

SECTION 23 81 00

UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Split-type air source heat pumps.
- B. Rooftop packaged air-conditioning units or air-source heat pumps.
- C. Split system air conditioning units.
- D. Heating and ventilating units.
- E. Hot water boilers.
- F. Recirculation pumps.
- G. Air coils.
- H. Electric cabinet convector.
- I. Electric unit heater.
- J. Hot water unit heater.
- K. Gas fired unit heater.
- L. Infrared tube heaters.
- M. Infrared hi intensity heater.
- N. Rooftop indirect evaporative air cooler.
- O. Gas fired furnace.
- P. Cooling tower.
- Q. Air filters.
- R. Boiler stack.

1.02 RELATED SECTIONS

- A. Air conditioning and heating controls are specified in Section 23 09 00 - Instrumentation and Control for HVAC.
- B. Testing, adjusting, and balancing of HVAC and air handling systems is specified in Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC

- C. Ductwork shall be furnished and installed in accordance with Section 23 31 00 - HVAC Ducts and Casings.

1.03 MEASUREMENT AND PAYMENT

- A. General: Separate measurement or payment will not be made for the Work required under this Section. All costs in connection with the work specified herein will be considered to be included or incidental to the Work of this Contract.

1.04 REFERENCES

- A. Air-Conditioning and Refrigeration Institute (ARI):

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| 1. | ARI 210/240 | Unitary Air-Conditioning and Air-Source Heat Pump Equipment |
| 2. | ARI 270 | Sound Rating of Outdoor Unitary Equipment |
| 3. | ARI 310 | Packaged Terminal Air-Conditioners |
| 4. | ARI 340 | Commercial and Industrial Unitary Heat Pump Equipment |
| 5. | ARI 360 | Outdoor Air-Conditioning Equipment |
| 6. | ARI 380 | Packaged Terminal Heat Pumps |
| 7. | ARI 410 | Standard for Forced Circulation Air-Cooling and Air-Heating Coil |
| 8. | ARI 430 | Standard for Central Station Air-Handling Unit |

- B. Air Movement Contractor's Association (AMCA)

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| 1. | AMCA 99 | Standards Handbook |
| 2. | AMCA 210 | Laboratory Methods of Testing Fans for Rating |
| 3. | AMCA 300 | Reverberant Room Method for Sound Testing of Fans |
| 4. | AMCA 301 | Methods for Calculating Fan Sound Ratings from Laboratory Test Data |
| 5. | AMCA 500D | Laboratory Methods Testing for Dampers for Rating |
| 6. | AMCA 500L | Laboratory Methods Testing for Louvers for Rating |

- C. American Gas Association (AGA):

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| 1. | Directory of Certified Appliances and Accessories |
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UNITARY HVAC EQUIPMENT

2. Z21.13 Gas-Fired Low Pressure Steam and Hot Water Boilers
- D. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
1. ASHRAE 14 Measurement for Energy and Demand Savings
 2. ASHRAE 15 Safety Standard for Refrigeration Systems
 3. ASHRAE 52.1 Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
- E. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessels Code (BPVC):
1. ASME BPVC SEC IV Rules for Construction of Heating Boilers
 2. ASME BPVC SEC VIII Rules for Construction of Pressure Vessels
- F. Anti-friction Bearing Manufacturers Association (ABMA)
1. ABMA STD 9 Load Ratings and Fatigue Life for Ball Bearings
 2. ABMA STD 11 Load Ratings and Fatigue Life for Roller Bearings
- G. ASTM International (ASTM):
1. ASTM E84 Test Method for Surface Burning Characteristics of Building Materials
- H. Cooling Technology Institute (CTI):
1. CTI ATC-105 Acceptance Testing Code
- I. Hydronics Institute (HI)
1. Testing and Rating Standard for Cast Iron and Steel Heating Boilers.
- J. National Electrical Manufacturers Association (NEMA):
1. NEMA 250 Enclosure for Electrical Equipment
 2. NEMA ICS 1 Industrial Control and Systems General Requirements
 3. NEMA MG 1 Motors and Generators
- K. National Fire Protection Association (NFPA):
1. NFPA 54 (AGAZ 223.1) National Fuel Gas Code
 2. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems

3. NFPA 70 National Electrical Code (NEC)

L. Sheet Metal and Air Conditioning Contractors National Association

1. SMACNA HVAC Duct Construction Standards

M. Underwriters Laboratories Inc. (UL):

1. UL 378 Draft Equipment

2. UL 726 Oil-Fired Boiler Assemblies

3. UL 900 Air Filter Units

4. UL 1995 Heating and Cooling Equipment

1.05 REGULATORY REQUIREMENTS

A. Refer to Section 20 10 13 - Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC, for requirements.

1.06 SUBMITTALS

A. General: Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 - Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings indicating plans, elevations, and sections; dimensions and weights of equipment; sizes of refrigerant piping connecting to and from equipment; electrical connections; wiring diagrams; control logic diagrams (sequence of events) product data for instruments and controls; safety devices; condensate drain; interlocks; and concrete pads.

