

SECTION 15500: AIR CONDITIONING EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL:

Refer to Section 15010 for General Requirements for Mechanical Work.

1.2 SCOPE:

Furnish and install all labor, materials, equipment, tools and services and perform all operations required in connection with, or properly incidental to, the construction of complete air conditioning equipment systems as indicated on the drawings, reasonably implied therefrom or as specified herein unless specifically excluded.

1.3 SCHEDULES ON DRAWINGS:

In general, all capacities of equipment and motor and starter characteristics are shown on schedules on the drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the characteristics will be permitted only on written approval of the Architect. Insofar as is possible, all items of the same type (i.e., rooftop units, fans, etc.) shall be by the same manufacturer. Where instructions on installation are not included on these specifications or on the plans, the manufacturer's instructions shall be followed. Equipment shall be labeled and provided with installation and operating instructions in accordance with Standard Mechanical Code, Section 303.

1.4 EQUIPMENT INSTALLATION AND WARRANTY SCHEDULE:

1.4.1 This Subcontractor shall refer to the architectural specifications for the required time schedule for the installation of equipment furnished as a part of this contract. The required time schedule will necessitate the setting-in-place of some items before the normal period of occupancy of the space and before the acceptance of substantial completion and subsequent approval by the Owner and Architect. The Subcontractor is advised that the warranty for each item of equipment will not begin until the documented time of beneficial use as defined in the architectural specifications, and the Subcontractor will, therefore, make the necessary arrangements with the equipment manufacturers for extended warranties as may be required.

1.4.2 All exterior equipment shall be provided with factory finished and fabricated, fully louvered coil guards completely enclosing coils preventing damage from outside sources. Wire screens or mesh are not acceptable. Where factory fabricated guards are not available, provide 300 series stainless steel, shop fabricated guards shall be provided.

1.5 REFERENCED STANDARDS:

ASHRAE Handbook - HVAC Applications (latest edition)
ASHRAE Handbook - HVAC Systems & Equipment (latest edition)
ASHRAE Handbook - Fundamentals (latest edition)
Standard for Mechanical Refrigeration Systems - ANSI B9.1
Standard For Installation of Air-Conditioning & Ventilating Systems - NFPA 90A
Water Cooling Towers - NFPA 214

International Mechanical Code (IMC)
Louisiana Boiler Inspection Law and Rules and Regulations
Reference SECTION 15010 for additional information

PART 2 - PRODUCTS

2.1 FILTERS: <S> <OM>

2.1.1 To protect the air-moving equipment during construction and for the purpose of testing and balancing, this Contractor shall furnish and install a complete set of temporary filters. These temporary filters shall be of glass fiber in heavy cardboard frame with suitable retainers to hold the media in place. Provide two (2) complete sets of each type of filter for each piece of air moving equipment, in addition to "start-up" filters.

2.1.2 All permanent filters for the air moving equipment (including, but not limited to, air handling units, packaged units, pt boxes, vav boxes, etc.) shall be 2" thick Farr 30/30 30% efficient pleated throw-away filters.

2.1.3 All final filters shall be 12" thick Farr Riga-Flo 200 90% efficient cartridge type filters. A differential "Magnahelic" pressure gauge registering 0" to 5.0" shall be installed across the filters.

2.2 EXHAUST FANS: <S> <OM>

2.2.1 Roof exhausters shall be of the belt-driven centrifugal type as manufactured by Greenheck or equal and have capacity as scheduled on the drawings. The fan shall be complete with a weather-proof protection for fans and motors, centrifugal type wheels, automatic shutter, non-fused disconnect switches, birdscreens and suitable motor and belt guards. The fans shall be supplied with the factory fabricated roof curb for sloped roof except where noted on the drawings. All fans shall bear the AMCA seal for air and sound performance, and shall be U.L. 702 listed and labeled.

2.2.2 Upblast roof exhausters shall be of the belt-driven centrifugal vertical discharge type as manufactured by Greenheck or equal and have capacity as scheduled on the drawings. The fan shall be complete with built centrifugal type wheels, automatic shutters, non-fused disc switches, birdscreens, permanently lubricated motor bearings and suitable motor and belt guards. Motor and drives shall be isolated from exhaust air steam with cooling air tube from a location free of discharge contaminants

Fans shall be fabricated with factory fabricated roof curb. All fans shall bear the AMCA seal for air and sound performance.

2.2.3 Acceptable Manufacturers: Greenheck, Loren Cook, Acme.

2.3 MOTOR STARTERS: <S> <OM>

2.3.1 Starters shall be NEMA approved magnetic, line voltage type with overload relays in each phase, phase loss protection and phase unbalance protection. Each starter will be provided with pilot light on H-O-A switch.

2.3.2 Interlocks as required, plus one (1) spare, shall be provided for each starter. Holding coils shall be 120V AC from an individual control power transformer.

2.3.3 Motor starters shall be provided for all motors 1 HP and above, unless indicated otherwise on the plans.

2.4 END SUCTION BASE MOUNTED PUMPS: <S> <OM>

2.4.1 Provide pumps as indicated, with capacities as scheduled on drawings, complete ready for piping and electrical connections.

