature shall be made either by thermometer or by temperature recorder.

4. The sequence of air balancing shall be as follows:

a. First, establish air flow quantity at supply fan by main duct traverse.

b. Next, establish air flow quantities in main ducts and branches.

c. Finally, establish air flow quantities at outlets, using proportional balancing among branch outlets. All multiple opening systems shall be left with at least one "open low"

inlet or outlet, to which all other system openings shall be proportionally balanced. The "open low(s)" on each system shall be indicated in the report.

d. After all outlets are adjusted to within the tolerances specified elsewhere in this Section, remeasure all system outlets, and retraverse all branch and main ducts to establish final "as balanced" flows.

e. All main air ducts shall be traversed, using a Pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges. The static pressure reading at the traverse point shall be recorded for each successive traverse.

1) A main duct is defined as either of the following:

a) A duct serving five or more outlets.

b) A duct serving two or more branch ducts.

c) A duct emanating from a fan or plenum.

2) All other ducts are branch ducts.

3) The intent of this operation is to measure by traverse, the total air quantity handled by the fan and to verify the distribution of air to zones and to adjust system pressure to minimum level required to satisfy the farthest air outlet.

f. Adjust fan speeds if results of system capacity tests are not within tolerances specified and repeat Paragraphs 3.04A4c, d and e above, as required.

g. Mark all final balancing damper positions with a permanent marker.

h. For systems which modulate between different flow modes (e.g. minimum outside air to 100 percent outdoor air or 100 percent return air to 100 percent exhaust) measure and report system flow under both extremes of modulation and check for excessive system flow deviation above design, when system is modulating between its end points.

5. Furnish data in excel spread sheet format tabulating the following:

a. Opening number, type, size and design flow rate.

b. Quantity of air in cfm at each air outlet and inlet.

c. Dry bulb temperature in each room.

d. Dry bulb temperature of the supply air.

e. Outdoor dry and wet bulb temperature at the time the above tests are conducted. (Wet bulb temperature only required for AC systems)

6. Adjust belts, sheaves and the alignment of air handling equipment.

7. Where various combinations of sheaves must be installed on fan systems to achieve the correct air delivery, change the sheaves and continue to take successive readings until the correct combinations are installed.

8. Furnish data in excel spread sheet format taken at each air moving device, to include fans, packaged units and air handling units, tabulating the following:

   a. Manufacturers, model number and serial number of units.

   b. All design and manufacturer's rated data.

   c. Total quantity of supply air in cfm.

   d. Total quantity of return air in cfm.

   e. Total quantity of exhaust or relief air in cfm.

   f. Total quantity of outside air in cfm.

   g. Outlet velocity - fpm.

   h. The rpm of each fan or blower.

   i. Maximum tip speed - fpm.

   j. The rpm of each motor.

   k. Voltage and ampere input of each motor (one reading for each phase leg on 3 phase motors).

   l. Pressure in inches w.g. at inlet of each fan or blower.

   m. Pressure in inches w.g. at discharge of each fan or blower.

   n. Pressure drops across system components such as louvers, filters, coils and mixing boxes.

   o. Submit the actual fan operating point on a copy of the fan shop drawing showing operating curve.

   p. List the following data from all fan motors installed.

      1) Manufacturer model and size.

      2) Motor horsepower, service factor and rpm.

      3) Volts, phases, cycles and full load amps.

      4) Equipment locations.

9. Systems with variable volume boxes and constant volume boxes furnish the following, with ATC contractor present for necessary coordination:

    a. At static pressure probe location measure static pressure with manometer and compare with reading registering at system panel or readout receptacle. The "most critical" volume box shall be determined by the Engineer from approved sheet metal shop drawing submittals. Observe damper linkage, at this box, instruct ATC contractor to vary static pressure setpoint as required so that with thermostat calling for full cooling, the most critical box damper is 75 percent open. (Score line on damper linkage and mark full open and closed positions of box damper. Using protractor mark 75 percent open position on volume box.)

B. Fume Hoods

1. For fume hoods, open sash one half way. Take six point reading across face of hood using hot wire anemometer or velometer with low flow probe (or average air across entire face of hood with rotating vane anemometer). Adjust volume damper in hood exhaust ductwork so that average velocity across hood face is plus or minus 100 fpm. In addition balance hoods to reduced cfm when that lab has occ/unocc setback of air flow. In addition to the face readings, pitot traverse each hood/snorkel exhaust duct and record simultaneously with face velocities and sash opening height.

C. HVAC Water Coils

1. Furnish data in excel spread sheet format tabulating the following:

    a. Manufacturer and model number of all units.

    b. All design and manufacturers rated data.

    c. Entering and leaving fluid temperatures.

    d. Quantity of air in cfm.

    e. Face velocity in fpm.

    f. Dry and wet bulb air temperature entering and leaving coil. Wet bulb temperature not required for heating coils.

    g. Capacity of coil in BTUH.

    h. Quantity of fluid circulated through coil in gpm.

    i. Fluid pressure drop in psig.