C. Product Data: Submit manufacturer's product data indicating total installation instructions, assembly support details thermal loads including sensible and total loads where applicable, motor horsepower and kilowatt rating, electrical characteristics, sequence of operation, type of refrigerant, pressures, suction and condensing temperatures, connection requirement, performance curves, start-up instruction and installation, testing procedures and start-up instructions.

D. Operation and Maintenance Data: Submit manufacturer's printed operation and maintenance instructions, in accordance with Section 01 78 23 - Operation and Maintenance Data, describing operating procedures and maintenance sequences. Include manufacturer's recommended spare parts list for maintenance requirements.

E. Warranties: Submit the respective manufacturer's warranty, warranting the performance of the equipment for a two-year period following final acceptance of the work, and for a 12-month period after the equipment is put into normal and continuous operation. Furnish labor, materials and equipment to adjust the air conditioning and heating equipment during the warranty period.

1.07 QUALITY ASSURANCE

- A. Provide products and installation conforming to NFPA 70, National and the California Electrical Code; ASHRAE 15, and the California Mechanical Code.
- B. Provide products of manufacturers specializing in the manufacture of HVAC equipment, that can show evidence of having produced HVAC equipment of approximately the same required capacity, and has been in successful operation for at least ten years.
- C. Test and rate the air-conditioning equipment and heat pumps in accordance with ARI 210/240, 310, 340, and 380 as applicable.
- D. Equipment shall be manufactured and tested in accordance with applicable UL requirements.
- E. Work Quality: Conform to applicable requirements of AMCA 99.

1.08 SITE CONDITIONS

- A. Examine surfaces and structures where equipment will be installed before the Work of this Section begins, assuring that the surfaces are capable of supporting the weight of the equipment. Surfaces that will become inaccessible after the equipment installation shall be completed before the equipment is installed. Assure that electrical facilities and services, that serve the equipment, have been installed, tested, and approved before installation of equipment.

PART 2 - PRODUCTS

2.01 GENERAL PRODUCT REQUIREMENTS

- A. Built-in thermostats furnished with heating and cooling equipment shall meet requirements of the CCR Title 24, California Energy Code, Part 6, Subchapter 2, All Occupancies - Mandatory Requirements for the Manufacture, Construction and Installation of Systems, Equipment and Building Components.
- B. Minimum efficiency of cooling equipment shall meet or exceed requirements of the CCR Title 24, Part 6, Sub chapter 2, "Mandatory Requirements for Space-Conditioning Equipment and Table 1-C, Efficiency Requirements for Space-Conditioning Equipment.
- C. Cooling equipment shall be listed on the California Energy Commission's (CEC) list of approved equipment and shall be certified, by the manufacturer, as complying with the CEC Appliance Efficiency Standards.
- D. Air conditioners and heat pumps shall be designed for and charged with non-ozone-depleting refrigerant as specified in Section 23 23 00 - Refrigerant Piping. Hydrogenated Chloro-Fluoride Carbon (HCFC) and Non Chloro-Fluoride Carbon (CFC) Refrigerant except as indicated.
- E. Disconnect switches, where provided, shall be accessible from outside control panel with control circuit transformer wired on disconnected side of the switch.
- F. Provide smoke detectors for air conditioning equipment to automatically shut-down the system upon detecting the presence of smoke as required by NFPA 90A, and connect to equipment controls and fire alarm system and connect to equipment controls and existing fire alarm system.

- G. Motors shall be furnished in accordance with the requirements of Section 20 60 13 - Motors for Facility Services.
- H. Dampers and louvers shall be rated in accordance with AMCA 500D and 500L, respectively.

2.02 THROUGH-WALL TYPE AIR-CONDITIONING UNITS AND HEAT PUMPS

- A. Provide factory-assembled and tested units designed for mounting through-wall. Provide air-cooled, cooling only, or combination electric heating and cooling units of either the section-type or integrated type as applicable and as defined in ARI 310, or ARI 210/240, heat pumps, as indicated. Provide units rated in accordance with ARI 310 or 380 producing not less than indicated capacities.
- B. Unit shall include fans and motors, integral temperature controls, outdoor louver, wall sleeve, 1 inch throwaway air filter, accessories for controlled ventilation and condensation removal, and electrical box for external power connection.
- C. Provide unit enclosure of minimum 18 gage galvanized steel, finished with baked enamel. Front panel shall be removable without the use of tools. Access to unit controls shall be gained by an access panel. Provide four-way adjustable discharge grilles. Provide return air entering between either kick plate and front panel or a low level in front panel. Line interior of enclosure with insulation having a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed as determined by ASTM E84.
- D. Provide horizontal bar-type louvers with flanged louver plate assembly constructed of 14 gage aluminum, anodized after fabrication.
- E. Provide one piece casing, self-bracing, fabricated of not less than 16 gage zinc-coated steel, phosphatized and finished with baked enamel. Design wall sleeve for field installing and fastening to outside air louver with a positive weather-and air-tight seal.
- F. Provide electric resistance heating coil, where indicated, having factory-mounted, automatic resetting, high-limit safety device wired to chassis. Safety device shall shut off heating unit when heating unit temperature exceeds manufacturer's recommended heating limit.
- G. Provide self-contained cooling section, either slide-in assembly or removable chassis type, hermetically sealed refrigeration compressor, separate condenser fan and motor, evaporator fan and motor, control box, condensation drain pan, and ventilation damper. Cooling section shall include refrigeration circuit tubing, wiring and safety controls, and shall be constructed as follows:
 - 1. Provide permanent split capacitor type motor, having an overload protection and fused capacitor.
 - 2. Condenser coil shall have copper tubes and aluminum fins. Fins shall be mechanically bonded to tubes.
 - 3. Evaporator coil shall have copper tubes and aluminum fins. Fins shall be mechanically bonded to tubes, and shall be positioned above an insulated galvanized steel drain pan.

