

SECTION 15510

HYDRONIC PIPING SYSTEMS

A. RELATED SECTIONS

1. Pipe and pipe fittings are specified in the following sections:
 - a. Section 15061, STEEL PIPE AND FITTINGS.
 - b. Section 15062, COPPER AND COPPER ALLOY PIPE AND FITTINGS.
2. Valves are specified in the following sections:
 - a. Section 15103, BALL VALVES.
 - b. Section 15104, BUTTERFLY VALVES.
 - c. Section 15106, CHECK VALVES.
 - d. Section 15110, SERVICE DRAINS.
 - e. Section 15112, BALANCING FITTINGS.
3. Expansion compensators are specified in Section 15121, EXPANSION COMPENSATORS.
4. Strainers are specified in Section 15123, PIPELINE STRAINERS.
5. Air vents are specified in Section 15124, AIR VENTS.
6. Pipe labels and valve tags are specified in Section 15190, IDENTIFICATION SYSTEMS.

B. PIPE AND FITTINGS

1. Pipe and fittings for water systems (2 inches and smaller) shall be copper, System Type C-1.
2. Pipe and fittings for heating hot water system (2-1/2 inches and larger) shall be steel, System Type S-4.
3. Pipe and fittings for chilled, condenser, and heat recovery water systems (2-1/2 inches and larger) shall be steel, System S-7.

C. ISOLATION VALVES

1. Isolation valves (2 inches and smaller) shall be ball valves, Valve Type B-1.
2. Isolation valves at equipment (2-1/2 inches and larger) shall be butterfly valves, Valve Type BF-4, for heating hot water system and Valve Type BF-2 for all other systems.
3. Isolation valves in piping runs (2-1/2 inches and larger) shall be butterfly valves, Valve Type BF-3, for heating hot water system and Valve Type BF-1 for all other systems.

D. BALANCING VALVES

1. Balancing valves (2 inches and smaller) shall be ball valves, Valve Type B-1, except that balancing valves in the bypass line at three-way control valves (1-1/4 inches and smaller) may be balancing fittings.
2. Balancing valves (2-1/2 inches and larger) shall be butterfly valves, Valve Type BF-3, for heating hot water system and Valve Type BF-1 for all other systems.

E. CHECK VALVES

1. Check valves at pump discharges (2 inches and smaller) shall be Valve Type C-3.
2. Check valves at pump discharges (2-1/2 inches and larger) shall be Valve Type C-6.
3. Check valves for general use (2 inches and smaller) shall be Valve Type C-1.
4. Check valves for general use (2-1/2 inches and larger) shall be Valve Type C-4.

F. DRAIN VALVES

1. Drain valves shall be service drains, Valve Type SD-1.

G. STRAINER BLOW-DOWN VALVES

1. Strainer blow-down valves shall be ball valves, Valve Type B-1.

H. STRAINERS

1. Strainers (2 inches and smaller) shall be Strainer Type ST-1.
2. Strainers (2-1/2 inches and larger) shall be Strainer Type ST-4.

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SECTION 15516

HYDRONIC SYSTEM ACCESSORIES

A. ACCEPTABLE MANUFACTURERS

1. Bell & Gossett ITT.
2. Armstrong Pumps Incorporated.
3. Or as approved.

B. AIR SEPARATORS

1. Air separators shall be of a type utilizing tangential inlet and outlet openings designed to create a low velocity vortex for separation of free air from the system water.
2. Air separators shall be provided with top air connection tapping and bottom drain connection tapping.
3. Separators shall be constructed for 125 psig working pressure, in full conformance with ANSI/ASME BPV-VIII, and shall be stamped to indicate such conformance.
4. Air separators shall be Bell & Gossett Rolairtrol, without strainer.

C. EXPANSION TANKS

1. Expansion tanks shall be constructed for 125 psig working pressure, in full conformance with ANSI/ASME BPV-VIII, and shall be stamped to indicate such conformance.
2. Tanks shall be of galvanized steel construction, thoroughly tested and guaranteed leakproof. Tank exteriors shall be primed and finish coated with machinery enamel or as approved.
3. Tanks shall be provided with tappings for gauge glass, tank fitting, and drain/air charge valve.

OR

C. EXPANSION TANKS

1. Expansion tanks shall be of the vertical, precharged, diaphragm type. Expansion tanks shall be constructed for 125 psig working pressure, in full conformance with ANSI/ASME BPV-VIII, and shall be stamped to indicate such conformance.
2. Tanks shall be of steel construction with a butyl-rubber diaphragm, thoroughly tested and guaranteed leakproof. Tank exteriors shall be primed and finish coated with machinery enamel, or as approved.
3. Tanks shall be designed for floor mounting, provided with tappings for tank fitting, drain valve, and air charge valve.

D. TANK FITTINGS

1. Tank fittings shall be designed to allow the free transfer of air to the compression tank from the air separator and the free flow of water between the tank and the system as required to allow for system expansion.
2. Tank fittings shall be of cast iron construction and shall be designed for a 125 psig working pressure.
3. Tank fittings shall be Bell & Gossett Type ATF or ATFL, as applicable.

E. COMBINATION TANK DRAIN AND AIR CHARGE VALVE

1. Combination valves shall be designed to allow the admission of air to the compression tank while draining water from the tank.
2. Combination valves shall be of cast bronze construction, shall be designed for a working pressure of not less than 125 psig, and shall be provided with a male hose thread connection to facilitate draining.
3. Combination valves shall be Bell & Gossett Model DT-2.

F. HYDRONIC SYSTEM PRESSURE REDUCING VALVES

1. Pressure reducing valves shall be of cast iron construction with brass trim, shall be equipped with an anti-syphon check valve and integral strainer, shall be designed for a working pressure of not less than 125 psig, and shall be field adjustable.
2. Pressure reducing valves shall be Bell & Gossett Model No. 12.

G. HYDRONIC SYSTEM PRESSURE RELIEF VALVES

1. Pressure relief valves shall be of the fail-safe, diaphragm operated type, shall be designed for a working pressure of not less than 125 psig, and shall be factory set.
2. Pressure relief valves shall be Bell & Gossett ASME relief valves.

H. APPLICATION

1. Provide an air separator, a pressure reducing valve, and expansion tank(s) for every closed hydronic system, whether or not shown on the drawings.
2. Provide a pressure relief valve for every closed hydronic system, whether or not shown on the drawings, unless such a valve is being supplied with the boiler or other heat-producing equipment.
3. Air separators shall be line size.
4. Pressure relief valves shall have a capacity of not less than the heating capacity of the associated heat-producing equipment.

I. INSTALLATION

1. Provide a tank fitting and a combination valve on every expansion tank.

OR

1. Provide a drain valve and an air charge valve on every expansion tank.
2. Plug the gauge glass tappings on expansion tanks.
3. Install a fast-fill bypass around every pressure reducing valve.
4. Open any valve installed between the air separator and the tank fittings and remove the handle.
5. Provide a drain valve for the air separator.
6. Provide a pressure gauge downstream of the pressure reducing valve.
7. Install relief valves on the heat-producing equipment side of any isolation valves.
8. Provide equipment support frames as indicated on the drawings. Frames shall be designed based on equipment being completely filled with water.
9. Provide concrete housekeeping pads for all floor mounted equipment.

10. Install all equipment in accordance with the manufacturer's written installation instructions.

J. GLYCOL MANAGEMENT SYSTEM

1. The Glycol Management System shall be built for indoor or outdoor use and have a TCFC motor with wiring enclosed in a liquid tight conduit.
2. The control box shall have a NEMA 3R rating and all connections and penetrations shall be weather tight.
3. The reservoir shall be covered, vented, 65 gallon, polyethylene tank.
4. Piping shall be copper with 3/4 inch female NPT connections.
5. The unit shall include a ball valve to isolate it from the building piping system.
6. The pump shall provide a minimum of 3.0 gpm at 80 psig and be provided with isolation valves and union.
7. The Glycol Management System shall contain the following safety devices and circuits.
 - a. Pressure relief valve on building loop.
 - b. Glycol system pressure gauge.
 - c. Positive shutoff check valve.
 - d. Control panel visible alarm light for:
 - 1) Low system pressure.
 - 2) Add solution warning.
 - 3) Low liquid level.
 - 4) Loss of power, and
 - 5) High liquid level.

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SECTION 15520

STEAM AND STEAM CONDENSATE PIPING SYSTEMS

A. RELATED SECTIONS

1. Pipe and pipe fittings are specified in the following sections:
 - a. Section 15061, STEEL PIPE AND FITTINGS.
2. Valves are specified in the following sections:
 - a. Section 15101, GATE VALVES.
 - b. Section 15102 GLOBE VALVES
 - c. Section 15106, CHECK VALVES.
 - d. Section 15110, SERVICE DRAINS.
 - e. Section 15112, BALANCING FITTINGS.
3. Expansion compensators are specified in Section 15121, EXPANSION COMPENSATORS.
4. Strainers are specified in Section 15123, PIPELINE STRAINERS.
5. Air vents are specified in Section 15124, AIR VENTS.
6. Pipe labels and valve tags are specified in Section 15190, IDENTIFICATION SYSTEMS.
7. Steam traps are specified in Section 15526, STEAM TRAPS.

B. PIPE AND FITTINGS, STEAM SUPPLY

1. Pipe and fittings (2 inches and smaller) shall be steel, System Type S-1.
2. Pipe and fittings (2-1/2 inches and larger) shall be steel, System Type S-4.

C. PIPE AND FITTINGS, CONDENSATE RETURN

1. Pipe and fittings (2 inches and smaller) shall be steel, System Type S-2.
2. Pipe and fittings (2-1/2 inches and larger) shall be steel, System Type S-5.

D. ISOLATION VALVES

1. Isolation valves (2 inches and smaller) shall be gate valves, Valve Type GT-1.
2. Isolation valves (2-1/2 inches and larger) shall be gate valves, Valve Type GT-4.

E. BLOWDOWN AND BYPASS VALVES

1. Valves (2 inches and smaller) shall be globe valves, Valve Type GL-1.
2. Valves (2-1/2 inches and larger) shall be globe valves, Valve Type GL-3.

F. CHECK VALVES

1. Check valves, at pump discharge (2 inches and smaller) shall be Valve Type C-3.
2. Check valves, at pump discharge (2-1/2 inches and larger) shall be Valve Type C-6.
3. Check valves, general use (2 inches and smaller) shall be Valve Type C-1.
4. Check valves, general use (2-1/2 inches and larger) shall be Valve Type C-4.

G. DRAIN VALVES

1. Valves shall be service drains, Valve Type SD-1.

H. STRAINERS

1. Strainers (2 inches and smaller) shall be Strainer Type ST-1.
2. Strainers (2-1/2 inches and larger) shall be Strainer Type ST-4.

I. TRAPS

1. All traps with gravity drainage of condensate shall be float and thermostatic type. Traps which are required to lift condensate shall be bucket type. Traps shall be as specified in Section 15526, STEAM TRAPS.

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SECTION 15525

SELF-CONTAINED THERMOSTATIC VALVES

A. ACCEPTABLE MANUFACTURERS

1. Danfoss, Incorporated.
2. Braukmann Controls Corporation.
3. Or as approved.

B. GENERAL

1. All self-contained thermostatic valves shall be of the nonelectric, modulating type and shall be complete with valve body, valve operator, room temperature sensor, and all necessary mounting accessories.
2. All valve bodies shall be of bronze construction with screwed inlet connection and threaded, union-type, outlet connection.
3. All valves shall be of the spring-loaded, normally-open type, and shall be suitable for use on both hydronic and two-pipe low pressure steam systems.
4. Self-contained thermostatic valve shall be Danfoss RA2000, or as approved.

C. VALVES FOR WALL MOUNTED RADIATION

1. All valves for wall-mounted convectors and fin tube radiation shall be of the straight body type.
2. All valves shall have an integral operator, a remote dial, and a remote sensor. Dial and operator, and sensor and operator shall be connected by a shielded capillary tube.
3. All valves shall have a rough bronze finish.

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SECTION 15526

STEAM TRAPS

A. ACCEPTABLE MANUFACTURERS (No Substitution)

1. Spirax Sarco, Incorporated.
2. Armstrong Machine Works.

B. STEAM TRAPS, GENERAL

1. All steam traps shall bear the name, initials, or trademark of the manufacturer, trap type, size, model number, and condensate flow direction.
2. All steam traps shall be suitable for service and operation at the MAXIMUM INLET STEAM PRESSURE of the piece of equipment being served.
3. All trap castings shall be free of cracks or hot tears and excessive porosity. Forgings shall be free of cracks. All parting lines on castings and flash lines on forgings shall be ground flush.

C. FLOAT AND THERMOSTATIC TRAPS

1. Float and thermostatic traps shall have cast iron body, stainless steel float mechanisms and trim, replaceable chrome or stainless steel valves and seats, and diaphragm or bellows type air vents.
2. Traps shall be Sarco Type FT-15, or as approved.

D. INVERTED BUCKET TRAPS

1. Inverted bucket traps shall have cast iron body, stainless steel float mechanisms and trim, replaceable chrome or stainless steel valves and seats, bimetallic vents, and integral strainers.
2. Traps shall be Sarco Type B, or as approved.

E. THERMOSTATIC TRAPS

1. Thermostatic traps shall have cast brass body, replaceable stainless steel valve and seat, stainless steel bellows.
2. Traps shall be Sarco Type TS-25, or as approved.

F. THERMODYNAMIC (CONTROLLED DISC) TRAPS

1. Thermodynamic traps shall have a stainless steel body and replaceable stainless steel disc.
2. Traps shall be Sarco Type TD-52, or as approved.

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SECTION 15527

STEAM VACUUM BREAKERS AND AIR VENTS

A. ACCEPTABLE MANUFACTURER (No Substitutes)

1. Ernst Gauge.

B. AIR VENTS

1. Air vent shall be suitable for working pressures of not less than 150 psig and capable of relieving a system vacuum of as low as 7-inches water gauge.
2. Air vents shall be Ernst Flows Part Number V331 (Special Electric Boat Number) Model BSSV, 1-inch size.
3. Install all air vents in vertical position.

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SECTION 15528

STEAM PRESSURE REDUCING VALVES

A. ACCEPTABLE MANUFACTURERS

1. Spirax/Sarco Company.
2. Leslie Company.
3. Fisher Control Company.
4. Spence Engineering Company Inc.
5. Or as approved.

B. MAIN VALVES

1. Main valves shall be of the double guided, single seated type suitable for dead end service. Valves shall be diaphragm operated and of packless construction.
2. Valve bodies shall be cast iron; plugs and seats shall be stainless steel stem guides shall be brass or bronze. Diaphragm shall be of the preformed multi-ply metal type without perforations or bolt holes.

C. LOADERS

1. Air Loaders: Air loaders shall be an adjustable, diaphragm operated, air pressure reducing valve designed to maintain a set pressure on one side of the main valve diaphragm to balance against main valve discharge pressure and thereby regulate the discharge pressure under all flow rates. Air loaders shall be provided with a filter and a discharge pressure gauge.
2. Steam Loaders: Steam loaders shall be an adjustable, diaphragm operated, steam pressure reducing valve designed to maintain a set pressure on one side of the main valve diaphragm to balance against main valve discharge pressure and thereby regulate the discharge pressure under all flow rates. Steam loaders shall be provided with an inlet strainer and a bleed provision.

D. TEMPERATURE PILOTS

1. Temperature pilots shall be of the air loaded type, reverse acting, with adjustable proportional band, 7-inch temperature sensing bulb, and air inlet and discharge pressure gauges. Pilots shall be provided with air pressure reducing valves, as necessary, and shall be designed to limit the main valve discharge pressure to the inlet air pressure at the pilot.

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SECTION 15529

STEAM SAFETY VALVES

A. ACCEPTABLE MANUFACTURERS

1. The Lunkenheimer Company.
2. Kunkle Valve Company.
3. Or as approved.

B. SAFETY VALVES

1. Safety valves shall be of the spring loaded, adjustable set point, pipe connection inlet and outlet type, with test handle, ASME Standard, National Board Certified.
2. Safety valves shall be pressure rated for not less than 250 psig, shall have bronze bodies, cadmium plated steel springs, bronze or stainless steel discs and seats, and bronze test handle. Set point adjusting mechanism shall be sealed.
3. Safety valves shall be Kunkle Figure 83-4, or as approved.