2.4.2 Pumps shall be back pull-out vertical split case, end suction, horizontal flexible coupled, base mounted configuration with case wear rings.

2.4.3 Construction shall be cast iron case, bronze fitted, frame mounted on a common base with monitor. Flexible coupling shall be Woods spacer type for rear pull-out, and shall have a guard. Suction and discharge connections shall be drilled and tapped for gauges.

2.4.4 Shafts shall be carbon steel. Seals shall be equal to John Crane for the intended use as recommended by pump manufacturer.

2.4.5 Bearings shall be oil lubricated ball bearings selected for 200,000 hours average, type B-10 life. If bearings fail under contractor warranty for any circumstances supplier shall replace at no charge.

2.4.6 Drip pan with drain connection shall be sloped and provided for chilled water service. Extend 1/2" type "L" hard drawn copper line to floor drain. Drip pan shall extend a minimum of 3" around pump base.

2.4.7 Motor shall meet NEMA standards for application, shall be high efficiency TEFC and shall not overload nameplate HP at any point on pump performance load and system curve.

2.4.8 Impellor diameter shall not exceed 85% of cutwater diameter maximum. Contractor shall submit cutwater dimensions with submittal data. Select operation point at or to the left of best effective point. Impellor design shall accommodate field wear ring installation.

2.4.9 Submittal data shall include, but not be limited to, single-line pump curve with trimmed impellor and catalog curve for comparison.

2.4.10 Provide two nameplates, one to be mounted on pump and one to be mounted on base with the following minimum requirements:

- A. Manufacturer
- B. Serial Number
- C. Model/Type
- D. Size
- E. GPM
- F. T.D.H.
- G. RPM
- H. HP
- I. Impellor trim diameter
- J. Provide example of nameplate with submittal

2.4.11 Provide suction diffuser with disposable start-up strainer and permanent removable strainer.

2.4.12 Acceptable manufacturers: Peerless, Aurora, Bell & Gossett.

2.5 SEMI-INSTANTANEOUS PACKAGED GAS FIRED BOILER: <S> <OM>

2.5.1 Furnish and install a boiler plant as specified and as scheduled on the plans. The boiler plant shall consist of hydronic boiler module(s). Each Boiler shall be UL Listed, CSD-1 approved, ASME coded and stamped, and incorporate a gas train designed in accordance with FM. Each Boiler shall have capacities as shown on the plans, when fired with natural gas. The Boiler manufacturer must publish known part load value efficiencies; the thermal efficiency must increase as the firing rate decreases. The boiler control panel shall incorporate the functions of temperature control, combustion safeguard control, message annunciation, and fault diagnostic display, on individual field replaceable circuit boards mounted within a single housing. Each boiler shall have a footprint of no more than 28" W, 55 1/2" L, 79" H with a UL Listing for zero side wall clearance. Each boiler shall have ASME approved relief valve.

2.5.2 Boiler modules shall be natural gas fired, condensing design with a modulating forced draft power burner and positive pressure vent discharge.

2.5.3 Modulating Air/Fuel Valve and Burner

The Boiler burner shall be capable of a 20 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall be nozzle mix design, with spark ignition and flame rectification. The burner head shall be cast stainless steel. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. The modulating air/fuel valve shall meter the air and natural gas input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment and shall be located within the boiler cabinet.

2.5.4 Pressure Vessel/Heat Exchanger

- A. The boiler shall be capable of handling return water temperatures down to 40°F without any failure due to thermal shock or fireside condensation. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. The pressure vessel for 2000 MBH input boilers shall have a maximum water volume of 30 gallons. The boiler water pressure drop shall not exceed 2 psig at 180 gpm. The boiler water connections shall be 4" flanged 150 lb. ANSI rated. The pressure vessel shall be constructed of SA53 carbon steel, with a 0.25-inch thick wall and 0.50-inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. For other boiler sizes see the plan schedule.
- B. The boiler shall be designed such that the thermal efficiency increases as the boiler firing rate decreases. The heat exchanger shall be constructed of a minimum 316L stainless steel tubes and tube sheets with a one-pass combustion gas flow design. The tubes shall be no less than 0.065-inch wall thickness. The upper and lower stainless steel tube sheet shall be no less than 0.313 inch thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig.

Access to the tube sheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less than 13.5-inch diameter.

2.5.5 The exhaust manifold shall be of corrosion resistant porcelainized cast iron with flue connection. The exhaust manifold shall have a gravity drain for the elimination of the condensation with collecting reservoir.