4. Condenser and evaporators shall each have one or more resiliently mounted fans. Fans shall be statically and dynamically balanced at factory. Blades and hubs shall be constructed of anodized aluminum with steel shafts and ball bearings. Condenser fans shall be direct-driven propeller type. Evaporator fans shall be direct-driven or belt-driven double inlet centrifugal fan with forward curved blades.
 5. Refrigerant circuits shall have gas and liquid piping, fittings, valves, thermostatic expansion valves, liquid line sight glasses, filters, replaceable core dryer-strainer, liquid charging valve, charging manifold, and pressure gauges.
- H. Provide ventilation damper assembly with automatic actuator. Damper shall close automatically on unit shut-down and loss of power. Damper shall be open on heating and cooling.
- I. Provide disposable type air filter with holding frame of galvanized steel construction. Sizes and capacities shall be as indicated. Air filters shall be UL-approved type tested in accordance with UL 900. Rated average efficiency shall be minimum 45 percent based on ASHRAE 52.1 test method.
- J. Controls shall consist of push-button, heat-off-cool selector switch, and adjustable thermostat with upper and lower limits. Additional controls for heat pumps shall include outdoor coil defrost thermostat and adjustable outdoor temperature thermostat.
- K. Safeties shall consist of automatic reset over-temperature and over-current protection for compressor, automatic reset over-temperature protection for fan motor; and two over-temperature protectors for electric heating coil.

2.03 SPLIT-TYPE AIR SOURCE HEAT PUMPS

- A. Requirements: Provide split type air source heat pumps consisting of indoor units and remote air-to-air outdoor units, rated in accordance with ARI 210/240. Air-Source Heat Pump Equipment Design separate units to be used together, and base ratings on the use of matched assemblies. Provide units complete with air filters, control dampers, base, factory installed internal insulation, controls, wiring, and internal refrigerant piping.
- B. Indoor Unit:
1. Indoor unit shall be completely assembled to form an integral unit in which all components are properly matched. Unit shall be located indoor as indicated. Unit shall be capable of both continuous 24-hour per day operation, and intermittent operation.
 2. Indoor unit shall consist of cabinet type centrifugal fan section, electric heating coil where indicated, direct expansion cooling coil section, and air filter and mixing box with dampers where indicated. Each section shall be constructed of a galvanized steel frame with removable minimum 18 gage galvanized steel panels. Sections shall be bolted together to make up a single unit. Bolting flanges shall be sealed to prevent leakages. Steel transition pieces or flexible connections shall be provided where shown or required.
 3. Access panels shall be provided for each section and both faces of the coils.
 4. Inlet and outlet sections of the unit for ducted air delivery shall have flanges or collars for attachment of flexible connections or ducts.

5. Blower shall be double width, double inlet, and centrifugal fan suitable for cabinet type design. Fan section shall consist of one or more fan wheels as required. Fan housing shall be constructed of steel members and plates reinforced for maximum rigidity. Shaft bearings shall be supported independently from the fan section panels. Blower shall be statically and dynamically balanced. Belt drives shall be designed for 50 percent overload capacity and shall be provided with adjustable pulleys. Blower-motor assembly shall be resiliently mounted on spring vibration isolators.
6. Coil section shall consist of a cooling coil and heating coil where indicated. Cooling coils shall be direct expansion type constructed of aluminum fins mechanically bonded to seamless copper tubes. Heating coils shall be electric type as specified herein. Coil sections shall be arranged to allow removal of the coils from either side of the housing, unless otherwise indicated. The coil section shall be provided with a waterproofed and insulated galvanized steel drain pan with drain connection.
7. Indoor unit cabinet shall be insulated with one-inch thick 1.5 pounds per cubic feet density glass fiber insulation. Unit cabinet shall be coated with baked enamel finish.
8. Provide either integral or remote filters, as indicated. Integral filters shall be 2 inches deep low efficiency filters as specified herein. The remote filters shall include 2 inches deep low efficiency filters and high efficiency bag filters in side servicing housing as specified herein.
9. Fan motors shall conform to NEMA MG 1. Motor starters shall conform with NEMA ICS 1. Motors shall be totally enclosed fan cooled. Motor starters shall be magnetic across-the-line type. Floor-mounted indoor unit starters and controls shall be enclosed in NEMA 4X enclosure. Ceiling suspended indoor unit starters and controls shall be enclosed in NEMA 12 general-purpose enclosure. All starter panels shall be furnished with circuit breaker main disconnect switch.