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SECTION 15530

REFRIGERANT PIPING SYSTEMS

A. ACCEPTABLE MANUFACTURERS

1. Henry Valve Company.
2. Or as approved.

B. PIPE AND FITTINGS

1. Pipe and fittings shall be refrigeration grade (sealed) copper, System Type C-3.

C. REFRIGERANT BALL VALVES

1. Valves shall be of the two-piece, conventional port type with forged brass body, vented type chrome plated ball, plated stem, teflon seats, blowout-proof stem design, and brass seal cap with teflon gasket.
2. Valves shall have extended copper solder ends to allow brazing without disassembling the valve.
3. Valves shall have a square wrench operating provision and stem stops for positive ball port positioning.
4. Valves shall have a working pressure rating of not less than 500 psig.
5. Refrigerant ball valves shall be as manufactured by Henry Valve Company, or as approved.

D. REFRIGERANT GLOBE VALVES

1. Valves shall be of the bronze body type with forged brass wing cap, forged brass bolted bonnet, gland type packing, plated steel stem with square operating nut, nylon disc, and solder ends.
2. Valves shall be of the backseating type to allow repacking under full operating pressure.
3. Valves shall have a working pressure rating of not less than 450 psig.
4. Refrigerant globe valves shall be Henry Type 203, or as approved.

E. CHARGING AND PURGE VALVES

1. Valves shall be of the angle type, shall be of diaphragm packless construction, and shall have forged brass body with forged brass bonnet, stainless steel spring, nylon disc, round hand wheel, bottom solder connection, flare side connection, and removable seal cap.
2. Valves shall be of the backseating type to allow diaphragm replacement under full operating pressure.
3. Valves shall have a working pressure rating of not less than 500 psig.
4. Charging and purge valves shall be Henry Type 643, or as approved.

F. MOISTURE-LIQUID INDICATORS

1. Units shall be of the color-change element type with element mounted under optical glass and protected by filter screen and pad. Units shall be complete with a protective cap for the viewing glass.
2. Moisture indicating element shall be housed in a replaceable cap assembly which shall be fastened to the main body of the unit. Unit main body shall be of the single port, straight through type with extended copper solder ends.
3. Moisture-liquid indicators shall be Henry Type 3003, or as approved.

G. FILTER-DRIERS

1. Units shall be of the replaceable cartridge type with spring-loaded cartridges.
2. Unit shell shall be of brass construction with flanged head and solder end piping connections. Shell shall be of the angle type with side inlet and bottom discharge and shall have a working pressure rating of not less than 350 psig. Shells shall be Henry Type 77, 78, or 79, as applicable for the required capacity, or as approved.
3. Unit cartridges shall be of the combination filter and drier type designed for removal of moisture, acids, sludge, and foreign materials. Cartridges shall be completely self-contained, self-positioning, and self-sealing and shall have a perforated brass casing. Cartridges shall be sized for their associated shells and shall be Henry Type 87-C, or as approved.

H. SEPARABLE JOINTS

1. Separable joints for refrigerant piping 5/8 inch outside diameter and smaller shall be flare-type couplings, brass construction, and 650 psig minimum working pressure.
2. Separable joints for refrigerant piping 7/8 inch outside diameter and larger shall be flange unions with solder ends, plated bolts, silicon bronze nuts, a fiber gasket, and a 400 psig minimum working pressure. Flange unions shall be Henry Type P30, or as approved.

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SECTION 15541

HORIZONTAL IN-LINE CENTRIFUGAL PUMPS

A. ACCEPTABLE MANUFACTURERS

1. Bell & Gossett ITT.
2. Armstrong Pumps Incorporated.
3. Or as approved.

B. IN-LINE CENTRIFUGAL PUMPS

1. Pumps shall be of the single stage, close coupled centrifugal type.
 - a. All pump internal components shall be serviceable without disturbing piping connections.
 - b. Pumps shall be bronze fitted with cast iron bodies.
 - c. Pump shaft seals shall be the mechanical type with carbon seal rings and ceramic seats suitable for temperatures to 225 degrees F and pressures to 125 psig.
 - d. Pump bearings shall be of the fully supported, oil lubricated, journal type for quiet operation.
 - e. Pump volutes shall be designed for 125 psig working pressure and shall pass a 250 psig factory pressure test.
 - f. Volute shall be provided with pressure gauge tapings at the suction and discharge and multiple vent tapings to accommodate various mounting positions.
 - g. Impellers shall be of the fully enclosed type and shall be hydraulically and dynamically balanced.
2. Pump motors shall be of the oil lubricated, journal bearing type.
3. Pump and motor shall be connected through an appropriate motor bracket assembly.
4. Pump shaft and motor shaft shall be joined through an adequately guarded flexible coupler.
5. Pump units shall be designed to allow for horizontal motor installation in both horizontal and vertical piping without the need for separate motor supports.
6. Pumps shall be provided complete with matching screwed connection companion flanges.
7. Entire pump unit, including companion flanges, shall be provided with a factory applied, machinery enamel finish.
8. Pump units shall be Bell & Gossett Series 60, or as approved.

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SECTION 15542

VERTICAL IN-LINE CENTRIFUGAL PUMPS

A. ACCEPTABLE MANUFACTURERS

1. Bell & Gossett ITT.
2. Armstrong Pumps Incorporated.
3. Or as approved.

B. IN-LINE CENTRIFUGAL PUMPS

1. Pumps shall be of the single stage, close coupled, centrifugal type.
 - a. All pump internal components shall be serviceable without disturbing piping connections.
 - b. Pumps shall be bronze fitted with cast iron bodies.
 - c. Pump shaft seals shall be the mechanical type with carbon seal ring and ceramic seat suitable for temperatures to 225 degrees F and pressures to 125 psig.
 - d. Pump shaft shall be fully protected from system water by a replaceable bronze shaft sleeve.
 - e. Pump volutes shall be designed for 125 psig working pressure and shall pass a 250 psig factory pressure test.
 - f. Volute shall be provided with a vent tapping, a drain tapping, and pressure gauge tappings at the suction and discharge.
 - g. Impellers shall be of the fully enclosed type and shall be hydraulically and dynamically balanced.
2. Pump motors shall be of the oil lubricated, ball bearing type, of speed as scheduled.
3. Pumps shall be designed for vertical motor installation in horizontal piping. Motor shall be supported by the pump body through an appropriate bracket/volute cover plate assembly and shall be provided with lifting lugs to facilitate removal and/or servicing.
4. Pump shall have screwed or flanged end connections as appropriate for the piping system in which the pump is installed.
5. Entire pump unit shall be provided with a factory applied, machinery enamel finish.
6. Pump units shall be Bell & Gossett Series 80, or as approved.

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SECTION 15544

BASE-MOUNTED END SUCTION CENTRIFUGAL PUMPS

A. ACCEPTABLE MANUFACTURERS

1. Bell and Gossett ITT.
2. Armstrong Pumps Incorporated.
3. Or as approved.

B. BASE-MOUNTED END SUCTION PUMPS

1. Pumps shall be of the single stage, radially split case, centrifugal type.
 - a. All pump internal components shall be serviceable without disturbing piping connections or motor.
 - b. Pumps shall be bronze fitted with cast iron bodies.
 - c. Pump shaft seals shall be of the mechanical type with carbon seal ring and ceramic seat suitable for temperatures to 225 degrees F and pressures to 120 psig.
 - d. Pump bearings shall be of the fully supported, regreaseable, ball type.
 - e. Pump volutes shall be designed for 125 psig working pressure and shall pass a 250 psig factory pressure test.
 - f. Volute shall be provided with pressure gauge tappings at the suction and discharge, a vent tapping, and a drain tapping.
 - g. Impellers shall be of the fully enclosed type and shall be hydraulically and dynamically balanced.
2. Pump motors shall be of the ball bearing type.
3. Pump shaft and motor shaft shall be joined through a flexible coupler. Coupler shall be protected by a safety guard that complies with the specific requirements of ANSI B15.1, Section B and OSHA 1910.219.
4. Pump and pump motor shall be mounted on a common base. Base shall be of structural steel construction and shall incorporate provisions for adjustment of pump and motor alignment.
5. Entire pump unit shall be provided with a factory applied, machinery enamel finish.
6. Pumps shall be Bell and Gossett Series 1510, or as approved.

C. SUCTION DIFFUSERS

1. Suction diffusers shall be of the angle type, shall be of cast iron construction, and shall include steel inlet vanes, diffuser-strainer-orifice cylinder, and adjustable foot support.
2. Suction diffusers shall be supplied with a disposable fine mesh start-up strainer.
3. Suction diffusers shall be Bell and Gossett, or as approved.

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SECTION 15545

BASE-MOUNTED DOUBLE SUCTION PUMPS

A. ACCEPTABLE MANUFACTURERS

1. Bell and Gossett ITT.
2. Aurora Pump.
3. Allis-Chalmers.
4. Or as approved.

B. BASE-MOUNTED DOUBLE SUCTION PUMPS

1. Pumps shall be of the single stage, vertical split case, double suction centrifugal type with vertical or combination vertical and horizontal piping connections.
 - a. All pump internal components shall be serviceable without disturbing piping connections or motor.
 - b. Pumps shall be bronze fitted with cast iron bodies.
 - c. Pump shaft seals shall be of the mechanical type with carbon seal ring and ceramic seat suitable for temperatures to 225 degrees F and pressures to 120 psig.
 - d. Pump bearings shall be of the fully supported, regreaseable, ball type.
 - e. Pump volutes shall be designed for 125 psig working pressure and shall pass a 250 psig factory pressure test.
 - f. Volute shall be provided with pressure gauge tappings at the suction and discharge, a vent tapping, and a drain tapping.
 - g. Impellers shall be of the fully enclosed type and shall be hydraulically and dynamically balanced.
2. Pump motors shall be of the ball bearing type.
3. Pump shaft and motor shaft shall be joined through a flexible coupler. Coupler shall be protected by a safety guard.
4. Pump and pump motor shall be mounted on a common base. Base shall be of structural steel construction and shall incorporate provisions for adjustment of pump and motor alignment.
5. Entire pump unit shall be provided with a factory applied, machinery enamel finish.
6. Pumps shall be Bell and Gossett Series VSCS, or as approved.

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SECTION 15546

CONDENSATE RETURN PUMPS

A. ACCEPTABLE MANUFACTURERS (No Substitutions)

1. Aurora Pump

B. CONDENSATE RETURN PUMPS

1. General: Condensate return pump units shall consist of a receiver, two pumps, and the appropriate control equipment.
2. Receiver: Receivers shall be of close grain cast iron construction, shall have provisions for mounting the pump(s) directly to the lower portion of the unit and shall have openings for side inlet, top inlet, vent and overflow connection, and float switch(es).
3. Pumps: Pumps shall be of the vertical, close-coupled, centrifugal type with cast iron housing and motor bracket. Pumps shall be bronze fitted throughout, shall be provided with replaceable bronze wear rings, and shall utilize mechanical seals. Pumps shall be designed to handle 200 degree F condensate without vapor binding.
4. Duplex units shall be provided with a mechanical alternator designed to provide alternate operation of the pumps under normal load and simultaneous operation under peak conditions. Alternator shall be used as the motor control device for pumps up to 1/4 horsepower and as a pilot device for two separate motor starters on units with pumps 1/3 horsepower and larger.
5. Condensate return pump units shall be Aurora Pump Series 220.

C. FINISHES

1. Units shall be provided with a factory applied enamel finish.

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SECTION 15566

WATER PRESSURE REDUCING VALVE

A. ACCEPTABLE MANUFACTURERS

1. Watts Regulator Company.
2. Leslie Company.
3. Spence Engineering.
4. Or as approved.

B. REDUCING VALVES

1. Valves shall be of the spring-loaded diaphragm type, with packless construction, external adjustment, bronze body, screwed ends, single seated, suitable for dead end service, without strainer, useable pressure up to 250 psig.
2. Reducing valves shall be Watts Model No. 223, or as approved.

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SECTION 15710

INDUCED DRAFT COOLING TOWERS

A. ACCEPTABLE MANUFACTURERS

1. Marley.
2. Baltimore Aircoil Company, Inc.
3. EVAPCO, Inc.
4. Delta.
5. Or as approved.

B. GENERAL

1. Cooling towers shall be of adequate capacity to match the performance indicated on the drawings.
2. Cooling towers shall be of the steel, factory assembled, induced draft, crossflow, flow distribution nozzle type and shall consist of nozzles, fans, fan motors and drives, casings, fill sections, eliminators, and all necessary appurtenances.
3. Cooling towers shall be equipped with auxiliary internal baffles to prevent cross flow through unit due to high winds.
4. Cooling towers shall be Marley Series 220, Model 221-221, or as approved.

C. CONSTRUCTION

1. All structural components, including hot water basin and stainless steel cold water basin, equipment supports and framework, casing, and fan cylinder shall be fabricated from heavy gauge steel. All wetted parts (water basins, internal casing surfaces, etc.) shall be of stainless steel construction. All non-wetted parts shall be fully galvanized. All components subjected to welding shall be hot-dip galvanized following welding. All galvanizing shall be equal to G-210.

D. FANS AND DRIVES

1. Fans shall be propeller type with cast aluminum blades. Blades shall be individually adjustable and replaceable.
2. Fans shall be direct driven through a right-angle, oil lubricated, geared speed-reducer or belt drive. Gear casing shall be furnished with oil level sight glass.
3. Fan and drive equipment shall be supported from the unit structural system and independent of the unit casing.

E. FILL, LOUVERS, AND DRIFT ELIMINATORS

1. Fill shall be film producing type PVC with louvers and drift eliminators integrated with each fill sheet. Fill shall be suspended from galvanized structural tubing so as to be elevated above the cold water basin. Drift losses shall not exceed 0.005 percent of tower flow. Air inlet splash losses shall be zero. Air inlets shall be provided with removable, galvanized wire mesh inlet screens.

F. WATER DISTRIBUTION AND CONTROL

1. Tower shall be provided with cast iron construction and right angle flow control valves at the inlet to each distribution basin. Distribution basins shall be provided with factory installed, removable, galvanized steel covers. Basins shall be designed to eliminate splash out at maximum design tower flow rate. Water shall be distributed evenly across fill by means of equally spaced polypropylene flow distribution nozzles mounted in basin on each floor.
2. Tower sump basin shall be completely leak tight; each basin shall be provided with a float-operated make-up water valve, a 4 inch diameter, galvanized overflow standpipe. Basin water discharge shall be through the basin floor. Outlet shall be drilled and gasketed to accommodate a standard 125 psig

pipe flange connection. Provide outlet openings with mud sills, anti-vortex screens, and removable trash screens.

G. TOWER ACCESS AND SAFETY

1. Provide tower with OSHA approved, factory installed, galvanized steel tubing handrail and knee rail around the entire top of the unit fan deck with an aluminum access ladder attached to the side of the unit casing.
2. Provide access to tower cold water basin by means of man-size, sliding access doors located on each side of the unit casing. Provide OSHA approved, factory installed, access ladder and platform for each access door.

H. CONTROL SYSTEMS

1. Each cell of the cooling tower shall be equipped with a factory-wired control system in a NEMA 3R raintight enclosure. This system shall control the operation of the fan motor. The panel shall include a fused disconnect switch with external operating handle, lockable in the off position; a fused control-circuit transformer to provide 1/60/120 volt output; a variable speed (VFD) motor starter (See Division 1600); an enclosure-mounted Hand-Off-Auto selector switch; an enclosure-mounted speed selector dial; a prewired, multiport terminal block for the connection of alarms or auxiliary equipment; and a separately-enclosed thermostatic temperature controller for automatic operation. The temperature controller shall be adjustable for the required cold water temperature. The panel shall be factory-mounted on the casing near the access door; shall be wired to the motor and other unit-mounted electrical components; and shall be fully tested prior to shipment. Control panels shall be UL listed assemblies.
2. Provide a system of electric immersion heaters and controls for each cell of the tower to prevent freezing of water in the collection basin during periods of shutdown. The system shall consist of one or more stainless steel electric immersion heaters installed in threaded couplings provided in the side of the basin. A NEMA 4 enclosure shall house a magnetic contactor to energize heaters; a transformer to provide 24 volt control circuit power; and a solid-state circuit board for temperature and low water cut-off. A control probe shall be located in the basin to monitor water level and temperature. The system shall be capable of maintaining 40 degrees F water temperature at an ambient air temperature of 0 degrees F.
3. Provide a vibration limit switch installed on the mechanical equipment support assembly and wired into the control panel. The purpose of this switch will be to interrupt power to the motor in the event of excessive vibration. It shall be adjustable for sensitivity and shall require manual reset.