2.5.6 Boiler Controls:

- A. The boiler control system shall be segregated into three components: Control Panel, Power Box, and Input/Output Connection Box. The entire system shall be Underwriters Laboratories Recognized.
- B. The control panel shall consist of 6 individual circuit boards utilizing surface-mount technology, in a single enclosure. These circuit boards shall be defined as follows: display board incorporating LED display to read temperature, and a VFD display module for all message annunciation; CPU board which houses all control functions; electric low water cutoff board with test and manual reset functions; power supply board; ignition/stepper board incorporating flame safeguard control; and connector board. Each board shall be individually field replaceable. The combustion safeguard/flame monitoring system shall utilize spark ignition and a rectification type flame sensor. The control panel hardware shall support both RS-232 and RS-485 remote communications. The controls shall annunciate boiler & sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of 8 separate status messages and 34 separate fault messages.
- C. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features are: Setpoint High Limit, Setpoint Low Limit, and Failsafe Mode. Setpoint High Limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. It is a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature. Setpoint Low Limit allows for a selectable minimum operating temperature.
- D. Failsafe Mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode; hence the control can be set to shut off the unit upon loss of external signal if so desired.
- E. The boiler control system shall incorporate the following additional features for enhanced external system interface: system start temperature feature; pump delay timer; auxiliary start delay timer; auxiliary temperature sensor; MA output feature which allows for simple monitoring of either temperature setpoint, outlet temperature, or fire rate; remote interlock circuit; delayed interlock circuit; and fault relay for simple remote fault alarm.
- F. Each boiler shall utilize an electric single seated safety shutoff valve with proof of closure switch in its gas train and incorporate dual over-temperature protection with manual reset in accordance with ASME Section IV and CSD-1.

2.5.7 Temperature Control Mode

- A. The boiler(s) shall operate in the following control mode: Indoor/Outdoor-Reset with the Aereco furnished (BMS) boiler management system remote panel. The panel can be field reconfigured to offer internal setpoint, or 4 to 20 mA temperature setpoint. The following is a description of I-O-R and the BMS.
- B. Indoor/Outdoor Reset:
1. Boiler shall include integral factory wired operating controls to control all operating and energy input of the boiler plant. The system shall be comprised of a microprocessor-based control utilizing pulse width modulation for bumpless transfer of header temperature. The controller shall have the ability to vary boiler input throughout its full range to maximize the condensing capability of the boiler and without header temperature swings.
 2. The boiler shall operate to vary header temperature setpoint on an inverse ratio in response to outdoor temperature to control discharge temperature $\pm 2^{\circ}\text{F}$. Unit shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. The boiler shall have LCD display for monitoring of all sensors and interlocks. Outdoor controller conduit and wiring furnished by Boiler Supplier.
- C. Boiler Management System (BMS):
1. The boiler Manufacturer shall supply as part of the boiler package a completely integrated Boiler Management System Programmer to control all operation and energy input of the multiple boiler heating plant. The Boiler Management System shall be comprised of a microprocessor based control utilizing a pulse width modulated (PWM) signal to communicate with the Boilers. The BMS controller shall have the ability to operate up to 8 boilers per BMS panel.
 2. The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The BMS shall control the boiler outlet header temperature within $\pm 2^{\circ}\text{F}$. The controller shall be a PID type controller for accurate temperature control with excellent variable load response. The BMS controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.

3. When set on Internal Setpoint Mode, temperature control setpoint on the BMS shall be fully field adjustable for 50°F to 200°F in operation. When set on Indoor/Outdoor Reset mode, the BMS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4ma to 20ma Temperature Control Mode, the BMS will operate the plant to vary header temperature setpoint linearly as an externally applied 4-20 ma signal is supplied. The BMS controller shall have a LCD display for monitoring of all sensors and interlocks. Nonvolatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time to each module by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central BMS system and individual modules shall be twisted pair low voltage wiring, with the boilers 'daisy-chained' for ease of installation. This conduit and wiring will be provided by the Boiler Supplier.

2.5.8 Accessories and Installation:

- A. All aspects of installation of Boiler Plant shall be in strict accordance with manufacturer's instructions.
- B. The vent system must conform to all manufacturers' recommendations and shall utilize UL listed stainless steel AL-29-4C Positive Pressure materials in a double wall configuration. This stack shall be supplied by the Boiler Supplier.
- C. Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves for service and maintenance. Each boiler shall require a minimum gas pressure of 7" W.C. at input scfh. Each boiler shall be provided with an individual supply gas regulator for proper gas regulation with a 2" NPT connection. Each boiler shall be supplied with an (field installed in discharge piping) automatic, pressure compensating, flow control valve of 4" size with maximum flow as scheduled on plans. Flow cartridges shall be field changeable for future GPM modifications and shall be constructed of stainless steel. The system Header temperature Sensor complete with sensor well shall be furnished with the boiler(s) and field installed in the discharge header at the location directed by the manufacturer. Wiring and conduit shall be supplied by the boiler supplier.

2.5.9 Warranty

The pressure vessel/heat exchanger of the boiler shall carry a 7 year prorated, limited warranty against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship. The six individual circuit boards of the control panel assembly shall carry a 2-year warranty against failure due to defective materials of workmanship. All other parts shall carry a 1-year parts warranty. In addition, a 1-year labor warranty including trouble-shooting shall be provided by the authorized factory service company. This service company shall have a service office located within 150 miles of the project site. A Warranty Certificate must be issued to the owner from the manufacturer and a copy of warranty must be submitted for engineer's approval.