C. Outdoor Unit:

1. Unit and components shall be completely factory assembled, pre-wired, tested, and ready to operate. Unit shall be capable of operating at rated capacity at the specified ambient air temperature and conditions. Equipment shall be suitable for outdoor installation at rooftop or ground level locations as indicated. Unit shall be capable of both continuous operation and intermittent operation.
2. Each unit shall have either one or two completely independent refrigeration circuits as indicated. Where two circuits are indicated for an individual unit, each circuit shall be suitable for load sharing and/or standby duty.
3. Each unit shall be provided with either one or two compressors as required by the specified refrigeration circuits. Compressors shall be reciprocating, serviceable semi-hermetic, or hermetic type with crankcase heater, with entire running gear assembly internally suspended, and externally mounted on resilient rubber mounts. Suction and discharge valves shall have hardened seats. Unit shall have multiple step capacity control, spring-loaded relief valve, and removable heads with unloader timers. Compressor motor shall be provided with heat sensing elements embedded in the motor winding.

4. Condenser coils shall be air-cooled type with minimum 3/8-inch outside diameter seamless copper tubing. Coil shall have aluminum plate fins mechanically bonded to copper tubes.
5. Condenser fans shall be statically and dynamically balanced propeller type, direct driven and discharging upward.
6. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with baked enamel. Cabinet panels shall be removable for service access to all operating components.
7. Unit shall be provided with 4-way reversing valve designed for fail-safe in heating position.
8. Internal refrigerant piping shall be hard-drawn type ACR copper tubing with wrought-copper fittings and brazed joints.
9. Compressor motor shall be rated for electric power characteristics as indicated. Motor shall conform to NEMA MG 1. Starters shall conform to NEMA ICS1. Motor shall be constant speed, low-starting current and high-torque squirrel-cage induction type, and shall have a magnetic across-the-line motor starter.
10. Provide each outdoor unit with unit mounted disconnect switch.

D. Unit Controls:

1. Unit controls shall be housed in a NEMA 4X enclosure for outdoor units and floor mounted indoor units, and NEMA 12 for other indoor units integral with the unit cabinet. The following control devices shall be provided:
 - a. Compressor motor magnetic starters.
 - b. Condenser fan motor magnetic starters.
 - c. Control power transformers.
 - d. Reversing valve control.
 - e. Occupied/unoccupied program relay.
 - f. Override timer.
2. Protective devices shall be designed to control operation under the following conditions:
 - a. Motor overload.
 - b. Under voltage.
 - c. Locked rotor.
 - d. Excessive winding temperature.

- e. High and low operating pressures.
 - f. Loss of refrigeration.
 - g. Compressor rapid cycling.
3. Where two compressors per unit are required, switch for alternating lead compressor timer shall be provided.

2.04 ROOFTOP PACKAGED AIR-CONDITIONING UNITS OR AIR-SOURCE HEAT PUMPS

- A. Requirements: Units shall be factory-assembled and tested, designed for roof installation, and consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics shall be as indicated.
- B. Casing: Manufacturer's standard casing construction, having corrosion protection coating, and exterior finish in accordance with Section 20 10 13 - Common Materials and Methods for Facility Services – Fire Suppression, Plumbing and HVAC. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 1/2-inch thick thermal insulation, knockouts for electrical and piping connections, power disconnect switch, and an exterior condensate drain connection and lifting lugs.
- C. Roof Curbs: Manufacturer's standard construction, 14 inch high minimum, insulated and having corrosion-protective coating, complete with factory-installed wood nailer and drain nipple.
- D. Additional Components: Remaining components and features shall be as specified in Article 2.03 herein. Units shall have economizer and return fan as required.

2.05 ROOFTOP PACKAGED AIR CONDITIONING UNITS

- A. General: Provide outdoor, roof mounted self-contained units with direct expansion cooling, gas combustion for heating where indicated, power exhaust fan and controls designed for variable volume, variable temperature operation where indicated and complete control system.
- B. Quality Assurance:
 - 1. Unit shall be rated in accordance with ARI Standards 270 and 360 and designed in accordance with UL Standard 1995.
 - 2. Unit shall be designed to conform to ASHRAE 15.
 - 3. Unit shall be ETL-tested and certified in accordance with ANSI Z21.47 Standard as a total package.
 - 4. Roof curb shall be designed to conform to nationally recognized standards.
 - 5. Insulation and adhesive shall meet NFPA 90A requirements for flame spread and smoke generation.