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SECTION 15720

REMOTE COOLING TOWER SUMP TANKS

A. ACCEPTABLE MANUFACTURERS

1. Adamson Company, Inc.
2. Ace Tank & Heater Company.
3. Richmond Engineering Company, Inc.
4. Bremen Tank Company.
5. Or as approved.

B. SUMP TANKS

1. Remote cooling tower sump tanks shall be of steel welded construction with a baked-on phenolic lining applied at a minimum thickness of 7 mils. Tank shall be provided with a top access 24 inch round manhole and shall be pressure tested at a minimum pressure of 5 psig.
2. Tanks shall be of the flat bottom, vertical side design suitable for installation without hold-down provisions or additional mounting accessories directly on a concrete floor.
3. Tanks shall be provided with the following openings (sizes as indicated on the drawings or as applicable for the associated equipment):
 - a. Gauge glass connections.
 - b. Make-up water connections (water column connections for float switch and make-up water connection).
 - c. Side outlet (with anti-vortex plate).
 - d. Top/side inlet (with diverter tee).
 - e. Overflow connection.
 - f. Drain connection.
 - g. Access manway opening for internal inspection and cleaning.

C. WATER FEEDERS

1. Make-up water feeders shall be of the float operated, automatic reset, pilot type with single seated, electric solenoid make-up valve.
2. Make-up water feeders shall consist of a low water controller coupled with line size normally closed, two-way solenoid valve in make-up water piping, or as approved.

D. LEVEL SENSORS

1. Level sensors shall be of the float operated, continuous readout, magnetic type consisting of a stainless steel magnet float mounted on a stainless steel slide rod and a signal conditioning module to provide a 4-20 ma output signal.
2. Level sensors shall provide a minimum ¼ inch measurement resolution and shall be suitable for fluid temperatures up to 160 degrees F.
3. Level sensors shall be Gems Sensors, Series XM/XT-800, or as approved.

E. FINISHES

1. Tanks shall be provided with a factory prime finish and filled or factory applied, 1-inch thick, insulation jacketed.

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SECTION 15750

CENTRIFUGAL WATER CHILLERS

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. Carrier Corporation.
3. McQuay: Snyder General.

B. GENERAL

1. Chillers shall be factory assembled, customized designed units with components selected to match the performance requirements indicated in the attached schedule.
2. Chillers shall be provided complete with all necessary accessories for a complete, trouble-free installation.
3. Chillers shall be of the electric motor driven, hermetic, single or multiple-stage, centrifugal type with a capacity control system capable of operating the machine at loads down to 25 percent of full capacity without the use of hot gas bypass. Air-cooled chillers shall be capable of operating down to 0 degrees F minimum.
4. Chiller packages shall be complete in every respect and shall include compressors, evaporators, condensers, all necessary motors, purge system, vibration isolators, oil coolers and associated piping, motor disconnect switches, reduced voltage type motor starter, control console and all necessary controls, initial charges of refrigerant and lubricating oil, and start-up service.

C. COMPRESSORS

1. Compressors shall be of the single or multi-stage centrifugal, hermetic, direct or gear drive type utilizing open or shrouded impellers.
2. Compressor casings shall be of cast iron construction so designed to be readily serviceable.
3. Compressor capacity control shall be of the inlet vane type.
4. Compressor motors shall be of the hermetically sealed, refrigerant cooled type with motor windings specifically designed for refrigerant compatibility. Motor windings shall match starter type hereinafter specified.
5. All unit compressor bearings shall be of the pressure lubricated type and the unit shall include the necessary oil pump, sump heater, and safety controls to stop the machine in case of insufficient lubrication pressure.

D. EVAPORATORS

1. Evaporators shall be of the shell and tube type with carbon steel shell, cast iron water boxes, integral finned copper tubes and steel tube sheets, and tube supports. Tubes shall be rolled into the tube sheets to form a leakproof bond.
2. Evaporators shall be complete with a liquid metering device to assure even refrigerant flow while maintaining a liquid seal between evaporator and condenser.
3. Evaporators shall be suitable for working pressures of not less than 150 psig and shall conform to ANSI B9.1 Safety Code for mechanical refrigeration and/or ANSI/ASHRAE 15-1994 Safety Code.
4. Evaporators shall be factory insulated.
5. Evaporators shall be sized to match the performance requirements indicated on the drawings.

E. CONDENSERS

1. Condensers shall be of the shell and tube type with carbon steel shell, cast iron water boxes, integral finned copper tubes and steel tube sheets, and tube supports. Tubes shall be rolled into the tube sheets to form a leakproof bond.
2. Condensers shall be sized to match the performance requirements indicated in the attached schedule.
3. Condensers shall be suitable for working pressures of not less than 150 psig and shall conform to ANSI B9.1 Safety Code for mechanical refrigeration and/or ANSI/ASHRAE 15-1978 Safety Code.

F. PURGE SYSTEM

1. Purge system shall be the compression or noncompression type complete with all necessary valves and accessories. System shall be completely factory installed and piped.
2. Noncondensables shall be purged automatically.
3. Water shall be purged manually through a blow-off valve.
4. Valves shall be provided to isolate the purge system.

G. CONTROL SYSTEM

1. Controls shall be provided, as required, to control and monitor chiller operation. Condenser pressure controls shall be suitable for providing smooth machine operation with condenser inlet water temperatures varying from a maximum of 85 degrees F to a minimum of 65 degrees F.
2. Capacity control system shall be of the self-contained, microprocessor based, electronic type and shall include a demand limiter which shall allow for manual selection of maximum compressor motor current equal to that at 40, 60, 80, or 100 percent of the maximum capacity current. All necessary thermostats, water flow switches, damper operators, etc., shall be provided with the unit.
3. All other necessary controls and control accessories shall be provided located in a steel control console with face components properly labeled. Such controls shall include, but not necessarily be limited to, pressure gauges for oil, evaporator, condenser, and purge drum pressures; anti-recycle timer; display of entering and leaving evaporator and condenser water temperature; run time display; switches for manual or automatic operation of oil pump and purge compressor; switch to operate the purge heater (with pilot light); and safety shut-down controls, with indicating lights to stop the machine in the event of low oil pressure, low chilled water or refrigerant temperature, high condenser pressure, or high motor temperature. Safety controls shall be of the noncycling, manual reset type. Motor protection shall protect the motor from phase loss, reversal or unbalance, distribution fault, and low voltage.
4. Include head pressure controls when chiller is installed to start-up from a free cooling cycle with low temperature (40 degrees F) condenser water temperature.
5. Unit controls shall interface with and provide the following from the building automation system:
 - a. Chilled water temperature reset.
 - b. Chiller alarm.
 - c. Water temperature.
 - d. Refrigerant leak.
 - e. Refrigerant Temperatures.

H. MOTOR STARTING EQUIPMENT

1. Provide a unit mounted, star-delta, closed transition motor starter, high capacity circuit breaker disconnect, and fused control power transformer. Starter cabinet shall be free standing, NEMA-1.

I. RESPIRATORS (BY ELECTRIC BOAT)

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SECTION 15756

STEAM TO WATER HEAT EXCHANGERS

A. ACCEPTABLE MANUFACTURERS

1. ITT Bell and Gossett.
2. Patterson-Kelly.
3. Taco, Inc.
4. Or as approved.

B. HEAT EXCHANGER

1. Heat exchangers shall be shell and tube, U-bend removable tube bundle type with steam in the shell and water in the tubes.
2. Heat exchangers shall be constructed to conform with the latest ASME Code for unfired pressure vessels, for minimum working pressure of 125 psi on tube side and shell side, and shall be provided with the ASME Code stamp.
3. Shell, tube sheets, and tube supports shall be made of steel. Heads shall be cast iron or steel. Tubes shall be 3/4 inch outside diameter seamless copper.
4. Exchangers shall have capacities rated at 0.0005 fouling factor and shall be Bell and Gossett Model SU, or as approved.

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SECTION 15757

PLATE AND FRAME HEAT EXCHANGERS

A. ACCEPTABLE MANUFACTURERS

1. ITT Bell and Gossett.
2. Alfa-Laval Thermal, Inc.
3. Or as approved.

B. HEAT EXCHANGER

1. Heat exchangers shall be of the expandable plate and frame type.
2. Heat exchangers shall be constructed to conform with the latest ASME Code for unfired pressure vessels, for minimum working pressure of 150 psi and shall be provided with the ASME Code stamp.
3. Removable plates shall be of the corrugated channel type. Plates shall be stainless steel construction.
4. Fixed frame plates shall be epoxy painted steel.
5. Plates shall be double gasketed to prevent cross-contamination. Gaskets shall be nitrile.
6. Exchangers shall have capacities rated at 0.0005 fouling factor and shall be Bell and Gossett Type GPX as indicated on the drawings, or as approved.

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SECTION 15781

COMPUTER ROOM AIR CONDITIONING UNITS

- A. ACCEPTABLE MANUFACTURER (No Substitutes)
1. Liebert Corporation.
- B. GENERAL
1. Computer room air conditioning units shall be complete factory packages capable of heating, cooling, humidification, dehumidification, water detection system, smoke detection, disconnect switch, and high efficiency filtration necessary for computer room environmental control.
 2. Units shall be of the vertical down-flow, direct expansion type and shall be complete with cabinet, fans, fan drives, compressors, evaporator coils, humidifiers, reheat provisions, and all necessary controls.
- C. CABINETS
1. Cabinets shall consist of thermally lined steel panels secured to a tubular steel frame. Panels shall be removable, as necessary for maintenance, and entire cabinet shall be finished with baked enamel of a color as selected by the Engineer.
 2. Cabinets shall have provisions for an air intake and adjustable pattern air discharge grilles.
- D. FANS
1. Fans shall be of the double width, double inlet centrifugal type with forward curved or backward inclined blades. Fans shall be direct driven or belt driven, as applicable, by motors rated to be nonoverloading at all normal points of operation for the unit.
 2. All fan wheels shall be statically and dynamically balanced.
- E. REFRIGERATION SYSTEM
1. Refrigeration system shall include evaporator coil, compressor, all necessary interconnecting piping, and all necessary accessories.
 2. Evaporator coil shall be of the aluminum fin, copper tube, direct expansion type and shall be provided with a drain pan.
 3. Compressor shall be of the hermetically sealed type with inherent motor protection and shall be complete with isolating springs for smooth, vibration-free operation.
 4. Accessories shall include service valves (such as suction and discharge valves, etc.), high/low pressure controls, and all other necessary operating components.
- F. HUMIDIFIER
1. The humidifier shall be of the infrared type consisting of high- intensity quartz lamps mounted above and out of the water supply.
 2. The evaporator pan shall be stainless steel and arranged to be serviceable without disconnecting water supply lines, drain lines, or electrical connections.
 3. The complete humidifier section shall be prepiped ready for final connection.
 4. The infrared humidification system shall use bypass air to prevent over-humidification of the computer room.

5. All necessary control valves, etc., shall be provided with the unit ready for final connection to a domestic cold water supply.

G. FILTERS

1. Filters shall be of the pleated type, rated not less than 20 percent efficiency based on ASHRAE 52-76, and shall be provided with tracks designed to hold the panels firmly in place.

H. CONTROLS

1. The manufacturer shall provide all controls necessary to properly sequence and operate all components hereinbefore specified. All controls shall be completely solid-state, self-contained with adjustable set points, and installed at the manufacturer's factory. Equipment shall require no field wiring or installation.
2. Controls shall include a factory-mounted and wired electrical disconnect switch.
3. Controls shall include interface with site Energy Management System for alarm annunciation.

I. REHEAT COILS

1. The reheat coils shall be electric type and shall be capable of maintaining room dry bulb conditions when the system is calling for dehumidification.
2. The reheat section shall include UL approved safety switches to protect the system from overheating.

J. ACCESSORIES

1. Each unit shall be provided with a solid-state water sensor system for moisture detection and a smoke detector. Both devices shall activate alarm system.
2. Each unit shall be provided with a nonlocking disconnect switch meeting NEC requirements.

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SECTION 15814

EVAPORATIVE PAN HUMIDIFIERS

A. ACCEPTABLE MANUFACTURERS

1. Dri-Steem Humidifier Co.
2. Armstrong International, Inc.
3. Or as approved.

B. HUMIDIFIERS

1. General

- a. Humidifiers shall be complete factory packaged units including as a minimum:

- 1) Insulated vaporizing chamber.
- 2) Heat exchanger.
- 3) Automatic make-up water provisions.
- 4) Automatic flush and drain provisions.
- 5) Inverted bucket steam trap.
- 6) Pneumatic steam control valve.
- 7) Duct mounted dispersion tube.
- 8) Vapor and condensate hoses.
- 9) Wall support brackets.

- b. Humidifiers shall be of the steam-to-steam, evaporative pan type, designed to use boiler steam for generation of clean steam using domestic water.

- c. Evaporative pan humidifiers shall be Dri-Steem Model STS, or as approved.

2. Vaporizing Chamber

- a. Vaporizing chamber shall be of all welded stainless steel construction with removable lid and clean-out plate for ease of cleaning and removal of mineral build-up.

- b. Vaporizing chamber shall be insulated with minimum 3/4 inch thickness rigid foam insulation with reinforced aluminum foil jacket.

3. Heat Exchanger

- a. Heat exchanger shall be of the straight tube design with welded steel return and supply headers. Heat exchanger tubes and headers shall be of Teflon coated stainless steel or copper construction.

4. Distributing Manifolds

- a. Each unit shall be provided with a steam distributing manifold. Manifolds shall be sized for the duct or plenum being served and shall have provisions for mounting directly to the duct or plenum wall.

- b. Manifolds shall be designed to separate and drain condensate to provide for supply of dry steam.

- c. Each manifold shall be provided with a steam hose and a condensate return hose. Hoses shall be sized for the capacity of the manifold and shall be of length as required to inter-connect generator and manifold.

5. Controls

- a. Humidifiers shall be equipped with electronic water level controls consisting of Teflon coated stainless steel probes, solenoid operated fill valve, and associated electronic level controls.
- b. Humidifiers shall be equipped with automatic drain and flush provisions consisting of an adjustable skimmer, solenoid drain valve, and timer for timed control of drain cycle.

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SECTION 15831

FIN TUBE RADIATION

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. The Vulcan Radiator Company.
3. Sterling Radiator Company, Inc.
4. Or as approved.

B. QUALITY ASSURANCE

1. All fin radiation capacities shall be IBR certified.

C. FIN TUBE RADIATION

1. Radiation shall consist of a mounting plate, element hangers, element supports, elements, dampers, and enclosures.
2. Mounting plate shall be continuous along the top of the enclosure, shall be suitable for use as a plaster stop, and shall have provisions for supporting both the element hangers and the enclosure front panel.
3. Element hangers shall be designed to hang from the mounting plate, clip the bottom edge of the enclosure front panel, and hold the element supports.
4. Element supports shall be of the cradle type with provisions for allowing element expansion and contraction without noise.
5. Hydronic Elements
 - a. Elements shall consist of aluminum fins mechanically bonded to copper pipe. One end of the element shall be swaged to accept standard copper tube; the opposite end shall be standard copper tube size. Ends shall be suitable for sweat connections.
6. Steam Elements
 - a. Elements shall consist of steel fins mechanically bonded to steel tubing. Tube ends shall be provided with NPT threaded ends.
7. Dampers shall be continuous, shall be designed to block air flow through the unit, and shall be adjustable (by means of a knob type actuator) from the enclosure front.
8. Enclosures shall be of steel construction of not less than 16 gauge thickness. Enclosures shall be designed to hang from the mounting plate and be clipped at the bottom. Ends of enclosure panels shall have provisions for splicing neatly to adjacent enclosure panels or trim accessories. No visible fasteners shall be used on enclosures.
9. Stamped Grills
 - a. Enclosures shall be equipped with stamped sheet metal air outlets in the enclosure panel. Grilles shall be either front mounted, top mounted, or sloped top and shall be Trane Type F, S, T, or E3, as applicable, or as approved.
10. Architectural Grill
 - a. Enclosures shall be of the flat top type with an extruded aluminum continuous discharge grille. Enclosures shall be Trane Type TA or E3A, as applicable, or as approved.