2.5.10 Field Service

Contractor shall provide the services of a local factory authorized representative to supervise all phases of equipment startup. All control wiring between Boilers, Header Temperature Sensor and the Boiler Management System shall be the responsibility of the boiler manufacturer Field Services. It shall comply with the Electrical and control wiring specifications. A copy of the startup papers with factory operation, installation and maintenance instructions shall be submitted at the completion of startup.

2.5.11 Acceptable Manufacturers:

AERCO International
Viessmann Manufacturing Company

2.6 HEAT TAPE: <S> <OM>

2.6.1 Furnish and install a complete UL listed system of heaters, components, controls to prevent above grade condenser water piping and domestic water make-up at the cooling tower from freezing.

2.6.2 The self-regulating heater shall consist of two (2) 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket. To provide a ground path and to enhance the heater's ruggedness, the heater shall have a braid of tinned-copper and an outer jacket fluoropolymer as required per section 427-23 of the NEC-1996. For installation on plastic piping, the heater shall be applied using aluminum tape (AT 180).

2.6.3 The heater shall have a self-regulating factor of at least 90 percent. The self-regulation factor shall be defined as the percentage reduction, without thermostatic control, of the heater output going from 40°F pipe temperature operation to 150°F pipe temperature operation.

2.6.4 The heater shall operate on line voltages of 120 volts without the use of transformers.

2.6.5 The heater shall be sized according to this table. The required heater output rating is in watts per foot at 50°F.

<u>Pipe Size</u>	<u>Minimum Ambient</u>	<u>Temperatures</u>
	-10°F	-20°F
3 inch or less	5 watt	5 watt
4 inch	5 watt	5 watt
6 inch	8 watt	8 watt
8 inch	2 strips - 5 watt	2 strips - 8 watt
12 inch to 14 inch	2 strips - 8 watt	2 strips - 8 watt

2.6.6 The heater shall be XL-Trace as manufactured by Raychem Corporation or prior approved equal.

2.6.7 All heating cable components shall be UL-listed for use as part of the system to provide pipe freeze protection. Components enclosures shall be rated NEMA 4X to prevent water ingress and corrosion. Installation shall require only standard hand tools and shall not require the installing contractor to cut into the heating cable core to expose the bus wires. Connection systems requiring

the installing contractor strip the bus wires, or which used crimps or terminal blocks, shall not be acceptable. All components that make an electrical connection shall be reenterable for servicing.

2.6.8 Heating cable circuit shall be protected by a ground fault device for equipment protection in accordance with section 427-22 of the NEC-1996.

2.6.9 Provide the following master control:

- a. Thermostatic Control-Ambient Sensing: The system shall be controlled by an ambient sensing thermostat set at 40°F either directly or through an appropriate contactor.

2.7 CHEMICAL TREATMENT: <S> <OM>

2.7.1 Provide complete water treatment systems for each of the following:

- a. Chilled Water Piping System
- b. Heating Water Piping System
- c. Condenser Water Piping System

2.7.2 Qualifications - The water treatment chemical and service supplier shall be a recognized specialist whose major business is in the field of water treatment. The supplier shall have been active in the field of industrial water treatment for at least ten years and shall have a fully staffed laboratory, development facility, service department, and full-time service personnel.

2.7.3 Chemicals: - Provide, at no additional cost to the owner, all chemicals required for treating and testing included water systems for one year of operation.

2.7.4 Water Analysis - The appropriate chemicals to be used will be determined by the analysis of a water sample taken from the building site by the water treatment supplier. Provide ingredients necessary to achieve the desired water conditions.

2.7.5 Instructions - Instruct owner's personnel in the use and operation of each water treatment system, including: monitoring equipment, feed equipment, preparation of chemical solutions, charging of the chemical solution reservoirs, proper handling of chemicals, and proper use of test kits, charts and logs.

2.7.6 Testing Equipment and Reagents - Furnish water test equipment and reagents in appropriate cases to verify control parameters.

2.7.7 Manufacturers - Design is based on products by Garratt - Callahan Chemical Company. Equal equipment by GESCO, Betz, or Culligan is acceptable.

2.8 HYDRONIC UNIT HEATERS: <S> <OM>

- A. Coils: Seamless copper tubing, 0.025 inch (0.64 mm) minimum wall thickness, silver brazed to steel headers and with evenly spaced aluminum fins mechanically bonded to tubing.
- B. Chasing: Shall be 18 gauge (1.20 mm) steel, phosphatized to prevent corrosion, with sturdy motor mount to absorb vibration and anchor the motor. Weld-nut type hanger connections

for hanger rods.

- C. Finish: Provide factory applied baked enamel finish on all visible surfaces to enclosure or cabinet.
- D. Fan: Shall be direct drive propeller type, statically and dynamically balanced.
- E. Air Outlet: Provide adjustable pattern diffuser on projection models and two way louvers on horizontal throw models. Painted with a baked enamel color finish.
- F. Motor: All standard motors to be total enclosed and have class B insulated windings. Standard 115 volt/60 cycle/1 phase motors shall have built-in overload protection. Standard motors 1/25 HP thru 1/8 HP shall be sleeve bearing. 1/6 HP thru 3 HP shall be ball bearing. Sleeve bearing motors can be oiled. Ball bearing motors are permanently lubricated. 1/25 HP thru 1/8 HP motors can be operated on variable speed.
- G. Control: Multiple speed control for field installation.
- H. Capacity: Based on 60° F entering air temperature, 180° F entering water temperature.