6. Unit casing shall be capable for withstanding Federal test method Standard No. 141 (Method 6061) 500-hour salt spray test.
 7. Unit shall conform to ISO 9002 manufacturing quality standard.
- C. Description: Self-contained, packaged, factory assembled and pre-wired, consisting of cabinet and frame, supply fan, controls, air filters, refrigerant cooling coil, compressor, condenser coil and condenser fan and gas fired heater, power exhaust and staged heating and cooling with automatic heat/ cool change over when heating is specified on drawings. Unit shall be furnished in accordance with the following minimum requirements:
1. Disconnect Switch: Factory mount disconnect switch on equipment.
 2. Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels with quick fasteners locking door handle type with piano hinges. Structural members shall be minimum 19 gage (0.90 mm) with access door or removable panels of minimum 20 gage (0.90 mm).
 3. Insulation: One half-inch thick neoprene coated glass fiber with edges protected from erosion. Aluminum foil-faced fiberglass insulation shall be used in the gas heat compartment.
 4. Supply Fan: Forward curved centrifugal type, resiliently mounted with V-belt drive, adjustable variable pitch motor pulley, and rubber isolated hinge mounted high efficiency motor. Refer to Section 20 30 13 - Vibration Isolation and Seismic Control for Facility Services. Fan and fan motor bearings to be ABMA 9 or 10 L-10 life of 50,000 hours.
 5. Air Filters: Two inch thick glass fiber, UL 900 Class I of II, disposable media in metal frames. Filters shall be accessible through an access panel.
 6. Roof Mounting Curb: 14 inches (350 mm) high-galvanized steel, channel frame with gaskets, mailer strips.
 7. Burner (if applicable)
 - a. Gas Burner: Induced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, modulating gas control valve, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot.
 - b. The heat exchanger shall be of the tubular-section type constructed of a minimum of 20-gage steel coated with a minimal 1.2 mil aluminum-silicone alloy for corrosion resistance.
 - c. Burners shall be of the ribbon or in-shot type constructed of aluminum-coated steel.
 - d. Gas Burner Safety Control: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until heat exchange is purged and pilot flame is proven, stop gas flow on ignition failure, energize induced draft fan, and after air flow proven and slight delay, allow gas valve to open.

- e. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.
 - f. Induced draft fan shall be of the direct-driven, single inlet, forward-curved, centrifugal type of propeller type. Induced draft fan shall be made from steel with a corrosion-resistant finish and shall be dynamically balanced.
8. Evaporator Coil
- a. Provide copper tube aluminum fin coil assembly with galvanized drain pan sloped to drain connection with pre-piped exterior trap.
 - b. Provide capillary tubes or thermostatic expansion valves for units of 6 tons (21 kw) capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons (26 kw) cooling capacity and larger.
9. Compressor
- a. Provide hermetic or semi-hermetic compressors, 3600 rpm maximum, with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter drier.
 - b. Five minute timed off circuit to delay compressor start.
 - c. Provide step capacity control by cycling compressors. Provide compressor unloading capability on 15 ton and larger units.
 - d. Each compressor shall be mounted on resilient, or spring type for 7.5 ton and larger capacity units, vibration isolators with seismic restraint.
10. Condenser Coil
- a. Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.
 - b. Provide direct driven propeller fans, resiliently mounted with corrosion resistant blades, fan guard, motor overload protection, wired to operate with compressor. Provide high efficiency fan motors.
 - c. Provide refrigerant pressure switches to cycle condenser fans.
11. Mixed Air Casing
- a. Galvanized steel with baked enamel finish with damper access doors.
 - b. Dampers: provide outside air, return air, and relief dampers, or powered exhaust where indicated, with damper operator and control package to automatically vary outside air quantity from fixed minimum to maximum of 100%. Outside air damper shall close completely upon unit shutdown. Relief dampers may be gravity type.

- c. Gaskets: Provide tight fitting dampers with edge gaskets maximum leakage 5 percent at 2 inches pressure differential.
- d. Damper Operator: Less than 50 volt with gear train sealed in oil with spring return on units 7.5 ton cooling capacity and larger.

12. Integrated Economizer

- a. Integrated type capable of simultaneous economizer and compressor operation to provide cooling with outdoor air.
- b. Equipped with low-leakage dampers not to exceed 3% leakage, at 1.0 in. water gauge pressure differential.
- c. Capable of introducing up to 100% outdoor air.
- d. Equipped with dry-bulb temperature control to govern economizer changeover.
- e. Package shall include an exhaust fan, motor, and damper for vertical flow units connected to economizer controller where indicated; otherwise provide, as a minimum, relief dampers to control over pressurization of building.