D. ACCESSORIES

1. All accessories (end caps, trim strips, access door sections, inside corners, outside corners, etc.) shall be of construction and appearance to match the enclosure and shall join to same neatly and firmly without the use of visible fasteners.

E. FINISHES

1. All steel enclosures and accessories shall be provided with a factory applied baked enamel finish, or as approved. Color shall be selected by Electric Boats representative from the manufacturer's standard color selection. Not less than six colors shall be available from which to choose.

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SECTION 15835

HYDRONIC/STEAM UNIT HEATERS

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. American Air Filter Company, Inc.
3. Modine Manufacturing Company.
4. Or as approved.

B. UNIT HEATERS

1. Unit heaters shall consist of a unit casing, a hot water/steam coil, and a direct-driven propeller fan.
2. Coils shall be constructed of aluminum fins mechanically bonded to copper tubes and shall be factory tested underwater at a pressure of not less than 200 psig.
3. Fan motor shall be of the permanently lubricated type where specifically indicated, with built-in thermal overload protection.
4. Fan blades shall be of aluminum construction and shall be secured to the fan motor shaft by means of a set screw.
5. Fan and motor assembly shall be attached to the casing through resilient mounts and shall be removable from the unit without disturbing piping connections.

C. HORIZONTAL UNITS

1. Horizontal units shall use a flat coil with the fan blowing the air through the coil in a horizontal direction. Unit shall be provided with an inlet guard and with adjustable, horizontal, discharge louver. Units shall be Trane Model S, or as approved.

D. VERTICAL UNITS

1. Vertical units shall use a square or circular wrap-around coil with the fan drawing the air in horizontally through the coil and discharging it downward. Units shall be Trane Model P, or as approved.

E. LOUVER CONE DIFFUSERS

1. Louver cone diffusers shall consist of a series of radial steel blades mounted in a suitable frame for attachment to the discharge of a vertical unit heater. Blades shall be adjustable to allow air discharge to be varied from horizontal diffusion to vertical downblow. Blades shall be designed to hold their set positions and shall be adequately braced, crimped, etc., to prevent rattling and vibration.

F. FINISHES

1. All unit heaters and accessories shall be provided with a factory applied baked enamel finish, or as approved.
2. Color shall be manufacturer's standard color.

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SECTION 15836

CABINET HEATERS

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. American Air Filter Company, Inc.
3. Or as approved.

B. GENERAL

1. Cabinet heaters shall consist of a cabinet, chassis, heating coil, filters, fans, fan motors, controls, and all necessary appurtenances.

C. BASIC CHASSIS AND COMPONENTS

1. Cabinet heaters shall include a basic chassis designed to hold the coil, fan assembly, and filters and to provide a mounting means for controls and cabinet panels. Basic chassis shall be of galvanized steel construction, formed and braced for rigidity, and shall be provided with mounting means for the unit.
2. Coils shall be of the aluminum fin, copper tube type with fins mechanically bonded to the tubes. Coils shall be factory tested under water at a pressure of not less than 250 psig. Water coils shall be suitable for minimum 200 degrees F at 300 PSIG operating pressure. Steam coils shall be suitable for minimum 338 degrees F and 100 PSIG steam operating pressure.
3. Fans shall be of the forward curved centrifugal type, direct driven, with fans and motor mounted on an easily removable support assembly. Support assembly shall be of galvanized steel construction.
4. Fan motors shall be of the open sleeve bearing type with built-in thermal overload protection.
5. Filters shall be of the 1 inch thick throwaway type using fibrous glass media in a heavy cardboard frame.

D. CONTROLS

1. Every vertical unit shall be provided with a factory mounted and wired three-speed fan switch with an off position suitable for use as an electrical disconnect.
2. Every vertical cabinet heater shall be provided with a factory mounted and wired integral line voltage thermostat with adjustable set point and shall be wired to cycle the unit fan. Control package shall be Trane No. H06.
3. Every horizontal concealed unit shall be provided with a remote mounted electric thermostat with subbase to select summer or winter mode of operation and one of three fan motor speeds plus off. Control package shall be Trane No. H04.

E. CABINETS

1. General
 - a. Cabinets shall be of steel construction with panels formed for rigidity.
 - b. All parts of cabinets in contact with coil discharge air shall be internally lined with not less than 1 inch of fiberglass insulation.
2. Vertical Recessed Cabinets
 - a. Vertical recessed cabinets shall be designed to be installed in the wall and off the floor. The front panel shall be provided with a stamped inlet grille near the bottom and a stamped discharge grille near the top. The front panel shall be of the four-side overlap type and shall be removable.

- b. Vertical recessed cabinet models shall be Trane Force-Flo Model FFHB, or as approved.

3. Vertical Wall-Hung Cabinets

- a. Vertical wall-hung cabinets shall be arranged to draw air in through the bottom of the unit and discharge air out through an integral stamped outlet grille in the cabinet top. Front and end panels shall be removable. An access panel shall be provided in the cabinet top for access to controls.
- b. Vertical wall-hung units shall be Trane Force-Flo Model FFFB, or as approved.

4. Horizontal Concealed Cabinets

- a. Horizontal concealed cabinets shall be designed to be installed above the ceiling, shall have ducted inlet and ducted discharge, and shall have front and back duct collars.
- b. Horizontal concealed cabinet models shall be Trane Uni-Trane Model FFCB, or as approved.

5. Horizontal Recessed Cabinets

- a. Horizontal recessed cabinets shall be designed to be installed fully recessed in the ceiling. The front panel shall be provided with stamped inlet and discharge grilles. The front panel shall be of the four-side overlap type and shall be removable or hinged.
- b. Horizontal recessed cabinet models shall be Trane Force-Flow Model FFEB, or as approved.

F. FINISHES

- 1. All units shall be provided with a factory applied baked enamel finish, or as approved. Color shall be selected by Electric Boat's representative from the manufacturer's standard color selection. Not less than six colors shall be available from which to choose.

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SECTION 15858

PACKAGED HEATING, VENTILATING, AND AIR CONDITIONING UNITS

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. Carrier Corporation.
3. McQuay.

B. QUALITY ASSURANCE

1. Fans
 - a. Fan balancing procedure shall meet or exceed the requirements of ARI 435.
 - b. Fan air side performance shall be certified in accordance with ARI 430.

C. GENERAL

1. Packaged heating, ventilating, and air conditioning units shall be completely factory assembled units (may be broken down for shipment) and shall include all components shown on the drawings (or implied by the schedules). Components shall be as specified in the following paragraphs.
 - a. All casings shall be of steel construction adequately reinforced to allow the unit to be suspended without undue vibration, deflection, or misalignment.
 - b. All casings shall be internally insulated with 1 inch thick fibrous glass, or as approved.
 - c. All casings shall be provided with access doors or removable access panels to facilitate servicing, maintenance, and component replacement.
 - d. All casings shall be provided with a factory applied baked enamel finish, or as approved.
2. Unit electronics, including motor drives, shall be designed for high temperatures (minimum 250 degrees F) or shall be located out of the air stream to prevent damage during periods when unit is shut down and steam supply is maintained active.
3. Packaged heating and ventilating units shall be Trane Climate Changer, or as approved.

D. FAN SECTION

1. Fan section shall consist of casing, fan, and drive.
2. Fans shall be of the centrifugal type with forward curved blades. Fan wheels shall be statically and dynamically balanced and shall be supported on a heavy steel shaft extending through both sides of the casing. Shaft shall rotate in self-aligning, flange type bearings located external to the unit.
3. Drive shall be of the V-belt type with motor mounted on the exterior of the fan casing. Provisions shall be made for adjustment of belt tension. Motor sheave shall be of the adjustable type to allow adjustment of the fan speed above and below that required to achieve the scheduled performance. Belts and sheaves shall be adequately guarded.
4. Fan, motor, and drive components shall be factory balanced, as a unit, at the design rpm.

E. INLET VANES

1. Inlet vanes shall operate in friction-free bearings and shall be interconnected to operate in unison. Inlet vane control linkage shall be suitable for attachment of a pneumatic damper operator to be provided by the temperature control manufacturer as specified in Section 15970, AUTOMATIC TEMPERATURE CONTROL, GENERAL.

F. COIL SECTION

1. Coil section shall consist of casing and coils. Coils shall be as indicated.
2. Hot Water Heating Coils
 - a. Hot water heating coils shall be furnished with aluminum fins bonded to copper tubes. Tubes shall be rolled into cast iron headers at connection ends. Headers shall be provided with access plugs for tube inspection and maintenance. Coils shall be mounted in a rigid galvanized steel casing around the entire coil perimeter. Coils shall be factory tested underwater at a pressure of not less than 250 psig. Coils shall be Trane Type W, WA, or WC, as applicable, or as approved.
3. Steam Heating Coils
 - a. Steam heating coils shall be of the steam distributing (non-freeze) type with aluminum fins bonded to copper tubes. Tubes shall be rolled into cast iron headers which have access holes for tube inspection and maintenance. Coils shall be mounted in a rigid galvanized steel casing around the entire coil perimeter. Coils shall be factory tested underwater at a pressure of not less than 250 psig.
4. Chilled Water Cooling Coils
 - a. Chilled water cooling coils shall be of the continuous tube type with aluminum fins bonded to copper tubes. Tubes shall be rolled into cast iron headers. Headers shall be designed to allow full and complete drainage. Coils shall be mounted in a rigid galvanized steel casing around the entire coil perimeter. Coils shall be factory tested underwater at a pressure of not less than 250 psig. Coils shall be dehydrated and shipped with a holding charge of dry nitrogen. Coils shall be Trane Type D, or as approved.
5. Direct Expansion Refrigerant Cooling Coils
 - a. Cooling coils shall be of the direct expansion type. Coils shall be of the continuous tube type with aluminum fins bonded to copper tubes. Coil supplies shall be provided with equalizing type vertical distributors suitable for use with hot gas injection at the coil inlet hot gas bypass systems. Coils shall be circuited to provide intertwined but separate refrigerant circuits for each compressor in the associated condensing unit. Coils shall be mounted in a rigid galvanized steel casing around the entire coil perimeter. Coils shall be factory tested underwater at a pressure of not less than 300 psig. Coils shall be dehydrated and shipped with a holding charge of dry nitrogen. Each coil circuit shall be provided with a liquid line solenoid valve and a thermal expansion valve as required for capacity control.
6. Coil section shall be provided with a drain pan completely insulated with seamless, cellular, sprayed, foamed-in-place insulation not less than 1/2 inch thick. Drainpan shall be provided with drain connections on both sides of the coil casing.

G. FILTER/MIXING BOX SECTION

1. Combination filter/mixing box section shall consist of casing, two sets of parallel blade inlet dampers, filter tracks, and panel filters.
2. Dampers shall utilize steel blades locked to steel shafts rotating in nylon bushings. Control rods shall extend through the casing and shall be suitable for attachment of automatic control linkage.
3. Damper locations shall be as indicated on the drawings. Damper blades shall be oriented to ensure thorough mixing of the two inlet air streams.
4. Filter tracks shall be of steel construction and shall be arranged to hold the filters in an angle pattern. Filters shall slide into the casing from the side, and access doors shall be provided at both sides of the casing to accommodate filter inspection, maintenance, and replacement.
5. Filters for filter/mixing box section shall be of the throwaway type as specified in Section 15880, AIR FILTER ASSEMBLIES.

H. FILTER SECTION

1. Filter section shall consist of casing and filter tracks.
2. Filters shall be cartridge type as specified in Section 15880, AIR FILTER ASSEMBLIES.

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SECTION 15860

SMALL CENTRIFUGAL FANS

A. ACCEPTABLE MANUFACTURERS

1. Cincinnati Fan and Ventilator Company, Inc.
2. Or as approved.

B. FANS

1. Fans shall be a complete factory package including fan wheel, fan housing, motor, drive, motor supports, and all required accessories. Fans shall be designed to be floor mounted.
2. Fans shall be single inlet, single width centrifugal type with statically and dynamically balanced wheels.
3. Fans shall be of AMCA Type A nonsparking construction with cast aluminum housings. Fan housings shall include an inlet flanged collar.
4. Fan capacities shall be rated in accordance with AMCA Standard 210.
5. Fans shall be of rotation and fan discharge direction indicated on the drawings. If not indicated, fan arrangements shall be chosen for minimum turbulence in the discharge ductwork.
6. Drives shall be of the direct drive type with the fan wheel mounted directly on the motor shaft. The motor shall be mounted on a heavy steel base.
7. Small centrifugal fans shall be Cincinnati PB Series, or as approved.

C. FINISHES

1. Fans shall be provided with a factory-furnished enamel finish.

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SECTION 15861

UTILITY FANS

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. ILG Industries.
3. Greenheck Fan Corporation.

B. UTILITY FANS

1. Utility fans shall be complete factory packages including fan wheel, fan housing, motor, drive (except direct-drive units), motor supports, drive housing, and all required accessories.
2. Utility fans shall be designed to be floor-mounted or ceiling-hung.
3. Fans shall be single inlet, single width centrifugal type with statically and dynamically balanced wheels.
4. Fan wheels shall be either forward curved or backward inclined as chosen by the manufacturer to meet the design performance.
5. Utility fans shall be of all steel construction. All housings shall be of lockseam or welded construction and shall be reinforced as necessary to prevent vibration. Fan housings shall include a flanged inlet collar.
6. Fan housings shall incorporate conical fan inlets and rolled fan cutoffs for maximum efficiency and quiet operation.
7. Belt-drive fans shall have the fan wheel mounted on a heavy steel shaft rotating in self-aligning pillow block bearings. Shaft bearings and motor shall each be mounted on heavy steel bases and provisions shall be made for adjusting belt tension. Motor sheave shall be of the adjustable type selected to allow fan speeds above and below that required to yield the scheduled performance. All belt drive fans shall be provided with a weatherproof housing over the motor/drive compartment.
8. Direct-drive fans shall have the fan wheel mounted directly on the motor shaft. Motor shall be mounted on a heavy steel base. Units for outdoor application shall be provided with a weatherproof housing over the motor compartment.
9. Utility fans shall be provided with a factory applied baked enamel finish, or as approved.

C. STANDARD OF QUALITY

1. Utility fans shall be Trane Utility Fans, or as approved.

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SECTION 15863

IN-LINE CENTRIFUGAL FANS

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. Penn Ventilator Company, Inc.
3. Or as approved.

B. FANS

1. Fans shall be complete factory packages including fan wheel, insulated fan housing, motor, drive, motor supports, and all required accessories.
2. Fans shall be double inlet, double width centrifugal type with statically and dynamically balanced wheels.
3. Fan wheels shall be of aluminum construction, backward inclined type.
4. Fan housings shall be of all steel construction. Housings shall be of lockseam or welded construction, insulated, and shall be reinforced as necessary to prevent vibration.
5. Fan housings shall incorporate conical fan inlets for maximum efficiency and quiet operation.
6. Fan housing shall be of the in-line type designed for horizontal ducted inlet and discharge.
7. Fan housing shall include removable or hinged panels for access to fan and drive.
8. Fan wheel shall be supported on a heavy steel shaft supported at each end in self-aligning pillow block or flange type bearings. Bearing supports shall be of a type to properly transmit the load to the fan housing regardless of fan mounting position.
9. Fan shall be of the belt driven type with motor mounted outside the fan housing. Motor sheave shall be of the adjustable type to allow adjustment of the fan speed above and below the speed required to yield the scheduled performance. Provisions shall be made for adjustment of belt tension and a belt drive guard shall be provided for all fans.
10. Fans shall be Trane Model CIBA, or as approved.

C. FINISHES

1. Unless specifically indicated otherwise, fans and all accessories shall be provided with a factory bonderized and baked enamel finish.