2.9 VARIABLE FREQUENCY DRIVE (VFD): <S> <OM>

Clarification- Variable Frequency Drives (VFDs) shall be provided by division 15 and installed under division 16. Start-up and incorporation into BMS shall be performed under division 17. [Add6-10]

- A. DESCRIPTION: Provide as described herein VFD which convert fixed frequency utility power into adjustable frequency power necessary to operate three phase AC motors at variable speed. This shall allow proportional variation in volume in volume flow of the air handling units that are variable volume or constant pressure systems. VFD shall incorporate microprocessor logic to ease user set up for application functions. Provide three (3) copies of ladder logic diagrams to FDA consultant for validation.
- B. SERVICE CONDITIONS:

The VFD shall operate satisfactorily in the following conditions:
 - 1. Operating ambient temperature - 10 to 40 C
 - 2. Storage temperature - 20 - 60 C
 - 3. Relative humidity to 90% noncondensing
 - 4. Vibration 1 G max under 20 Hz; 0.2 G at 20 to 60 Hz
- C. STANDARD ENCLOSURE:
 - 1. The VFD and the BYPASS PANEL and all peripheral equipment required for proper operation of the VFD's shall in NEMA 1 wall mount enclosures, one per VFD.
- D. ELECTRO-MECHANICAL CONSTRUCTION SHALL BE AS DESCRIBED BELOW:
 - 1. Input voltage
 - a. As scheduled on the ELECTRICAL drawings.

2. Output current overload rating of 125% of motor FLA for 1 minute.
3. Voltage source design using PWM inverter technology.
4. Microprocessor based control circuit generating sine coded PWM output current waveform.
5. Non-volatile memory (NV RAM); all programming is maintained when disconnected from power.
6. Corrects displacement power factor to 98% throughout the motor speed range and eliminates power line notching, through the use of diode bridge input section or power factor correction capacitors and isolation transformer.
7. Input phase insensitive, sequencing of the 3 phase input lines is not required.
8. Capable of single phase input operation - required 50% drive derating and three phase motor on the output.
9. Fused DC bus with capacitive filtering.
10. Insulated Gate Bipolar Transistors (IGBT) output, allowing motor noise, at 60 Hz, less than 2 dB (@ 1 meter) above that resulting from across the line operation.

In the event that the VFD manufacturer does not utilize IGBT technology they shall provide output reactors in each VFD to reduce noise.

11. Three current transformers detect the output current to provide: Electronic thermal overload protection, Three phase current limit, Ground fault protection, Short circuit protection and Speed search capability.

As an alternate the VFD manufacturer must provide isolation transformer, external motor overload and external logic to accomplish speed search must be provided.

12. Digital operator keypad and display provides local control and readout functions -or- provide individual meters for readout and PLC for terminal status indication:
 - a. Run/Stop/Jog commands.
 - b. Speed command.
 - c. Reset command.
 - d. Output frequency meter and speed command meter, which can be programmed for other speed related indications including, RPM, CFM, FPM and % max. RPM.
 - e. Volt meter, Amp meter, Kilowatt meter functions.
 - f. Input and output terminal status indication.
 - g. Diagnostic indication.

- F. PERFORMANCE FEATURES - All VFD's furnished shall meet the performance standards described herein:

1. The VFD shall provide output frequency and voltage modulation with selectable volts/hertz ratio for optimum variable torque output.
 - a. Output frequency from 0 to 400 Hz.
 - b. Output voltage from 0 to motor rated voltage.
2. Fixed carrier frequency programmable up to 15 KHz, allowing motor noise, at 60 Hz, less than 2 dB (@ 1 meter) above that resulting from across the line operation -or- output reactor must be provided to reduce noise.
3. Compatible with standard NEMA B motors.
4. UL listed and CSA approved.
5. Lock out reverse operation.
6. Drive defaults to 80% of last speed through internal logic -or- provide a PLC to accomplish this function.
7. Soft start, linear or S-curve function.
8. Ramp to stop or coast to stop selection.
9. Provide braking through DC injection with voltage level, current limit and duration adjustable, and selectable for either stop (deceleration braking) or braking before start (anti-windmill braking) -or- provide a mechanical brake and time delay relay to accomplish.
10. Critical frequency rejection capability in 3 ranges with adjustable span of 0 to 10 Hz to avoid possible vibration problems at driven equipment resonant frequencies -or- provide a PLC to accomplish this function.
11. Two (2) second momentary power loss ride thru (drive logic is maintained) -or- provide external capacitors or battery backup to accomplish this function.
12. Auto restart (up to 10 attempts) -or- provide a PLC to monitor fault condition and accomplish restart. The auto restart for the equipment on this project shall be set at the time of start-up to five (5) attempts at starting prior to a lockout situation occurring.
 - a. The VFD shall have the ability to start into free running (coasting) motor via speed search feature.
13. High starting torque capability for high inertia loads.
14. Full range auto torque boost for high inertia loads.
15. Stall prevention.