13. Operating Controls

- a. Provide low voltage, adjustable room thermostat to control compressor and condenser fan, and supply fan to maintain temperature setting.
 - 1) Include system selector switch off-heat-auto-cool and fan control switch (auto-on).
 - 2) Provide single acting thermostat with minimum 2 stage cooling.
 - 3) Locate thermostat in room as shown.
 - 4) Provide fan time delay to prevent cold air delivery.

14. Safety Controls

- a. Unit shall incorporate a solid-state compressor lockout, that provides reset capability at the space thermostat, should any of the following safety devices trip and shut off compressor:
 - 1) Compressor over-temperature, over-current.
 - 2) Low-pressure switch.
 - 3) Freezestat (evaporator coil).
 - 4) High-pressure switch.

- b. Heating section shall be provided with the following minimum protection:
 - 1) High-temperature limit switch.
 - 2) Induced-draft pressure switch.
 - 3) Flame rollout switch (manual reset).
 - 4) Flame proving controls.
 - 5) Redundant gas valve(s).
15. Operating Controls – Single Zone Units
- a. Electric solid-state microcomputer based room thermostat located as indicated.
 - b. Room thermostat shall incorporate:
 - 1) Automatic switching from heating to cooling.
 - c. Room thermostat display shall include:
 - 1) Time of day.
 - 2) Actual room temperature.
 - 3) Programmed temperature.
 - 4) System model indication: Heating, cooling, auto, off, fan auto, fan on.
 - 5) Stage heating or cooling operation.
16. Operating Controls – Variable Volume Units
- a. Temperature sensing element located in return air shall signal electronic logic panel to control mixing dampers and cooling in sequence. Mixing section shall operate as first stage of cooling and revert to minimum outside air above approximately 75 degrees F (24 degrees C) as determined by temperature of return and outdoor air.
 - b. Temperature sensing elements located in return air shall control cooling by cycling compressors, cylinder unloading, and hot gas bypass.
 - c. Control logic shall allow supply air reset under low load or airflow conditions.
 - d. Seven day time clock with spring carry over or electronic clock with battery backup shall control unit on occupied/un-occupied schedule. At night, unit shall be off. Locate clock in remote control panel with status lights.
17. Head Pressure Control Package: A solid-state control with condenser coil temperature sensor for controlling condenser-fan motor speed to maintain condensing temperature

between 90 F and 100 F at low outdoor ambient temperature shall be provided on 7.5 ton and larger units.

2.06 SPLIT SYSTEM AIR CONDITIONING UNITS

- A. General: Provide air handling units and remote air cooled condensing units that form a complete, fully compatible and operable system, rated in accordance with ARI 240.
- B. Description:
1. Air Handling Units: shall be furnished complete, including, but not limited to casing, supply fan, direct expansion coil, mixing box, filter section, and controls all factory assembled and pre-wired and shall meet following requirements:
 - a. Casing: Sectional Type of galvanized steel with removable galvanized steel access panels provide access to: a) both faces of evaporator coil(s), b) filters, c) mixing dampers, d) fan motor, e) Fan and f) controls. Exterior of casing shall be finished with enamel coating. Interior of casing shall be insulated as specified in Section 20 10 13. Provide galvanized steel condensate pan sloped to draining drain connection and pre-piped trap.
 - b. Insulation: Neoprene coated, glass fiber, applied to internal surfaces with adhesive and weld pins with exposed edges of insulation coated with adhesive.
 - 1) "K" value at 75 degrees F. Maximum 0.26 Btuh/inch/sq ft/degrees F.
 - 2) Density: 1 inch thick, 1-1/2 lbs/cu ft.
- C. Fans
1. Type: forward curved, double width, double inlet, and centrifugal type fan.
 2. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.
 3. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
 4. Bearings: self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with aluminum tube and grease fitting rigidly attached to casing.
 5. Mounting: Locate fan and motor internally mounted on weld steel base coated with corrosion resistant paint and attached to casing using resilient vibration isolators. Factory mount motor on slide rails. Provide access to motor, drive, and bearing through removable casing panels or hinged access doors.
 6. Flexible Connection shall separate fan and coil, and adjacent sections.
- D. Bearings and Drives

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1. Bearings: Heavy-duty pillow block type, self-aligning, grease- lubricated ball bearings, with ABMA 9 (L-10 life at 50,000 hours).
2. Shafts: solid, hot rolled steel, ground and polished, with Key-way, and protectively coated with lubricating oil.
3. V-Belt Drive: Coat iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer of minimum 1.5 times nameplate rating of the motor.
4. Belt Guard: Fabricate to SMACNA Standard; 0.106 inch (2.6 mm) thick, ¾ inch (20 mm) diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, and use of tachometer with guard in place.

E. Coils

1. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel.
2. Eliminators: Three break of galvanized steel, mounted over drain pan.
3. Fabrication:
 - a. Tubes: 5/8-inch (16 mm) OD seamless copper expanded into fins, brazed joints.
 - b. Fins: Aluminum.
 - c. Casing: Die formed channel frame of galvanized steel.
 - d. Headers: Seamless copper tubes with silver brazed joints.
 - e. Liquid Distributors: Brass or copper venturi distributor with seamless copper distributor tubes.
 - f. Configuration: Down feed with bottom suction.