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SECTION 15866

PANEL FANS

A. ACCEPTABLE MANUFACTURERS

1. Penn Ventilator Company, Inc.
2. Carnes Company.
3. Acme Engineering and Manufacturing Corp.
4. Or as approved.

B. QUALITY ASSURANCE

1. All fan capacities shall be AMCA rated.

C. PANEL FANS

1. General: Panel fans shall consist of a heavy formed steel panel, a propeller fan, and all necessary reinforcing, supports, etc., to yield a rigid, quiet operating unit. Fan panel shall serve the dual purpose of providing a mounting means for the fan in a wall, roof, etc., and of providing a formed fan inlet for more efficient operation. Propeller shall be of steel construction with the blades securely welded to heavy steel hub. Propellers shall be statically and dynamically balanced. Fans shall be designed to operate at any angle.
2. Direct Drive Type: Direct driven fans shall have the propeller mounted directly on the motor shaft and the motor shall be securely fastened to steel support members which are, in turn, securely fastened to the fan panel. Direct driven fans shall be Acme Dynamaster, or as approved.
3. Belt Drive Type: Belt driven fans shall have the propeller mounted on a shaft which is rotating in not less than two ball bearings. Shaft bearings and motor shall be securely fastened to steel support members which are, in turn, securely fastened to the fan panel. Proper means shall be provided for adjusting the belt tension of the multiple V-belt drive. Belt driven fans shall be Acme Windmaster, or as approved.

D. SAFETY GUARDS

1. Safety guards shall be of heavy gauge wire mesh construction and shall completely cover the rear (motor) side of the fan, when used. Guards shall bolt directly to the fan panel and shall be readily removable for fan servicing. Safety guards shall be Acme Model BA, or as approved.

E. WALL COLLARS

1. Wall collars shall be designed to hold the fan and motorized shutter. Collars shall be of steel construction and shall be of the same inside dimensions as the overall dimensions of the fan panel.

F. MOTORIZED SHUTTERS

1. Motorized shutters shall be of the parallel blade type with felted edges.
2. Motor shall be of the stall type and shall be of electrical characteristics the same as the fan motor or shall include an appropriate transformer.
3. Shutters shall be sized to fit in the associated wall opening.

G. FINISHES

1. Panel fans and all accessories shall be provided with a bonderized and baked enamel finish.

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SECTION 15870

POWER ROOF VENTILATORS

A. ACCEPTABLE MANUFACTURERS

1. Penn Ventilator Company, Inc.
2. Carnes Company.
3. Acme Engineering and Manufacturing Corp.
4. Jenn Industries Incorporated.
5. Or as approved.

B. QUALITY ASSURANCE

1. All fan capacities shall be AMCA rated.

C. POWER ROOF VENTILATORS

1. General
 - a. All ventilators shall be of the centrifugal type with statically and dynamically balanced fan wheels.
 - b. Fan wheels 18 inches and less in diameter may be either forward curved type or backward inclined type; all wheels over 18 inches in diameter shall be backward inclined, non overloading type.
 - c. Unless specifically noted otherwise, all ventilators shall be of the V-belt driven type with an adjustable motor sheave. Sheave shall be sized to allow operation at speeds above and below the speed required to achieve the performance scheduled.
 - d. All ventilators shall be provided with bird screens on the discharge opening.
 - e. Except for units scheduled to have explosion-proof motors, all ventilators shall be provided with a factory-installed electrical disconnect switch located under the hood.
 - f. Ventilator drives shall be mounted on a rigidly reinforced base which shall be vibration isolated from the ventilator body.
 - g. Ventilators shall have a base designed to fit over a roof curb. Base shall be designed to include a formed fan inlet for more efficient operation.
2. Low silhouette type ventilators shall have a rectangular, flat roof housing with downward discharge. Fan wheels shall be narrow width, large diameter to keep unit height minimal. Housing shall be supported on struts which transmit the load to the base. Low silhouette ventilators shall be Penn Ventilator Low Contour Dynafan, or as approved.
3. Upblast type ventilators shall have a flat domed type housing especially designed for discharging the air upward, away from the roof, while maintaining weather protection to the interior whether running or not. Upblast ventilators shall be Penn Ventilator Fumex, or as approved.
4. Ventilators shall be of all aluminum construction (except for motor, drive, and drive supporting members).

D. MOTORIZED DAMPERS

1. Motorized dampers shall be of the parallel blade type with felted edges.
2. Damper motor shall be of the stall type and shall be of electrical characteristics the same as the fan motor or shall include an appropriate transformer.
3. Dampers shall be sized to fit in the roof curb or fan neck.

E. FINISHES

1. Power roof ventilators shall have a mill finish.

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SECTION 15875

WELDING FUME EXHAUST SYSTEMS AND ACCESSORIES

A. ACCEPTABLE MANUFACTURERS

1. Ammerman Co., Inc.
2. The Engwald Corporation.
3. Car-Mon Products Inc.
4. Or as approved.

B. GENERAL

1. The welding fume exhaust system shall consist of a factory fabricated , flexible hose exhaust hood assembly, and all interconnecting ductwork.

C. FLEXIBLE ARM AND HOSE ASSEMBLY

1. Assembly shall consist of weld-proof type, 5 inch diameter neoprene hose supported by a counterweighted steel support arm with a minimum of two (2) swivel joints spaced equally along the arm to allow for adjustment of suction hood height. Arm assembly shall be provided with locking mechanism to fix suction hood at desired height. Lock shall be operable from suction hood.
2. Flexible arm and hose assembly shall be minimum 12 feet long and shall be secured to ceiling-mounted support frame with a grease lubricated swivel joint which allows minimum 360 degree movement of arm assembly.
3. Flexible arm and hose assembly shall be Engwald Model W-300-12, or as approved.

D. SUCTION HOOD

1. Suction hood shall be steel construction with integral ball type swivel joint. Suction hood shall be minimum 9 inches high by 12 inches wide by 10 inches long.

E. EXHAUST DUCTWORK

1. Fabricate ducts from minimum 24 gauge galvanized steel. All ducts shall be properly seamed, braced, stiffened, supported, and rendered mechanically airtight.

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SECTION 15880

AIR FILTER ASSEMBLIES

A. ACCEPTABLE MANUFACTURERS

1. HEPA Filters
 - a. Flanders Filters, Inc.
 - b. Airguard, A Clarcor Company.
 - c. Or as approved.
2. Cartridge and Throwaway Filters
 - a. Farr Company.
 - b. American Air Filter Co., Inc.
 - c. Flander Filters, Inc.
 - d. Airguard, A Clarcor Company.
 - e. Or as approved.
3. Carbon Filters
 - a. Farr Company.
 - b. Airguard, A Clarcor Company.
 - c. Or as approved.

B. QUALITY ASSURANCE

1. The following publications referenced in this section are listed here by organization, basic designation, title, and year of issue. The publications are listed throughout the remainder of the section by basic designation only.
 - a. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) Standards.
 - 1) Standard 52.1-1992; Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
 - 2) Standard 52.2-1999; Method of Testing General Ventilation and Air-Cleaning Devices for Removal Efficiency by Particulate Size.
2. Efficiency Ratings
 - a. ASHRAE: ASHRAE Standard 52.1-1992, based on reports from independent test lab on filters procured on the open market. The test lab shall be independent of filter manufacturer. Test report shall be less than two (2) years old.
 - b. MERV: ASHRAE Standard 52.2-1999, based on reports from independent test lab on filters procured on the open market. The test lab shall be independent of filter manufacturer. Test report shall be less than two (2) years old.
 - c. DOP: Dioctylphthalate Smoke Test
 - 1) Filters must be individually tested and certified to have the specified efficiency when tested in accordance with Mil Spec. 282, thermally generated mono-disperse .3 micron DOP smoke full rate capacity and observed with a properly calibrated laser particle counter and be UL586 approved.
 - 2) Factory automated (repeatable) scan for leaks using cold DOP, any leak greater than .01 percent of up stream concentration must be repaired. Scan shall be performed at 90 FPM face velocity with a traverse rate not above 10 FPM, and a photometer of proper range and calibration per IES Standard RPCC001-86.

Results shall be submitted with filter cartridge manufacturer's data. Each filter must have a permanent label, indicating serial number, date of test, air flow, pressure drop, penetration, and leak-free certification. Separate copy of filter label data shall be included in each carton. These labels must be furnished to the Owner at the completion of the installation along with a layout indicating the location of each filter by serial number.

C. THROWAWAY FILTERS

1. Disposable 2 inch thick, unless otherwise noted, pleated cartridge, synthetic fiber cells, fire-resistant. UL Class 1 listing.
2. ASHRAE test method efficiency of 25 percent to 30 percent (MERV rating of 6 to 7). Maximum initial air pressure drop of 3/10 (0.30") inch water gauge with two thousand (2000) CFM through a 24 inch by 24 inch by 2 inch deep unit. There shall be a minimum of 12 pleats per foot of filter face area.
3. Frames shall be constructed of heavy duty, high wet-strength beverage board. Frame shall incorporate diagonal support members to ensure pleat stability.
4. Throwaway filters shall be Farr Type 30/30, or as approved.

D. CARTRIDGE FILTERS

1. Cartridge type with continuous sheet of all glass paper medium closely pleated and supported by a welded wire grid. Frames shall be furnished with neoprene gaskets at the sealing edge.
2. ASHRAE test method efficiency of 95 percent (MERV rating of 14 to 15), 65 percent (MERV rating of 10), 45 percent (MERV rating of 8), or 35 percent (MERV rating of 7) as applicable. Maximum initial air pressure drop of 1 inch water gauge with two thousand (2000) CFM through a 24 inch by 24 inch by 11-5/10 inch deep unit.
3. Filter frames shall be minimum 16 gauge galvanized steel and shall incorporate diagonal support members to ensure filter element stability.
4. Filter media shall be mechanically and chemically bonded to frame. Sealer shall be self-extinguishing type.
5. Cartridge filters shall be FARR RIGA-FLOW, or as approved.

E. CARBON FILTERS

1. Carbon filters shall be of the activated carbon adsorber, total detention, rechargeable type. Adsorbers shall consist of minimum 18 gauge enclosing frame with corrugated heavy mesh screen. Capped fill holes and 12 pounds of carbon fill.
2. Carbon fill shall be 60 percent activity coconut shell type with an ozone removal efficiency of not less than 80 percent.
3. Each adsorber shall be rated at 500 CFM with a maximum air resistance of 0.32 inches water gauge.
4. Carbon filters shall be Farr RIGA-SORB 80R, or as approved.

F. HEPA FILTERS

1. Cartridge with continuous sheet of all glass medium (per MIL Spec. F51079B) closely pleated using aluminum separators with seamed edges. Adhesive sealer shall be self-extinguishing type.
2. Alternate construction shall be pleated media (media quality as above) in separatorless construction. Pressure drop shall not exceed 1/2 inch water gauge at rated CFM. This alternate construction must be pre-approved by Owner.

3. Zinc coated sixteen (16) gauge steel or aluminum frame with viscous fluid seal at sealing edges. Gasketed type seals are unacceptable. Comply with UL586, UL900 Class 2, and MIL Spec. F510680.
4. DOP test method efficiency of 99.99 percent.
5. Maximum pressure drop through a 24 inch by 24 inch by 11-5/10 inch deep of 1 inch water gauge with eleven hundred (1100) CFM air flow rate.
6. HEPA filters shall be Flanders Laminar Flow Grade, Type C Filters.

G. DUCT MOUNTED FILTER HOUSINGS

1. Duct mounted filter housings shall be factory fabricated and assembled units complete with housing, side access doors, holding frames, filter tracks, pre-filter and final filter.
2. Housings shall be heavy gauge galvanized steel with adequate reinforcing and pre-punched flanges to facilitate field installation.
3. Each assembly shall be provided with two access doors to facilitate removal and replacement of pre-filters and final filters from either side of the unit. Doors shall be constructed of heavy gauge, galvanized steel, adequately reinforced with positive sealing, heavy duty latches, and resilient gasketing.
4. Holding frames shall be made of heavy gauge galvanized steel with resilient gasketing and positive sealing clips. The frames shall be designed to accommodate any standard 12x24x12 or 24x24x12 filters without alteration.
5. Filter tracks shall be built into each housing to allow for easy slide-in and slide-out of filter units. Tracks shall accommodate both pre-filter and final filter units and shall be equipped with gasketing to provide a seal against the holding frames.
6. Filter housings shall be FARR Type 3P glide/pack, or as approved.

H. HEPA FILTER HOLDING FRAMES

1. Factory fabricated field assembled holding frame system with holding frames constructed of 16 gauge, zinc coated, corrosion resistant steel. Each frame section shall have a minimum of four (4), removable, spring loaded bolts capable of forcing the fluid seal of the filter against the knife edge seal of the frame with constant force. Holding frames shall be guaranteed leak free.
2. HEPA filter frames shall be Flanders channel-wall.

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SECTION 15888

BENCH TOP (NON PRODUCTION) PAINT EXHAUST BOOTH AND ACCESSORIES

A. ACCEPTABLE MANUFACTURERS

1. The DeVilbiss Company.
2. Binks Manufacturing Company.
3. Or as approved.

B. GENERAL

1. Paint exhaust booths shall be of the free standing, factory fabricated, bench type. Booths shall be three sided with integral bench top within hood enclosure.
2. Exhaust booths shall be furnished complete with filter bank, filter pads, filter draft gauge, exhaust fan, weather cap, and lights.
3. Exhaust booths and accessories shall be in full conformance with NFPA 33.
4. Paint exhaust booths shall be DeVilbiss, Proclean Bench Booth, or as approved.

C. HOUSING PANELS

1. Exhaust booth walls and ceiling panels shall be flanged type with exterior flanges, mitered corners, and constructed of minimum 18 gauge galvanized steel. All interior surfaces of booth shall be smooth.
2. Panels shall be provided with a factory-applied enamel finish on both sides.
3. Exhaust booth outside overall dimensions shall be nominal 76 inches wide, 86 inches high, and 62 inches deep. Exhaust booth inside working area dimensions shall be nominal 72 inches wide, 54 inches high, and 36 inches deep.
4. Housing ceiling panel shall include framed opening for installation of specified light fixture.

D. FILTERS

1. Filter pads shall be minimum 1 inch thick, throw away type, constructed of minimum eight (8) layers of expanded kraft paper and one (1) layer of polyester. Filter pads shall be fire retardant type and shall have a clean resistance of not more than 0.1 inches water gauge when operating at a face velocity of 125 FPM.
2. Filter pads shall be UL, Class 2, listed and approved and shall be DeVilbiss, Proclean, or as approved.

E. FAN

1. Exhaust fans shall be belt-driven, non-sparking, axial type with bearings and belts isolated from the exhaust air stream by an airtight metal housing. Fan's drive shall include provision for adjustment of belt tension.
2. Fan housings shall be tubular steel construction with flange inlet. Housing shall be of sufficiently heavy and reinforced construction to carry fan wheel, bearing supports, and accessories without deflection or vibration.
3. Fan wheels shall be of the radial blade type with aluminum, airfoil type blades securely fastened to an aluminum, central hub. Fan wheels shall be statically and dynamically balanced.

F. LIGHTS

1. Exhaust booths shall be provided with one 120 volt, 4-tube, fluorescent light fixture. Light fixtures shall be designed for mounting in the housing panels framed opening.
2. Light fixture shall be sealed and gasketed type and UL listed for installation in Class 1, Group 2, hazardous locations.
3. Light fixtures shall be furnished complete with all required mounting hardware and shall be DeVilbiss Model LF-9501, or as approved.

G. WEATHER CAP AND ROOF FLANGE

1. Weather caps and roof flanges shall be of the same diameter as the exhaust booth duct connection and exhaust fan and shall be of galvanized steel construction.
2. Weather caps shall be provided with integral gravity backdraft damper and rain guard and shall be DeVilbiss Model XH-4725, or as approved.

H. FILTER DRAFT GAUGE

1. Filter draft gauges shall be inclined or inclined-vertical tube manometer type and furnished complete with 3/4 ounce bottle of indicating fluid.
2. Filter draft gauges shall be mounted in a molded plastic housing and shall be Dwyer Instruments Inc., Mark II, or as approved.