D. Refrigeration Machines

1. Furnish data in excel spread sheet format tabulating as follows:

    a. Manufacturer, model number, size and serial number of all units.

b. All design and manufacturer's rated data.

c. Suction and condensing temperatures, and pressures.

d. Temperatures of entering and leaving chilled and condenser water.

e. Voltage and ampere input of motors under full load (one for each phase leg).

f. Capacity of machine in Btuh.

g. Quantity of chilled and condenser water circulated through machine in gpm.

h. Fluid pressure drops in psig.

E. Pumps

1. Furnish data in excel spread sheet format tabulating the following:

a. Manufacturer, model number, size and serial number of all units.

b. All design and manufacturer's rated data.

c. Quantity of fluid circulated by each pump in gpm.

d. Suction and discharge pressures across each pump in psig or feet of head.

e. Voltage and ampere input of each motor (one reading for each phase leg on three phase motors).

f. Percent efficiency of each pump.

g. Horizontal, vertical and angular misalignment of pump and driver after two hours operation and after remaining idle overnight.

h. Submit actual pump performance point on a copy of the pump shop drawing operating curve.

F. Heat Exchangers and Water Cooled Condensers

1. Furnish data in excel spread sheet format tabulating the following at full flow for design and actual:

a. Manufacturer, model number, size and serial number of all units.

b. All design and manufacturer's rated data.

c. Shell side pressure drop.

d. Shell side gpm.

e. Shell side temperature differential.

f. Tube side pressure drop.

g. Tube side gpm.

h. Tube side temperature differential.

i. Relief valve setting.

G. Water/Glycol System

1. The flow of water through all coils shall be adjusted by manipulating balancing valves until the rated pressure drop through the coil or metering device is obtained.

2. The balancing agency shall perform the following testing and balancing functions.

a. Request that the mechanical contractor clean all strainers.

b. Check all air vents at the high points of the water system and determine if they are installed and operating.

c. Set all balancing valves and automatic temperature control bypass valves to the full-open position for balancing. For three-way valves, the design flow rate drop shall first be obtained with the three-way valve set so that all water flows through the coil. The bypass balancing valve shall then be adjusted on each coil until equal pressure drop (or flow rate) between supply and return connections is obtained, with the three-way valve set to bypass the coil.

d. Adjust pump throttling devices if required to meet design gpm requirements. Check pumps for proper operation.

e. Adjust water flow from the central plant if applicable.

f. Balance all heating and cooling coils to within 10 percent of design flow requirements.

H. Hot Water/Glycol Boilers

1. Furnish data in excel spread sheet format tabulating as follows:

a. Manufacturer, model number, size and serial number of all units.

b. All design and manufacturer's rated data.

c. Temperatures of entering and leaving hot water/glycol.

d. Voltage and ampere input of motors under full load (one for each phase leg).

e. Capacity of machine in Btuh.

f. Quantity of hot water/glycol circulated through the boiler in gpm.

g. Hot water/glycol pressure drops in psig.

I. Electric Heating Coils

1. Furnish data in excel spread sheet format tabulating the following:

a. Manufacturer and model number.

b. All design and manufacturer's rated data.

c. Actual operating current and voltage for all legs.

d. Coil location and identification.

3.05 STANDBY EQUIPMENT

A. Where systems are provided with standby equipment, the system shall be balanced for operation in standby as well as normal operation.

3.06 FINAL ACCEPTANCE

A. At the time of final inspection, the balancing agency shall recheck, in the presence of the Engineer, specific and random selections of data recorded in the certified test-and-balance report.

B. Points and areas for recheck shall be selected by the Engineer.

C. Measurements and test procedures shall be the same as the original test and balance.

D. Selections for recheck, specific plus random, shall not normally exceed 15 percent of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.

E. Specific systems for recheck shall include the following:

1. Supply and exhaust in chemical storage areas

2. Laboratory hoods

3. Exhaust hoods

4. Systems ventilating classified areas.

F. If the specific rechecks are more than 5 percent deviation from the report or specified flows, all of the systems, that require specific recheck, shall be rebalanced. If 5 percent or 5 of the random checks, which ever is less, exceeds a 10 percent deviation from the specified flows, the report shall be rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified test-and-balance report submitted, and a new inspection test made, all at no additional cost to the Owner.

3.07 OPPOSITE SEASON TEST

A. The balancing agency shall perform an inspection of the HVAC system during the opposite season from that in which the initial adjustments were made. The balancing agency shall make any necessary modifications to the initial adjustments to produce optimum system operation.

END OF SECTION