F. Filters

1. Filter Box: Section with filter guides, access doors from both sides, for side loading with gaskets and blank-off plates.
2. Filter Media: UL 900 listed, Class I or Class II, approved by Engineer.
3. Flat 2 inches (50 mm) disposable panel filters.

G. Dampers

1. **Mixing Boxes:** Galvanized steel section with exterior enamel coated and factory mounted outside and return air dampers of galvanized steel with vinyl bulb edging and edge deals mounted in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in parallel blade arrangement.
2. **Damper Leakage:** Maximum 2 percent at 4 inch wg (1 kPa) differential pressure when sized for 2000 fpm ((10 m/s) face velocity.
3. **Air Cooled Condensing Units:** Self-contained, packaged, factory assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, integral sub-cooling coil, controls, liquid receiver, and screens.
 - a. **Construction and Ratings:** In accordance with ARI 210/240. Testing shall be in accordance with ASHRAE 14.
 - b. **Performance Ratings:** Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90A.
 - c. **Casing**
 - 1) House components in galvanized steel panels with weather resistant, baked enamel finish.
 - 2) Mount starters, disconnects, and controls in NEMA 4 OR 4XR weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is opened.
 - 3) Provide removable access doors or panels with quick fasteners and piano hinges.
 - d. **Roof Curbs:** Manufacturer's standard construction, or shop fabricated 18 gage minimum, 14 inch high minimum, insulated and having corrosive protective coating, complete with factory-installed wood nailer and drain nipple.
 - e. **Condenser Coils**
 - 1) **Coils:** Aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 425 pig (2900 kPa), and vacuum dehydrate.
 - 2) **Coil Guard:** Expanded Metal.
 - f. **Fans and Motors**
 - 1) Vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Equip with roller or ball bearings with grease fittings extended to outside of casing.
 - 2) Weatherproof motors suitable for outdoor use, single phase permanent split capacitor or 3 phase, with permanent lubricated ball bearings and built in current and thermal overload protection.

g. Compressors

- 1) Compressor: Semi-hermetic reciprocating type of Hermetic reciprocating type.
- 2) Mounting: Statically and dynamically balance rotating parts and mount on spring vibration isolators. Internally isolate hermetic units on springs.
- 3) Lubricating System: Reversible, positive, displacement oil pump with oil charging valve, oil level sight glass, and magnetic plug or strainer.
- 4) Motor: Constant speed 1800 rpm suction gas cooled with electronic sensor and winding over temperature protection, designed for across-the-line starting. Furnish with starter.
- 5) Capacity Reduction Equipment: Suction valve unloaders, with lifting mechanism operated by electrically actuated solenoid valve, with unloaded compressor start; controlled from suction pressure.
- 6) Sump Oil heater: Evaporates refrigerant returning to sump during shut down. Energize heater continuously.

h. Refrigerant Circuit

- 1) Provide each unit with one refrigerant circuit, factory supplied and piped.
- 2) For each refrigerant circuit, provide:
 - a) Filter dryer replaceable core type.
 - b) Liquid line sight glass and moisture indicator.
 - c) Thermal expansion valve for maximum operating pressure.
 - d) Insulated suction line.
 - e) Suction and liquid line service valves and gage ports.
 - f) Liquid line solenoid valve.
 - g) Charging valve.
 - h) Discharge line check valve.
 - i) Compressor discharge service valve.
 - j) Condenser pressure relief valve.

H. Controls

1. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, molded case disconnect switch, factory wired with single point power connection. Factory mount disconnect switch on unit.
2. For each compressor, provide across-the-line starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For each condenser fan, provide across-the-line starter with starter relay.
3. Provide safety controls arranged so any one will shut down machine:
 - a. High discharge pressure switch manual reset for each compressor.
 - b. Low suction pressure switch automatic reset for each compressor.
 - c. Oil Pressure switch (manual reset).
4. Provide the following operating controls:
 - a. Thermostat located in room cycles compressors, activates cylinder unloaders and activates solenoid valves in refrigerant circuit.
5. Provide controls to permit operation down to 0 degrees F (-18 degrees C) ambient temperature.
 - a. Thermostat to cycle fan motors in response to outdoor ambient temperature.

2.07 HEATING AND VENTILATING UNITS

- A. General: Provide outdoor roof mounted horizontal or indoor vertical heating and ventilating units as indicated that are packaged by a manufacturer in a modular form. The units shall be constructed with heating coils, mixing boxes, combination filter/mixing box section, filter section, and fan section.
- B. Casing
 1. Construction: Fabricate on channel base and drain pan of weld steel. Assemble sections with gaskets and bolts. Casing shall be galvanized steel, with outside finish and shall be Manufacturers standard paint on exterior. Floor Plate shall be galvanized steel, 1.382 inch (3.5 mm) thick.
 2. Insulation: Neoprene coated, glass fiber, applied to internal surfaces with adhesive and weld pins with exposed edges of insulation coated with adhesive.
 - a. "K" (Ksi[©] value at 75 degrees F (42 degrees C): maximum 0.26 Btuh/inch/sq ft/degrees F (0.037 W/m/Degree K).
 - b. Density: 1 inch (25 mm) thick, 1-1/2 lbs/cu ft (24 kg/cu m).