I. AIRFLOW RATE MONITOR

1. Provide airflow rate monitoring per OSHA requirements.

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SECTION 15891

METALLIC HVAC DUCTWORK

A. ACCEPTABLE MANUFACTURERS

1. Hardcast.
2. Durodyne.
3. Foster.
4. Johns-Manville.
5. Or as approved.

B. QUALITY ASSURANCE

1. The following publications referenced in this section are listed here by organization, basic designation, title, and year of issue. The publications are listed throughout the remainder of the section by basic designation only.
 - a. American National Standards Institute (ANSI) Publication
 - 1) ANSI H35.2; Dimensional Tolerances for Aluminum Mill Products; 1985.
 - b. American Society for Testing and Materials (ASTM) Publications
 - 1) ASTM A 366; Standard Specification for Steel, Carbon, Cold-Rolled Sheet, Commercial Quality; 1985.
 - 2) ASTM A 525; Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process; 1986.
 - 3) ASTM A 527; Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality; 1985.
 - 4) ASTM A 569; Standard Specification for Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet and Strip, Commercial Quality; 1985.
 - c. National Fire Protection Association (NFPA) Publications
 - 1) NFPA 90A; Standard for the Installation of Air Conditioning and Ventilating Systems; 1985.
 - 2) NFPA 91; Standard for Exhaust Systems for Air Conveying of Materials; 1992.
 - 3) NFPA 96: Standard for the Installation of Equipment for the Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment, 1987.
 - d. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA), Publication
 - 1) SMACNA Duct Manual; HVAC Duct Construction Standards, Metal and Flexible, First Edition; 1985.

C. SHEET MATERIALS FOR DUCTWORK CONSTRUCTION

1. Galvanized steel shall be carbon steel sheets with galvanizing zinc coating on both sides and shall be of lock-forming quality. Sheets shall conform to ASTM A 525 and ASTM A 527 with a G60 coating designation.
2. Black steel shall be carbon steel sheets, minimum 16 gauge, skin-passed temper, conforming to ASTM Specification A 366 or A 569.

3. Aluminum shall be aluminum alloy sheets and shall be of lock-forming quality. Sheets shall conform to ASTM B 209, Alloy 3003, Temper H14. Dimensional tolerances for sheets shall conform to ANSI H35.2.

D. DUCTWORK CONSTRUCTION, GENERAL

1. All ductwork shall be constructed in full conformance with the SMACNA Duct Manual, Section I, for rectangular ductwork, and with the SMACNA Duct Manual, Section III, for round and flat oval ductwork.
2. All ductwork shall be constructed for the static pressure construction classes specified herein.

E. STATIC PRESSURE CONSTRUCTION CLASSES

1. All supply ductwork served by variable volume air handling units, from the fan discharge to the variable volume reheat box inlets, shall be constructed to the 4 inch w.g. pressure class.
2. All return ductwork served by variable volume air handling units shall be constructed to the 2 inch w.g. pressure class.
3. All kitchen hood exhaust ductwork including the plenums shall be constructed to the 2 inch w.g. pressure class.
4. All other ductwork and plenums shall be constructed to the 2 inch w.g. pressure class

F. FITTING CONSTRUCTION, RECTANGULAR DUCTS

1. All ductwork fittings shall be constructed in full conformance with the SMACNA Duct Manual, Section II, except as follows:
 - a. All elbows in kitchen exhaust ductwork shall be radius type.
 - b. All other elbows shall be of the square throat type with turning vanes.
 - c. Branch connections shall be of the 45 degree entry type or conical type, as applicable.
 - d. Splitter dampers shall not be used.

G. FITTING CONSTRUCTION, ROUND AND FLAT OVAL DUCTS

1. All ductwork fittings shall be constructed in full conformance with the SMACNA Duct Manual, Section II, and with the SMACNA Duct Manual, Section III, except as follows:
 - a. All elbows shall have a centerline-radius-to-duct-diameter ratio of not less than 1.5, regardless of duct velocity.
 - b. All tees shall be of the conical or wye fitting type; Figure 3-4 shall not be used.

H. FITTING CONSTRUCTION, ROUND AND FLAT OVAL DUCTS

1. All ductwork fittings shall be constructed in full conformance with the SMACNA Duct Manual, Section II, and with the SMACNA Duct Manual, Section III, except as follows:
 - a. All elbows shall have a centerline-radius-to-duct-diameter ratio of not less than 1.5, regardless of duct velocity.
 - b. All tees shall be of the conical or wye fitting type; Figure 3-4 shall not be used.

I. THERMAL/ACOUSTICAL LINING

1. Liner application and installation details shall be in full conformance with the SMACNA Duct Manual, Section II.

2. The following ductwork systems, or portions thereof, shall be provided with thermal/acoustical lining.
 - a. All supply air ductwork downstream of variable volume boxes.
 - b. All supply air ductwork from packaged heating and ventilating units.
 - c. All return air ductwork except that serving cabinet heaters.

J. DUCTWORK SEALING

1. All ductwork systems shall be sealed in accordance with Table 1-2 of the SMACNA Duct Manual for the appropriate pressure class.
2. All ductwork constructed to the 1 inch w.g. pressure class shall also be sealed. Sealing for these ducts shall meet Seal Class C.
3. All exhaust ductwork serving hoods over cooking equipment shall have all seams and joints sealed by watertight continuous external weld in conformance with NFPA-96.

K. DUCTWORK INSTALLATION

1. All ductwork shall be installed as recommended in the SMACNA Duct Manual.

L. DUCTWORK HANGERS

1. Hang all ductwork securely from the building structure. Provide supplemental framing as required.
2. Use hanger materials and accessories as recommended in the SMACNA Duct Manual and follow the SMACNA Duct Manual recommendations closely as regards hanger spacings and other construction details.

M. ACCESS DOORS

1. Provide suitable duct access doors for all automatic control dampers, fire dampers, smoke dampers, duct-mounted humidifier distributors, and all other components which are located within the ductwork and which might require periodic inspection or maintenance.

N. DUCT INSULATION FASTENERS

1. Duct insulation fasteners shall be of the weld or epoxy secured type. Fasteners shall include a nylon stop clip. Fasteners shall be as manufactured by Durodyne, or as approved.

O. THERMAL/ACOUSTICAL LINER

1. Liner shall be coated, resin bonded, flexible, 1 inch thick fibrous glass.
2. Liner density shall be not less than 1.5 pounds per cubic foot and the liner thermal conductivity shall not exceed an average of .26 (BTU)(inch)/(hour)(degrees F)(square foot) at 75 degrees F.
3. Liner shall have sound absorption coefficients of not less than .28, .51, .63, .80, .89, and .91 at 125, 250, 500, 1000, 2000, and 4000 hertz, respectively.
4. Liner shall have an air friction correction factor (as applied to straight galvanized metal duct friction loss) of not more than 1.1 at 4000 fpm.
5. Thermal/acoustical liner shall be Johns-Manville Linacoustic, or as approved.

P. TAPES, ADHESIVES, AND SEALANTS

1. Tape shall be of the pressure-sensitive type with aluminum foil backing and a modified butyl rubber adhesive. Tape shall be Hardcast Aluma-Grip AFT-701, or as approved.

2. Adhesive for adhering thermal/acoustical liner shall be quick- setting, nonflammable, fire-resistive elastomer type suitable for both steel and aluminum ducts. Adhesive shall be Foster Spark-Fas 85-20 for brush application or Foster Spark-Fas 85-11 for spray application, or as approved.
3. Ductwork sealant shall be waterbased, nonflammable liquid rubber type. Sealant shall be Hardcast Flex-Grip 550, or as approved.

Q. FACTORY-FABRICATED DUCT JOINING SYSTEMS

1. System shall consist of preformed, flange type sections designed to be slipped onto a plain duct end; formed and embossed corner pieces designed to slip into the flange sections in such a manner as to produce a rigid rectangular frame; clips to hold adjacent flange sections together; sealant for the duct-to-flange connection; gaskets between adjacent flange sections; and corner bolts to secure adjacent corner pieces.
2. Duct joining system shall be of appropriate SMACNA rigidity class for the duct size and pressure and shall be as manufactured by Exanno Corporation, Ductmate Industries, or as approved.

R. FACTORY-FABRICATED DUCTWORK

1. Nothing in this section shall be deemed to preclude the use of factory-fabricated ductwork and fittings, provided that they are constructed and installed in full conformance with the specifications contained herein and in the referenced standards.

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SECTION 15895

FLEXIBLE DUCTS

A. ACCEPTABLE MANUFACTURERS

1. AIR DIFFUSION/SUPPLY DUCTS

a. Duct Sox (No Substitutions)

2. TERMINAL CONNECTION DUCTS

- a. Flexible Technologies, A Division of Automation Industries, Incorporated.
- b. General Environment Corporation.
- c. Certain Teed Corporation.
- d. Or as approved.

B. QUALITY ASSURANCE

1. All flexible ducts shall be UL-181 listed as a Class I duct.

C. AIR DIFFUSION/SUPPLY DUCTS

- 1. Air diffusion/supply ducts shall be constructed of porous, fire retardant, polyester fabric with integral air supply slots. Fabric shall be minimum 6.75 oz/sq. yd., and shall pass a UL 181 burn test.
- 2. Air diffusion/supply ducts shall be Duct Sox Model Sedona CF (No Substitutions) .

D. TERMINAL CONNECTION DUCTS

- 1. Terminal connection ducts shall be of the factory insulated type with an internal zinc or vinyl coated steel spring helix. A liner shall separate the air stream from the insulation. The insulation shall be fibrous glass of not less than 1 inch thickness and not less than 1 pound per cubic foot density. The insulation shall be covered with a laminated, scrim reinforced, mylar/neoprene vapor barrier jacket or a copolymer vapor barrier jacket.
- 2. Flexible ducts shall be rated for not less than 15 inches water gauge working pressure and shall be Thermaflex Type M-KH, or as approved.

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SECTION 15896

METALLIC FUME EXHAUST DUCTWORK

A. ACCEPTABLE MANUFACTURERS

1. Durodyne.
2. Hardcast.
3. Or as approved.

B. QUALITY ASSURANCE

1. The following publications referenced in this section are listed here by organization, basic designation, title, and year of issue. The publications are listed throughout the remainder of the section by basic designation only.
 - a. American Society for Testing and Materials (ASTM) Publications
 - 1) ASTM A 525; Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process; 1986.
 - 2) ASTM A 527; Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality; 1985.
 - 3) ASTM B 209; Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 1986.
 - b. National Fire Protection Association (NFPA) Publications
 - 1) NFPA 91; Standard for Exhaust Systems for Air Conveying of Materials; 1992.
 - 2) NFPA 77; Recommended Practice on Static Electricity, 1988.
 - c. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA), Publication
 - 1) SMACNA Duct Manual; HVAC Duct Construction Standards, Metal and Flexible, First Edition; 1985.
 - 2) SMACNA Duct Manual; Round Industrial Duct Construction Standards; 1977.

C. SHEET MATERIALS FOR DUCTWORK CONSTRUCTION

1. All ductwork shall be galvanized steel. Galvanized steel shall be carbon steel sheets with galvanizing zinc coating on both sides and shall be of lock-forming quality. Sheets shall conform to ASTM A 525 and ASTM A 527 with a G60 coating designation.

D. DUCTWORK CONSTRUCTION, GENERAL

1. All ductwork shall be minimum 24 gauge, constructed in full conformance with the SMACNA Industrial Duct Manual.
2. All ductwork shall be constructed for the static pressure construction classes specified herein.

E. STATIC PRESSURE CONSTRUCTION CLASSES

1. All exhaust ductwork including the plenums shall be constructed to negative 2 inch w.g. pressure for Class 1 applications.

F. DUCTWORK CONNECTIONS

1. All ductwork connections shall be in full conformance with the SMACNA Industrial Duct Manual.

G. FITTING CONSTRUCTION, ROUND DUCTS

1. All ductwork fittings shall be constructed in full conformance with the SMACNA HVAC Duct Manual, Section III, except as follows:
 - a. All elbows shall have a centerline-radius-to-duct-diameter ratio of not less than 1.5, regardless of duct velocity.
 - b. All tees shall be of the conical, 45 degree lateral, or wye fitting type.

H. DUCTWORK SEALING

1. All ductwork transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.

I. DUCTWORK INSTALLATION

1. All ductwork shall be installed as recommended in the SMACNA Duct Manuals and in full conformance with NFPA 91.

J. DUCT INSULATION FASTENERS

1. Duct insulation fasteners shall be of the weld or epoxy secured type. Fasteners shall include a nylon stop clip. Fasteners shall be as manufactured by Durodyne, or as approved.

K. TAPES, ADHESIVES, AND SEALANTS

1. Tape shall be of the pressure-sensitive type with aluminum foil backing and a modified butyl rubber adhesive. Tape shall be Hardcast Aluma-Grip AFT-701, or as approved.
2. Ductwork sealant shall be water based, nonflammable liquid rubber type. Sealant shall be Hardcast Flex-Grip 550, or as approved.

L. ACCESS DOORS

1. Access doors shall be of the hinged, gasketed type.

M. ELECTRICAL BONDING

1. All ductwork shall be electrically bonded across all duct joints and flexible connections to provide electrical continuity throughout the entire system and all its components.
2. Ground each duct system to building structural steel at a minimum of two (2) points. Connection points shall be at opposite ends of the system.
3. Bonding and grounding connections shall be made with minimum No. 2 gauge copper conductor in full accordance with NFPA 77.

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SECTION 15899

DUCTWORK CONSTRUCTION PENETRATIONS

A. FIRESTOP SEALANT SYSTEMS

1. Firestop sealant systems shall be as specified in Section 07270, FIRESTOPPING.

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SECTION 15911

FIRE AND SMOKE DAMPERS

A. ACCEPTABLE MANUFACTURERS

1. Ruskin Manufacturing Company.
2. Prefco Products, Inc.
3. Air Balance, Inc.
4. Or as approved.

B. QUALITY ASSURANCE

1. All fire dampers and combination fire and smoke dampers, shall be UL classified, listed, and labeled in accordance with the following:
 - a. UL555 for fire dampers.
 - b. UL555 and UL555S for combination fire and smoke dampers.

C. CURTAIN FIRE DAMPERS

1. General: Curtain type fire dampers shall be of the folded, interlocking blade type with the blades held in the open position by means of a fusible link rated to melt at 160 degrees F. Dampers serving horizontal ducts shall close by gravity; dampers servicing vertical ducts shall close by means of a stainless steel spring. The entire damper shall be of heavy gauge galvanized steel construction. Every damper shall incorporate an integral sleeve or shall be provided with a separate, properly sized sleeve to facilitate installation. Sleeves shall be 16 gauge, minimum.
2. Type A Dampers: Type A dampers shall have height and width dimensions equal to the duct dimensions listed on the drawings. The folded blades and the blade guides may both project into the air stream but the damper shall have a nominal free area of not less than 80 percent. Type A dampers shall be Ruskin Model IBD, Type A, or as approved.
3. Type B Dampers: Type B dampers shall have a width dimension equal to the duct width. The height of the damper shall be sufficient to allow the entire folded blade to be outside the air stream. Blade guides may project into the air stream but the damper shall have a nominal free area of not less than 90 percent. Type B dampers shall be Ruskin Model IBD, Type B, or as approved.
4. Type C Dampers: Type C dampers shall have both height and width dimensions sufficiently greater than the duct dimensions to allow both the folded blades and the blade guides to be outside the air stream. The damper shall have a nominal free area of 100 percent. The damper shall have a duct fitting collar of the appropriate size and shape to accept the duct served. Type C damper shall be Ruskin Model IBD, Type C (for rectangular ducts), Type CR (for round ducts), or as approved.

D. CEILING FIRE DAMPERS

1. General: Ceiling fire dampers shall be of the hinged butterfly blade type with the blades held in the open position by means of a fusible link rated to melt at 160 degrees F. The entire damper shall be of heavy gauge galvanized steel construction.
2. Ceiling dampers shall be provided with extended frames for flex duct installation and shall be Ruskin Model CFD2 or CFDR2, as applicable, or as approved.

E. COMBINATION FIRE AND SMOKE DAMPERS

1. Combination dampers shall be of the multiple, pivoted, parallel blade type. Damper frame and blades shall be of heavy steel construction. Blades shall have an airfoil cross-section.
2. Combination dampers shall be provided with blade edge seals and jamb seals as necessary to meet UL555S requirements for Leakage Class II.