16. Standard frequency reference (speed) input signals; 0-10 Vdc, 4-20 mA.
17. Accepts reverse or direct acting frequency reference input signal.
18. Programmable bias and gain for frequency reference input signal.
19. External fault input (i.e. firestat or freezestat) programmable to command ramp to stop, coast to stop, emergency stop or continue operation -or- provide external relays to accomplish this function.
20. Speed search to start a rotating motor and load -or- provide external logic to accomplish safe restart.
21. Terminals and programming for remote run/stop and speed reference.
22. Remote operation run/stop, 2 wire or 3 wire control.
23. Local/remote operation input via contact closure.
24. Analog output (0 to 10 Vdc) proportional to frequency or current.
25. RUN/FAULT OUTPUT CONTACTS (1 amp resistive) selectively activated at initial fault occurrence or after final auto restart attempt.
26. Stall prevention by reducing output voltage and frequency during momentary overload. Automatically resume normal operation when overload occurs.
27. Digital diagnostic indication and protection for:
 - a. DC bus under voltage and over voltage.
 - b. Load over torque.
 - c. Fuse blown.
 - d. Motor overload.
 - e. Heat sink over temperature.
 - f. Instantaneous over current.
 - g. Operator error.
 - h. Central processor fault.
 - i. External fault.
 - j. Dynamic braking fault.

G. ADJUSTMENTS AND PROGRAMMABILITY:

1. Incremental/Floating Point Control
 - a. One contact closure input causes acceleration for duration of the closure, another causes deceleration. When both switches are open the last speed command is held.
2. Factory default settings for the most common HVAC applications. These settings can be easily re-established through a reset code.

3. Program security code.
4. Thirty (30) operational changes possible in control and display functions without stopping the drive including:
 - a. Acceleration and deceleration time.
 - b. Frequency command.
 - c. Frequency command bias and gain.
 - d. Multi-step speed references.
 - e. Jog reference.
 - f. Monitor display.
5. Two independent, selectable acceleration/deceleration ramp times.
6. Acceleration time from 0.1 to 6000 seconds.
7. Deceleration time from 0.1 to 6000 seconds.
8. Maximum and minimum output frequency from 0 to 400 Hz.
9. Programmable upper and lower frequency limits.
10. Pre-set selectable Volts/Hertz (V/Hz) patterns plus 1 custom pattern.
11. Auto speed reference (instrument follower) input signal adjustable for bias and gain.
12. Programmable start and stop ramp time.
13. Four programmable multi-function input terminals.
14. Multi-function output contacts programmable for:

Run mode	Zero speed detect
Overtorque detect	Coast to stop detect
Run reference mode	Speed reference mode
Output frequency detect	Speed synchronization
Low voltage detect	Operation ready
Speed reference missing	Braking resistor fault
Drive fault	Firestat/freezestat
15. Adjustable torque and current limit from 0 to 170%.
16. Ramp to stop or coast to stop selection.
17. Adjustable upper and lower frequency limits independent of pre-set V/Hz pattern.
18. Programmable lock out code, to prevent operator access to parameter settings.
19. Nine (9) selectable pre-set speed programming capability.

20. Programmable jog speed.

2.9.1 COMPONENTS - Furnished with all VFD's

- A. Input section - VFD power input stage converts three phase AC line power into a fixed DC voltage via a solid state full wave diode rectifier with metal oxide varistor (MOV) protection.
- B. Intermediate section - DC bus maintains a fixed DC voltage with filtering and short circuit protection as a DC supply to the VFD output section. It is interfaced with the VFD diagnostic logic circuit to continuously monitor and protect power components.
- C. Output section - Insulated gate bipolar transistors (IGBT) convert DC bus voltage to variable frequency and voltage PWM sine coded output to the motor.

2.9.2 ACCESSORIES

- A. Bypass control allows operation of the motor across the line should the VFD require service:
 - 1. Bypass and drive are factory assembled and electrically interlocked.
 - 2. VFD can be removed with bypass control left in place.
 - 3. NEMA 1 enclosure.
 - 4. DOOR INTERLOCKED DISCONNECT.
 - 5. VFD input contactor.
 - 6. BFD output contactor.
 - 7. Bypass contactor.
 - 8. Overload relay.
 - 9. 115 VAC control transformer.
 - 10. Safety circuit terminal strip.
 - 11. Drive-Off-Line selector.
 - 12. Power on light.
 - 13. VFD select light.
 - 14. Line select light.
 - 15. Normal-Test selector.
 - 16. Hand-Off-Automatic switch.
- B. A Factory certified VFD technician shall provide START-UP SUPERVISION AND PROGRAMMING of the VFD's for proper operation. This work shall not be performed by the installing contractor. The factory certified VFD technician shall provide operator training to the building's operations personnel.
- C. The UNIT MANUFACTURER shall provide one (1) year parts and LABOR warranty. This warranty shall not be provided by the installing contractor. The labor warranty shall include mileage and subsistence to the from the jobsite. No additional costs shall be incurred by the owner during the period of the warranty.