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3. Dampers shall be provided with an extended sleeve to allow for external operator outside the protected wall. Damper linkages shall be concealed in the frame, outside the airstream.
4. Dampers shall be operated by a spring-return, stall-type, electric motor operator assembly which requires power to maintain the damper in the open position. Motor shall be interruptible by the breaking of the power circuit by either a built-in firestat or a remote smoke detector provided under the Work of Division 16 as part of the fire alarm system. Damper motors shall be furnished and factory mounted by the damper manufacturer.
5. Combination fire and smoke dampers shall be Ruskin Model FSD60 with Ruskin Model TS150 Firestat operator, or as approved.

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SECTION 15912

FLEXIBLE CONNECTIONS

A. FLEXIBLE CONNECTIONS

1. Flexible connections shall consist of fabric strip permanently secured to sheet metal connector strip in such a manner as to be airtight.
2. Flexible connections, whether purchased or shop-made, shall be constructed in accordance with Figure 2-19 of the SMACNA Duct Manual.
3. Fabric for flexible connections shall be neoprene coated glass fabric weighing not less than 30 ounces per square yard.

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SECTION 15913

ROOF CURBS

A. ACCEPTABLE MANUFACTURERS

1. The Pate Company.
2. Vent Products Co.
3. Penn Ventilator Company, Inc.
4. Or as approved.

B. ROOF CURBS

1. Roof curbs shall be of heavy gauge galvanized steel construction, shall be of box section design with integral base plate, and shall have continuously welded corner seams.
2. Curbs shall be internally insulated with 3 pound density rigid fiberglass board insulation not less than 1-1/2 inches thick.
3. Curbs shall be of a design without cants, and shall be designed to be roofed over.
4. Curbs shall be sized to fit the equipment to be supported, and shall be not less than 11 inches high.
5. Curbs shall include a factory installed wood nailer strip around the top perimeter.
6. Curbs shall be Pate Model PC-2A, or as approved.

C. SOUND ATTENUATING BAFFLE ASSEMBLY

1. Sound attenuating baffles shall be constructed of a galvanized steel frame with 1 inch thick rigid fiberglass sound attenuating panels.
2. Sound attenuating panels shall be minimum 12 inches long and maximum 3 inches on center. Panel frames shall be rounded to provide for minimum pressure drop.
3. Sound attenuating assemblies shall be removable from the curb.
4. Roof curbs with sound attenuating baffles shall be Pate Model PSC-2, or as approved.

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SECTION 15914

AIR FLOW MONITORING STATIONS

A. ACCEPTABLE MANUFACTURERS

1. Air Monitor Corporation.
2. Cambridge Filter Corporation.
3. Or as approved.

B. DUCT AIR MONITORING DEVICES

1. Duct air monitoring devices shall consist of an air straightener section, static pressure sensors, and total pressure sensors mounted in a single casing.
 - a. Air straightener section shall consist of an expanded aluminum honeycomb arrangement designed to eliminate turbulence upstream of the sensors.
 - b. Static pressure sensors shall be located around the perimeter of the casing and shall be connected to an external tube header with a single output connection.
 - c. Total pressure sensors shall be located in a standard traverse arrangement and shall be connected to a network of headers and manifolds in such a manner that a single output signal will give a true average reading of duct velocity.
 - d. Casing shall be of heavy galvanized steel construction, shall include duct flanges on inlet and discharge ends, and shall be of the configuration (rectangular, round, or flat oval) indicated on the drawings.
2. Duct air monitoring devices shall be Air Monitor Corp. Model D.A.M.D. or Fan-E, as applicable, or as approved.

C. WALL METERS

1. Wall meters shall provide a continuous readout of airflow volume in cubic feet per minute. Units shall consist of a diaphragm actuated differential pressure gauge mounted in a heavy gauge chrome-plated metal panel. Meters shall be furnished with complete factory installed internal tubing with readily accessible terminations for connection to field piping.
2. Wall meters shall be by Air Monitor, or as approved.

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SECTION 15915

INTAKE AND EXHAUST WALL LOUVERS

A. ACCEPTABLE MANUFACTURERS

1. American Warming and Ventilating, Inc.
2. Carnes Company.
3. Construction Specialties, Inc.
4. Or as approved.

B. QUALITY ASSURANCE

1. All louver capacities shall be AMCA rated.

C. LOUVERS

1. Louvers shall be of the stationary type, 4 inch nominal thickness, with fully drainable blades.
2. Louvers shall be of extruded aluminum construction with frames and blades not less than .081 inches thick.
3. Blades shall be formed for weathertightness and shall drain individually to a vertical drain channel built into the louver jamb.
4. Blades shall be set at an angle of approximately 45 degrees and shall be spaced on approximately 4-1/4 inch centers.
5. Louvers shall have a frame suitable for mounting in a masonry opening and shall be provided with an extended sill on the bottom. Sill shall be American Warming and Ventilating Type 2, or as approved.
6. Louvers shall be American Warming and Ventilating Model LE-21, or as approved.

D. BIRD SCREENS

1. Bird screens shall be of aluminum construction and shall utilize wire of not less than .063 inch diameter woven into a 1/2 inch mesh pattern. Screens shall be complete with aluminum mounting frames.

E. LOUVER FINISH

1. Louvers shall be provided with a factory finish of one (1) paint prime coat plus one (1) metallic color coat plus a minimum 1.3 mil clear fluorocarbon (Kynar/500) final coat.
2. Each coat shall be separately thermocured at a bake temperature of 450 degrees F.
3. Color shall be as selected by Electric Boat's representative from the manufacturer's full range of colors.

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SECTION 15934

VARIABLE VOLUME REHEAT BOXES

A. ACCEPTABLE MANUFACTURERS

1. The Trane Company.
2. Carnes Company.
3. Tempmaster Corporation.
4. Or as approved.

B. GENERAL

1. Variable volume reheat boxes shall be of the variable constant volume type with integral reheat coils.
2. Boxes shall be designed to be supplied by a high velocity, medium pressure duct system and deliver a variable constant volume of low velocity reheated air to the room, or rooms, through a duct and diffuser system.
3. Boxes shall consist of casing with appropriate duct connections, attenuation section, control dampers, reheat coil, pneumatic damper operator, and all necessary accessories.
4. Boxes shall be designed for quiet operation at inlet static pressures as high as 6 inches water gauge and shall be Trane Model VCWE or VCEE, as applicable, or as approved.

C. CASINGS

1. Casings shall be of heavy gauge galvanized steel construction and shall be suitably reinforced to prevent noise, rattles, etc.
2. Duct connections shall be suitable for the associated duct system pressure.
3. Casings shall be internally lined with 1 inch thick, minimum, fibrous glass insulation with neoprene coating on the air side.

D. HYDRONIC COILS

1. Coils shall be constructed of aluminum fins mechanically bonded to copper tubes and shall be factory tested under water at a pressure of not less than 300 psig. Ends shall be suitable for sweat connections.

E. ELECTRIC COILS

1. Coils shall be of the open resistance type utilizing nickel-chromium heating elements.
2. Coil section shall include a factory mounted, integral control panel. Control panel shall house sequencing pneumatic-electric switches, circuit fuses, a safety airflow switch, terminal connections for the coil, and a disconnect switch interlocked with the panel door.
3. Coil shall have a disc-type automatic thermal primary safety and a manual reset secondary cutout (or fusible link).
4. Coil and control panel combination shall be UL listed.

F. CONTROL DAMPERS

1. Control dampers shall be specially designed to provide tight shut-off and to minimize static pressure drop, air turbulence, and noise generation throughout their modulating range.
2. Control damper assembly shall be isolated from the unit casing such that any distortion of the casing will not interfere with damper operation.

G. CONTROL SYSTEM

1. Control system shall include a damper operator, a pressure compensating system, and calibration taps.
2. Damper operator shall be of the pneumatic type with a spring range suitable for sequencing damper operation with the reheat coil P-E switches or shall be electronic type.
3. Pressure compensating system shall utilize pressure sensors, volumetric controllers, and similar devices to automatically adjust the damper as necessary to maintain a constant volume of air at any particular setting of the thermostat branch pressure independent of the duct static pressure upstream of the terminal reheat box.
4. Control system shall allow for setting of minimum and maximum air flow rates.

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SECTION 15940

GRILLES, REGISTERS, AND DIFFUSERS,
GENERAL REQUIREMENTS

A. ACCEPTABLE MANUFACTURERS

1. Krueger Division of Philips Industries.
2. Barb Aire, Incorporated.
3. Carnes Company.
4. Anemostat Products Division, Dynamics Corporation of America.
5. Titus Manufacturing Corporation.
6. Frommelt Safety Products.
7. Metalaire, Inc.
8. Or as approved.

B. GENERAL

1. All products shall be of first quality construction.
2. All products shall be capable of meeting all specified air distribution parameters.
3. All diffusers shall have a margin type fully compatible with the ceiling type in which installed or shall be suitable for exposed duct installation, as applicable.
4. Grilles, registers, and diffusers shall have construction details as specified in the sections pertaining to the particular unit type.
5. All accessories shall be fully compatible with the units with which they are used.

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SECTION 15941

LOUVER CONE FACE DIFFUSERS

A. ACCEPTABLE MANUFACTURERS

1. See Section 15940, GRILLES, REGISTERS, AND DIFFUSERS, GENERAL REQUIREMENTS.

B. SQUARE FACE, FIXED PATTERN DIFFUSERS

1. Diffusers shall consist of a square diffuser shell, complete with either an integral round duct collar or a square duct collar with round adaptor, and a series of concentric square cones. Cones shall be removable for access to accessories.
2. Diffusers shall have the cones fixed in place and shall deliver a horizontal air pattern.
3. Diffusers shall be Krueger Series SH with round duct adaptor, or as approved.

C. SQUARE FACE, ADJUSTABLE PATTERN DIFFUSERS

1. Diffusers shall consist of a square diffuser shell, complete with either an integral round duct collar or a square duct collar with round adaptor, and a series of concentric square cones. Cones shall be removable for access to accessories.
2. Diffuser cones shall be adjustable up and down to vary the discharge pattern from horizontal to vertical.
3. Diffusers shall be Krueger Series SH-A-4A with round duct adaptor, or as approved.

D. VOLUME DAMPERS

1. Volume dampers shall be of the multiple blade type designed to fit in the diffuser neck or the duct connection. Dampers shall be fully adjustable by means of a removable key. Dampers shall be designed to hold their adjustment under all normal air flow rates and static pressures. Dampers shall be Krueger Model R-10, or as approved.

E. EQUALIZING GRIDS

1. Equalizing grids shall be designed to fit in the duct take-off from the main and equalize and straighten the air stream ahead of the entry to the diffuser. Grids shall be Krueger Model RSG-15, or as approved.

F. DIFFUSER MATERIAL

1. Diffusers and all accessories shall be of steel construction.

G. DIFFUSER FINISHES

1. Diffusers shall have a factory applied, white, baked enamel finish.

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SECTION 15942

TOTAL AIR DIFFUSERS

A. ACCEPTABLE MANUFACTURERS

1. See Section 15940, GRILLES, REGISTERS, AND DIFFUSERS, GENERAL REQUIREMENTS.

B. TOTAL AIR DIFFUSERS

1. Total air diffusers shall be of the non-aspirating type, designed to deliver relatively large quantities of air with minimal throw.
2. Diffusers shall consist of a perforated parabolic grille with directional vane adjustment, a full size distribution box, a cone type damper at the box inlet collar, and a perforated diffuser plate.
3. Diffusers shall be suitable for lay-in installation in an exposed grid ceiling.
4. Total air diffusers shall be Krueger Model TAD, or as approved.

C. DIFFUSER MATERIALS

1. Diffusers and all accessories shall be of steel construction.

D. DIFFUSER FINISHES

1. Diffuser shall have a factory applied, white, baked enamel finish. The inside of the distribution box, and all internal accessories, shall be painted flat black.

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SECTION 15944

BAR FACE GRILLES AND REGISTERS

A. ACCEPTABLE MANUFACTURERS

1. See Section 15940, GRILLES, REGISTERS, AND DIFFUSERS, GENERAL REQUIREMENTS.

B. GENERAL

1. Bar face grilles and registers shall consist of a series of thin bars, set on edge, mounted in a substantial frame which shall include a face flange around the entire perimeter of the unit. Bars shall be spaced on 3/4 inch nominal centers. Face flange shall be approximately 1-1/4 inches wide, shall be neatly mitered at all corners, and shall be provided with a sealing gasket around the entire perimeter.

C. SUPPLY UNITS

1. Supply units shall have two sets of bars, both of the adjustable deflection type, set at right angles to each other. The face bars shall be horizontal. Supply units shall be Krueger Series 880H, or as approved.

D. RETURN AND EXHAUST UNITS

1. Return and exhaust units shall have one set of bars, fixed in position. Sidewall units shall have the bars deflected approximately 35 degrees from perpendicular, and the bars shall be horizontal. Ceiling units shall have the bars set perpendicular to the face. Return and exhaust units shall be Krueger Series S80H or Series S80HZ, as applicable, or as approved.

E. VOLUME DAMPERS

1. Every register shall be provided with an integral opposed blade volume damper operable by a removable key from the front of the unit. Volume dampers shall be designed to hold their setting under all normal air flow rates and static pressures.

F. MOUNTING FRAMES

1. Mounting frames shall be of material and size compatible with the associated grille or register and shall include provisions for the attachment of the grille or register. Mounting frames shall be Krueger Series 8PF, or as approved.

G. GRILLE AND REGISTER MATERIALS

1. Grilles, registers, and all accessories shall be of steel construction.

H. GRILLE AND REGISTER FINISHES

1. Grilles and registers shall have a factory applied, white, baked enamel finish. Frames shall be field paintable to match the surface in which installed.

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SECTION 15945

PERFORATED PLATE FACE GRILLES

A. ACCEPTABLE MANUFACTURERS

1. See Section 15940, GRILLES, REGISTERS, AND DIFFUSERS, GENERAL REQUIREMENTS.

B. GRILLES AND REGISTERS

1. Grilles and registers shall consist of a square shell with an integral square duct collar and a hinged perforated metal face plate. The shell shall be formed to provide a face flange around the entire perimeter of the perforated plate. Grilles and registers shall be Krueger Series 1190, or as approved.

C. VOLUME DAMPERS

1. Every register shall be provided with an integral opposed blade volume damper, operable by a removable key from the front of the unit. Volume dampers shall be designed to hold their setting under all normal air flow rates and static pressures.

D. GRILLE AND REGISTER MATERIAL

1. Grilles, registers, and all accessories shall be of steel construction.

E. GRILLE AND REGISTER FINISHES

1. Grilles and registers shall have a factory applied, white, baked enamel face. All interior surfaces shall be painted flat black.

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SECTION 15950

DRUM LOUVERS

A. ACCEPTABLE MANUFACTURERS

1. See Section 15940, GRILLES, REGISTERS, AND DIFFUSERS, GENERAL REQUIREMENTS.

B. DRUM LOUVERS

1. Drum louver shall consist of a 1-1/4 inch wide, 18 gauge steel rectangular frame with a rotating drum with adjustable vanes.
2. Drum louvers shall incorporate a rotating drum, capable of a 60 degree angular adjustment, and adjustable deflecting vanes.
3. Drum louvers shall be Titus Model DL, or as approved.

C. VOLUME DAMPERS

1. Volume dampers shall be of the steel, heavy duty, opposed blade type designed to fit in the neck or the duct connection. Dampers shall be fully adjustable by means of a removable key. Dampers shall be designed to hold their adjustment under all normal air flow rates and static pressures.

D. DRUM LOUVER MATERIAL

1. Drum and all blades shall be of heavy gauge extruded aluminum construction.
2. Outer border shall be of roll formed 18 gauge steel.

E. DRUM LOUVER FINISHES

1. Drum louvers shall have a factory applied, white anodic acrylic finish.

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SECTION 15970

AUTOMATIC TEMPERATURE CONTROL,
GENERAL

A. ACCEPTABLE MANUFACTURERS

1. American Auto-Matrix.

B. SYSTEM DESCRIPTION

1. The building control systems specified herein shall be as follows:
 - a. New systems and equipment shall be direct digital control utilizing electric or electronic actuation devices as outlined below.
 - b. Modifications to existing control systems and equipment shall match the system type being modified.
2. Regardless of system type, control systems shall perform all the automatic control and energy management functions as required in this specification.
3. The building control system serving new systems and equipment shall consist of a network of electronically interconnected independent, stand-alone control units. Each stand-alone control unit shall be capable of performing all specified control functions in a completely independent manner. Control units shall be networked for single point programming and for the sharing of information and control instructions between panels. System panels shall be accessible by means of a built-in operator interface and from the system head end computer. Each control unit shall have a dedicated local display.
4. A central processing unit (fully configured personal computer) and associated software shall be provided to control operator input/output, data transmission to and from the stand-alone units, and perform all hereinafter specified software functions.
5. The temperature and equipment control system serving new systems and equipment shall be primarily electric/electronic utilizing electronic sensors with electric actuation of dampers, valves, and miscellaneous control devices. Control Manufacturer shall furnish and install all controls and appurtenances as may be necessary in order to provide a complete, workable system. Control Manufacturer shall also be responsible for all control wiring 120 volt and less necessary to provide the sequences of operation specified hereinafter. (This clause shall include fan interlocking and terminal unit control panels and control devices.)
6. The system and each component of the system shall be Year 2000 compliant as defined in Section 1, Special Considerations.

C. STAND-ALONE CONTROL UNITS

1. Each control unit shall be capable of full operation either as a completely independent unit or as a part of the building-wide control system. All units shall contain the necessary equipment for direct interface to the sensors and actuators connected to it.
2. Control strategies for each building shall be Owner definable.
3. Each control unit shall include its own micro-processor controller with single or multiple interface microprocessor controllers to perform system point signal conditioning and analysis; power supply, input/output modules, system communications hardware and software to provide for the sharing of data with other stand-alone units and to communicate with the head end computer, termination modules, and battery. The battery shall be self-charging and be capable of supporting

all memory within the control unit if the commercial power to the unit is interrupted or lost for a minimum of seventy-two (72) hours.

4. Each system shall include a device to provide a means of local access to the systems microprocessor controllers. This device shall display status and analog information, adjust controller variables, manually control system equipment, and display and clear alarm conditions.
5. Control units shall be fully programmable.
6. Control units shall be capable of receiving up to 15 analog inputs and 8 digital inputs, processing them through the inherent programs, and sending out up to 8 digital control signals and 8 analog control signals. Analog inputs shall be in the form of 4-20mA, 0-10V, or resistance temperature detection device signals.
7. The control units shall directly control pneumatic and electronic actuators and control devices. Each control unit shall be capable of providing the following control outputs:

<u>Digital Outputs (Contact Closure)</u>	<u>Analog Outputs</u>
--	-----------------------

- | | |
|--------------------------------|----------------------------------|
| - Motor Starters, Sizes 1 to 4 | - 3-15 PSI
4-20 ma
0-16 dc |
|--------------------------------|----------------------------------|

8. Every input and every output shall be readable from the head end computer and from the unit local access device.
9. Every control unit shall be capable of operating as a stand-alone device but shall be able to communicate with every other control unit on the network and with the head end computer. Control units shall have the ability to share data and programs with other units on the network and every point shall be alarmable (as applicable) at the head end computer.
10. Control units shall be housed in a steel enclosure with a hinged and lockable front panel.
11. System shall allow Owner changes of setpoints, programs, alarmable points, etc., and all unused input and output terminals shall be left in such a way that additional devices may be added in the future.
12. Each control unit shall contain self-diagnostics that continuously monitor the proper operation of the unit. A malfunction of the unit will be reported and will inform the operator of the nature of the malfunction and the control unit affected. It shall be possible to annunciate malfunctions as well as other control unit alarms at a selected central operator's terminal.

D. BUILDING CONTROL FUNCTION CAPABILITIES

1. Each stand-alone control unit within the building control system shall perform both temperature control functions and energy management routines as defined by the operator.
2. All temperature control functions shall be executed within the stand-alone control unit. Loop control shall be executed via direct digital control algorithms. The user shall be able to customize control strategies and sequences of control and shall be able to define appropriate control loop control. Control loops shall support all of the following control modes:
 - a. Two-position (on-off, slow-fast, etc.).
 - b. Proportional (P).
 - c. Proportional plus integral (PI).
 - d. Proportional, integral, plus derivative (PID).
3. It shall be possible to fully create, modify, or remove control algorithms within a specific stand-alone control unit while it is operating and performing other control functions. Input for these changes may be made directly into the stand-alone control unit or via the head end computer. Each control loop shall be fully user definable in terms of:
 - a. Sensors/actuators that are part of the control strategy.
 - b. Control mode.

- c. Gain.
- d. Control action.
- e. Sampling time.

Provide stand-alone control units that are able to share point information such that control sequences or control loops executed at one control unit may receive input signals from sensors connected to other stand-alone control units within the network. If the network communication link fails or the other stand-alone control unit malfunctions, the control loop shall continue to function using the last value received from the stand-alone control units. Upon loss of commercial power to any stand-alone control unit, the other units within the network shall not be affected, and the loss of operation of that unit shall be reported at the designated operator's terminal. All control strategies and energy management routines defined for the stand-alone control unit shall be retained during a power failure via the battery within the unit for a minimum of eight (8) hours. Upon resumption of commercial power, the control unit shall resume full operation without operator intervention. The unit shall also automatically reset its clock such that proper operation of timed sequences is possible without the need for manual reset of the clock.

Should a loss of power exceed memory back-up, the building operator shall be able to manually restore all system programs off of diskettes or other mass storage system. The mass storage system used shall provide the ability to load at each control unit or from the head end computer.

E. HEAD END COMPUTER

1. Head end computer shall be a fully configured IBM compatible personal computer complete with Windows operating system, HARD DISK, 3-1/2 inch disk drive, CD Rom Drive, 14 inch VGA color monitor, VGA color graphics board, latest version of PC-DOS, mouse, key board, and minimum of one (1) serial and one (1) parallel communications ports. Microprocessor shall be Intel Pentium.
2. Provide an inkjet graphics printer. Carriage width shall provide for 8-1/2 inch wide paper.
3. System software shall provide graphic user interface through which viewing and commanding may be done using a "mouse" pointing device. The requirement to use the keyboard shall be for only those functions specifically requiring text or numeric input.

The graphic user interface shall also provide the following functions and features:

- a. Windowing user interface, based on Microsoft "Windows" or similar software, which supports concurrent viewing and commanding of system operations. The system shall be capable of simultaneously showing and performing a minimum of three of the functions listed below in any combination, using operator-sized windows:
 - Time of day scheduling (viewing and changing).
 - Dynamic color graphics (viewing and changing).
 - Alarm screen (viewing and acknowledging).
 - Trend screen (viewing).
 - Graphics construction (viewing and pasting into graphic).
 - Graphics symbols (viewing and pasting into graphic).
- b. On-line directory, available for point selection when building graphics or as needed to avoid reference to notebooks or other written material.
- c. Time of day scheduling, with a week-at-a-glance calendar format and providing for overrides up to a week in advance. The facility shall provide for establishing logical relationships between system components (e.g., pumps, cooling towers, etc.) so an operator may simply override the start or stop time of a system by name, preserving the established component relationships. Multiple days shall be programmable from a single schedule.
- d. Provisions for holidays and special days to support both types of unusual work schedules. These shall be programmable up to one year in advance. Selection of holidays and special days shall be done using a mouse to select appropriate days on a graphically-displayed calendar.

- e. Status indication within graphics through operator-selected colors or patterns. Points shall be commanded using only graphics and the mouse, where symbols are selected with the mouse, then commanded from a drop down menu (or, alternatively, from a function key). Provide for graphic linking such that graphics may be linked in hierarchical order for logical system penetration.
 - f. Dynamic analog bar indication of analog values such as temperature. Provide the ability to superimpose these graphs upon schematic or other graphics to show associated values. Provide the ability to change the setpoint of the displayed analog value by moving an indicator on the bar with the mouse.
 - g. Context sensitive help, which gives instructions appropriate to the current operation.
 - h. Operator selected point groups, which may be recalled by name to view the current status of associated points.
 - i. Flexible sort capability, such that the system operator may find and display all points with common text and/or numeric strings which he/she selects.
 - j. Automatic collection of trend data from stand-alone control units, accomplished a minimum of 4 times per day. The operator shall be able to define the type of collection as follows:
 - Time based, where information is stored at sample intervals defined by the operator.
 - Change of value based, where information is collected each time a point value changing beyond a threshold selected by the operator.
 - k. Freehand, computer assisted graphic construction using the mouse, standard full screen stencils, commonly used symbols, and useful shapes shall all be provided to assist in graphic construction. Windowing shall allow selection of a symbol or shape in one window and the subsequent transfer of that symbol to a second graphics construction window for use by means of the mouse. To ensure rapid graphic construction, it shall not be necessary to exit either window to effect the transfer.
 - l. Automatic up and downloading. Database changes made at the central unit shall be automatically downloaded to the appropriate control units. Similarly, database changes made at individual control units shall be automatically uploaded to the central unit to ensure database continuity.
4. Provide communications software package which shall be capable communications with site head end computers via the site's data network.

F. USER PROGRAMMABILITY

- 1. All temperature control strategies and energy management routines shall be definable by the operator through an operator's terminal. It shall be possible for the operator to modify the system functions independently after receiving the training from the Contractor as previously specified.
- 2. The system shall be provided complete with all equipment and documentation necessary to allow trained operator to independently perform the functions listed below.
 - a. Read the value of a measured variable (i.e., temperature).
 - b. Start or stop equipment.
 - c. Monitor the status of equipment being controlled.
 - d. Read the setpoint of a control loop.
 - e. Determine the control strategies that have been defined for a specific piece of equipment.
 - f. Generate displays of control strategies.
 - g. Add/delete control loops to the system.
 - h. Add/delete points to the system.
 - i. Create, modify, or delete control strategies.
 - j. Assign sensors and/or actuators to a control strategy.
 - k. Tune control loops through the adjustment of control loop parameters.
 - l. Enable or disable control strategies.

- m. Generate hard copy records of control strategies on a printer.
- n. Select points to be alarmable and define the alarm state(s).

G. THERMOSTATS

- 1. Line voltage thermostats shall be of the non-mercury switch type with a single pole, single throw switch rated for a load of not less than 7 amperes at 120 volts, 60 cycle, single phase. Thermostats shall have a differential of not more than 2 degrees F.

H. TEMPERATURE SENSORS

- 1. Temperature sensors shall be direct acting, nickel wire resistance temperature detection devices with adjustable span. Sensors shall be suitable for use as analog input devices for stand-alone control units.
- 2. Room sensors shall be housed in a blank thermostat type cover and shall include local night set back override switch and set point adjustment.
- 3. Duct sensors shall be flange or stem mounted to the ductwork and have a single point or averaging nickel wire resistance type element, as applicable (averaging type in air handling units only).
- 4. Liquid sensors shall be bulb mounted in a separable well and be selected for an appropriate temperature range.
- 5. Outdoor air sensors shall have the sensing element outdoors and the transmitter indoors. Sensing element shall be provided with a heavy metal guard to both protect it from physical damage and shield it from direct sunshine.

I. HUMIDITY SENSORS

- 1. Relative humidity sensors shall be direct acting electronic type devices using a thin film resistor. Sensors shall be suitable for use as analog input devices for remote terminal units.
- 2. Room sensors shall be housed in a blank thermostat type cover.
- 3. Duct sensors shall have a probe-mounted element, shall be flange-mounted to the ductwork.

J. SOLAR HEAT GAIN SENSORS

- 1. Sensors shall consist of black anodized aluminum solar energy collectors mounted in sealed, transparent, weathertight enclosures designed for outside installation.
- 2. Sensing elements shall be nickel wire wound resistance temperature detection devices as specified for temperature sensors..

K. STATIC PRESSURE TRANSMITTERS

- 1. Static pressure sensors shall be electronic type devices; shall have a 4-20mA output signal; shall be flange-mounted to the ductwork; shall be capable of measuring positive, negative, or differential static pressure; and shall be suitable for use as analog input devices for remote terminal units.
- 2. Static pressure sensors shall be selected with a range appropriate for the application and shall be suitable for use as analog input devices for remote terminal units.

L. PNEUMATIC-ELECTRIC SWITCHES

- 1. Pneumatic-electric switches shall be single-pole, double-throw devices with adjustable setpoint and differential. Switch contacts shall be rated for not less than 6.0 amps at 120 volts.

M. VALVES

- 1. Steam valves shall be of the single seated type with modified linear plug characteristics and a diaphragm-operated, spring-operated actuator. Actuator spring range shall be selected for the

application. Pilot positioners shall be provided wherever necessary to accomplish proper sequencing. Valves shall be as manufactured by Honeywell.

2. Water valves for use in condenser water system (tower bypass control valves) shall be of the butterfly type with pneumatic operator. All necessary mounting brackets, linkages, etc., shall be provided.
3. Water valves used in hot water systems, chilled water systems, and process cooling water systems shall be of the two-way or three-way type as indicated. Valves shall be provided with a diaphragm-operated, spring-opposed actuator with the spring range selected for the application. Pilot positioners shall be provided wherever necessary to accomplish proper sequencing. Valves shall be as manufactured by Honeywell,.

N. DAMPERS

1. Control dampers shall be of galvanized steel construction throughout with damper blades formed for maximum rigidity with minimum air flow resistance. Damper blades shall be mechanically locked to the blade axles. Axles shall rotate in non-metallic bearings. Blades shall be provided with end seals and interlocking edges for minimal air leakage in the closed position.
2. All damper linkages shall be adjustable to ensure proper mating of blade edges.
3. Damper blades shall not exceed 8 inches in width and shall be constructed of not less than 16 gauge material.
4. Dampers for use in any application involving the control of outdoor air shall be provided with inflatable edge seals or similar devices to ensure absolute minimal leakage.
5. Dampers shall have a maximum leakage rate of 20 cfm per square foot of face area at a 4 inch water gauge differential static pressure.
6. Bladder-type dampers (air valves) shall be of the linear type, shall operate with a turndown ratio greater than 50:1, and shall operate at pressure drops of 0.25 INWC to 6 INWC. Bladder-type damper shall utilize inflatable EPDM bladders and shall be of galvanized steel with aluminum bladder covers. Dampers shall be provided with removable end panels for servicing. Bladder dampers shall be of the normally open type and shall be as manufactured by Tek-Air Systems, Inc. or as approved.

O. DAMPER MOTORS

1. Pneumatic damper motors shall be of the piston-operated, spring-opposed type. Actuator shall be properly sized for the load. Spring range shall be selected for the application. Pilot positioners shall be provided wherever necessary to accomplish proper sequencing.
2. Electric damper motors shall be 24 VAC, which are 0-10 VAC input proportional and designed to operate position dampers. Operator shall be synchronous motor driven with 25 to 150 pound force sensor safety stops. Enclosure shall be cast aluminum. Actuator shall be rated for ambient temperatures of -35 degrees F to +130 degrees F.

P. AIR PIPING

1. Compressed air piping shall be seamless copper tubing or black fire-retardant type instrument polyethylene tubing. Copper tubing shall be used for all exposed equipment room applications.

Q. COMPRESSED AIR SYSTEM

1. Compressed air systems shall include, as a minimum, two compressors with individual motors, an ASME storage tank, intake air silencers, a refrigerated air drier complete with condensate drainer, and three valve bypass piping, a pressure relief valve, high and low side pressure gauges, a high efficiency air filter, motor control pressure switches, an electrical alternator, and magnetic combination starter/disconnect switches located in a unit mounted NEMA-1 enclosure. All power wiring from starters to compressor motor terminals and all control wiring shall be factory installed.
2. Compressors shall be of the belt-driven reciprocating type and shall be mounted directly on the receiver storage tank. Belt guards shall be provided.

3. Air drier shall be of the constant running mechanical refrigeration type capable of reducing the discharge dewpoint to -10 degrees F when dehydrating at 100 psig inlet. Drier starter and controls shall be factory furnished, installed, and wired.

R. MISCELLANEOUS DEVICES

1. Required switches, relays, transformers, flow switches, and similar accessories shall be standard products of the Control Manufacturer and shall be selected for the intended service.
2. Provide contactors, flow switches, sensors, switches, starters, panels, and miscellaneous devices required, but not specifically specified elsewhere, to operate and control total project mechanical and electrical equipment as listed, specified, scheduled, required by manufacturers of controlled equipment, or required by codes.

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