2.9.3 SOURCE QUALITY CONTROL

- A. Mean time between failure (MTBF) 100,000 hours minimum.

- B. In-circuit testing of all printed circuit boards.
- C. Printed circuit boards burned in for 96 hours at 85° C.
- D. Functional testing of printed circuit boards after burn in.
- E. Fully assembled VFD tested with induction motors.
- F. All integrated circuits tested to .5% AQL acceptance criteria.

2.9.4 DRIVES SCHEDULE

- A. Rated input voltage as scheduled on the ELECTRICAL prints.
- B. Variable torque horsepower - as scheduled for the air handling units.
- C. Maximum continuous output current shall be the FLA of the motors.

2.9.5 Approved Manufacturers: MagneTek, Cutler Hammer, Allen Bradley.

Add the following paragraph 2.10: [Add2-22]

2.10 COOLING TOWER: <S> <OM>

2.10.1 The contractor shall furnish and install a two-cell induced-draft, cross flow-type or counter flow type, factory-assembled, film-filled, industrial-duty, galvanized steel cooling tower situated as shown on the plans. The limiting overall dimensions of each tower cell shall be 9.50 ft wide, 18.00 ft long, and 13.00 ft high to the top of the fan guard. Towers exceeding the maximum height requirement are acceptable if the total height of the tower and structural base does not exceed 16'-6". Total operating power of 15.0 HP per cell. Tower shall be equal to Marley Model NC8304E-2. The contractor shall assemble the any sections that may ship separately. The contractor shall provide motor starters for towers. The Building Automation System contractor shall provide any and all control components necessary to properly stage and control the cooling towers.

2.10.2 Thermal Performance: The tower shall be capable of cooling 1370 GPM of water from 98.00 deg F to 85.00 deg F at a design entering air wet-bulb temperature of 80.00 deg F, and its thermal rating shall be Certified by the Cooling Tower Institute.

2.10.3 Performance Warranty: CTI Certification notwithstanding, the cooling tower manufacturer shall guarantee that the tower supplied will meet the specified performance conditions when the tower is installed according to Plans. If, because of a suspected thermal performance deficiency, the Owner chooses to conduct an on-site thermal performance test under the supervision of a qualified, disinterested third party in accordance with CTI or ASME standards during the first year of operation; and if the tower fails to perform within the limits of test tolerance; then the cooling tower manufacturer will pay for the cost of the test and will make such corrections as are appropriate and agreeable to the Owner to compensate for the performance deficiency.

2.10.4 Design Loading: The tower and all its components shall be designed to withstand a wind load of 30 psf, as well as a Zone 4 seismic load, per UBC. It shall be designed to

withstand shipping and hoisting loads of 2g horizontal and 3g vertical. Fan deck and hot water basin covers shall be designed for 50-psf live load or a 200 lb concentrated load. Guardrails shall be capable of withstanding a 200 lb. concentrated live load in any direction. Forklift slots shall be provided in the basin side supports to allow handling of the tower at grade level.

2.10.5 Construction:

A. Except where otherwise specified, all components of the cooling tower shall be fabricated of heavy-gauge steel, protected against corrosion by G-210 galvanizing. The tower shall be suitable for circulating water having a pH of 6.5 to 8.0; a chloride content (NaCl) up to 750 ppm; a sulfate content (SO₄) up to 1200 ppm; a calcium content (CaCO₃) up to 800 ppm; oil and grease up to 10 ppm; silica (SiO₂) up to 150 ppm; and design hot water temperatures up to 120 deg F.

B. The specifications, as written, are intended to indicate those materials that will be capable of withstanding the above water quality in continuing service, as well as the loads described herein. They are to be regarded as minimum requirements. Where component materials peculiar to individual tower designs are not specified, the manufacturers shall take the above water quality and load carrying capabilities into account in the selection of their materials of manufacture.

C. The cooling tower provided shall include all design and material modifications necessary to meet the fire rating requirements of Factory Mutual (FM), and shall be listed in the FM Approval Guide, latest edition.

2.10.6 Mechanical Equipment:

A. Fans shall be propeller-type, incorporating heavy-duty blades of cast aluminum alloy. Blades shall be individually adjustable. Fans shall be driven through a right angle, industrial-duty, oil-lubricated; geared speed reducer designed for five (5) year oil change intervals. Speed reducers employing pulleys and belts will not be accepted. The motor shall be mounted outside the casing of the tower, and shall be connected to the gear reducer by a dynamically balanced, stainless steel tube & flange driveshaft.

B. Motors shall be 15.0 HP maximum, TEFC, 1.15 service factor, variable torque, and specially insulated for cooling tower duty. Speed and electrical characteristics shall be 1800 RPM, single winding, with voltage as scheduled on the electrical drawings. Motor shall operate in the shaft-horizontal position, and nameplate horsepower shall not be exceeded at design operation. All motors shall be premium efficiency, suitable for use with variable frequency drive (VFD).

C. The complete mechanical equipment assembly for each cell shall be supported by a rigid, galvanized steel structural support that resists misalignment between the motor and the gear reducer. The mechanical equipment assembly shall be warranted against any failure caused by defects in materials and workmanship for no less than five (5) years following the date of tower shipment. This warranty shall cover the fans, speed reducers, driveshafts and couplings, and the mechanical equipment supports. The electric motor shall carry a manufacturer's warranty of at least one year.

D. A vibration limit switch shall be 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.

2.10.7 Fill, Louvers & Drift Eliminators:

A. *Fill shall be film-type, thermal formed PVC, manufactured from 15 mil or heavier stock, with louvers formed as part of each fill sheet. Fill shall be suspended from hot-dip galvanized structural tubing supported from the upper tower structure, and shall be elevated at least 2" above the floor of the cold water basin to facilitate cleaning. Air inlet faces of the tower shall be free of water splash out.*

B. *Drift eliminators shall be PVC, triple-pass, and shall limit drift losses to no more than 0.005% of the design GPM flow rate.*

2.10.8 Hot Water Distribution System:

A. *Two open basins (one above each bank of fill) shall receive hot water piped to each cell of the tower. These basins shall be installed and sealed at the factory, and shall be equipped with removable, galvanized steel covers capable of withstanding the loads described herein.*

B. *Each basin shall include an inlet hole and bolt circle to accept a 125# flange connection per ANSI B16.1. Removable, interchangeable polypropylene nozzles installed in the floor of these basins shall provide full coverage of the fill by gravity flow. Heavy-duty flow-regulator valves shall be provided at the hot water inlet connections. These valves shall be disc-type, with cast iron bodies and stainless steel operating stems. There shall be a locking handle to maintain the valve setting in any position. Valves shall be right-angle configuration, precluding the need for inlet elbows.*

2.10.9 Casing, Fan Deck, & Fan Cylinder:

A. *The casing, fan deck and fan cylinder shall be heavy-gauge galvanized steel, and shall be capable of withstanding the loads described herein. The top of the fan cylinder shall be equipped with a conical, non-sagging, removable fan guard, fabricated of welded 5/16" and 7 gauge rods, and hot-dip galvanized after fabrication.*

2.10.10 Access:

A. *A large 30" high x 36" wide galvanized steel access door shall be located in each endwall casing for entry into the cold water basin and fan plenum area. Access doors shall be operable from inside as well as outside the tower, and shall provide continuous access from cell to cell in multi-cell towers.*

B. *The top of the tower shall be equipped with a sturdy handrail, complete with knee rail and toe board. Handrails, knee rails and posts shall consist of 1.66" O.D. x 15 gauge galvanized structural tubing, the handrail of which shall be capable of withstanding a 200 pound concentrated live load in any direction. Posts shall be spaced on centers of 8'- 0" or less. A 1'- 6" wide aluminum ladder with 3" I-beam side rails and 1.25" diameter rungs shall be permanently attached to the endwall casing of the tower, rising from the base of the tower to the top of the handrail. Provide a ladder extension for connection to the foot of the ladder attached to the tower casing. This extension shall be long enough to rise from the grade level*

to the base of the tower. The installing contractor shall be responsible for cutting the ladder to length; attaching it to the foot of the tower ladder; and anchoring it at its base.

C. A heavy gauge galvanized steel safety cage shall surround the ladder, extending from a point approximately 7' above the foot of the ladder to the top of the handrail surrounding the fan deck.

2.10.11 Cold Water Collection Basin:

A. The cold-water basin shall be heavy-gauge series 300 stainless steel, and shall include the number and type of suction connections required to accommodate the outflow piping system shown on the Plans. Suction connections shall be equipped with galvanized debris screens. A factory-installed, float-operated, mechanical make-up valve shall be included. A 4" diameter PVC pipe overflow shall be provided in each cell of the tower. The basin shall include a depressed center section into which accumulated silt can be flushed and overflow standpipes shall be removable to permit flush-out cleaning of the basin. Towers of more than one cell shall include stainless steel flumes for flow and equalization between cells. The interconnecting flume between cells shall be equipped with a removable cover plate to permit the shutdown of one cell for maintenance purposes, or to permit independent cell operation.

B. 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 deg F water temperature at an ambient air temperature of 12 deg F.

2.10.12 Acceptable manufacturers: Marley, Baltimore Air Coil, Evapco. [Add2-22]

PART 3 - EXECUTION

3.1 HEAT TAPE:

3.1.1 Heat Tape Installation:

- A. Apply the heater linearly on the pipe after piping has been successfully pressure tested. Secure the heater to piping with cable ties or fiberglass tape.
- B. Apply "electric traced" signs to the outside of the thermal insulation on 20'-0" centers.

3.1.2 Testing

After installation and before and after installing the thermal insulation, subject heater to testing using a 2500 VDC megger. Minimum insulation resistance shall be 20 megaohms regardless of length.

3.2 HYDRONIC UNIT HEATERS INSTALLATION:

- A. Install in accordance with manufacturer's instructions.

- B. Suspend hot water unit heaters with rod hangers from building structure anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- C. Provide hydronic unit heaters with shut-off valve on supply and lockshield balancing valve on return piping. Provide float operated automatic air vents with stop valve.
- D. Cleaning:
 - 1. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
 - 2. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

END OF SECTION