3. Access Doors: Of sufficient quantity and size to provide full access to both sides of coil filters and dampers and shall be of galvanized steel construction designed for flush mounting, with gasket, latch, and handle assembly.
- C. Roof Curbs for roof mounted units: Manufacturer's standard construction or shop fabricated 18 gage minimum, 14 inch high minimum, insulated and having corrosive protective coating, complete with factory-installed wood mailer and drain nipple.
- D. Fans
1. Type: Forward curved, double width, double inlet, centrifugal type fan.
 2. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.
 3. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
 4. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with aluminum tube and grease fitting rigidly attached to casing.
 5. Mounting: Provide access to motor, drive, and bearing through removable casing panels or hinged access doors. Mount base on vibration isolators.
- E. Bearings and Drives
1. Bearings: Heavy-duty pillow block type, self-aligning, grease-lubricated ball or roller bearings, with ABMA 9 or 10 (L-10 life at 50,000 hours).
 2. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
 3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 items nameplate rating of the motor.
 4. Belt Guard: Fabricated to SMACNA Standard; 0.106 inch (2.6 mm) thick, ¾ inch (20 mm) diamond mesh wire screen weld to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- F. Coils
1. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside fully contained within casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

2. Drain Pans: 24 inch (600 mm) downstream of coil.
3. Eliminators: Three break of galvanized steel mounted over drain pan.
4. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410.
5. Fabrication:
 - a. Tubes: 5/8 inch (16 mm) OD seamless copper expanded into fins, brazed joints.
 - b. Fins: Aluminum.
 - c. Casing: Die formed channel frame of galvanized steel.
6. Water Heating Coils:
 - a. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - b. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes. Furnished with automatic vent valve.

G. Filters

1. Filter Box: Section with filter guides, access doors from both sides, for side loading with gaskets and blank-off plates.
2. Filter Media: UL 900 listed, Class I or Class II, approved by Engineering.
3. Flat 2 inches (50 mm) deep disposable panel filters.

H. Dampers (if applicable)

1. Mixing Boxes: Galvanized steel section with exterior factory mounted outside and return air dampers of galvanized steel with vinyl bulb edging mounted in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in parallel blade arrangement with damper blades positioned across short air opening dimension.
2. Damper leakage: Maximum 2 percent at 4 inch wg (1 kPa) differential pressure when sized for 2000 fpm (10 m/s) face velocity.

2.08 HOT WATER BOILERS

- A. General: Furnish and install factory assembled, factory fire-tested, self contained, readily transported steel membrane wall water tube boiler ready for automatic operation except for connection of water, fuel, electrical, and vent services. The hot water boiler shall be mounted on integral structural steel frame base with integral forced draft burner, burner control, boiler trim, refractory, insulation, and jacket. Unit shall conform to ASME BPVC SECIV and SECVIII and AGA Z21.13 and UL726 for construction of boilers and be AGA certified.

B. Boiler Shell:

1. Construct boiler to applicable ASME Boiler and Pressure Vessels Code for allowable working pressure of 30 psi water.
2. Provide two lifting eyes on top of boiler.
3. Provide adequate tappings, observation ports, removable panels and access doors for entry, cleaning, and inspection. Removable access panels(s) to burner and separate removable access panels to water tubes shall each be full width and height designed to provide unobstructed access to burner and water tubes.
4. Insulate casing with 1-1/2 inch minimum thick glass fiber blanket insulation covered by sectional galvanized or zinc coated steel sheet metal jacket. Water tube access panel and chamber shall be insulated with high temperature insulation board permanently attached to panel and casing.
5. Factory paint boiler, base, and other components with hard finish enamel.

C. Hot Water Boiler Trim:

1. Provide Low Water Cut-off with drain valve and manual reset to automatically prevent burner operation whenever boiler water falls below safe level.
2. Provide complete automatic reset type temperature controls that shall, as a minimum a) control burner on/off to maintain temperature and b) control burner firing rate to maintain temperature. A manual reset type temperature control shall also be provided to control the burner to prevent boiler water temperature from exceeding safe system water temperature.
3. Provide pressure control of fixed setting type to control burner to ensure minimum operating pressure.
4. Provide a blend pump installed between supply and return connections designed to ensure minimum continuous circulation through the hot water boiler.
5. Provide ASME rated pressure relief valves, piped to drain.
6. Provide combination pressure and thermometer gage.

D. Fuel Burning System:

1. Provide forced draft automatic burner designed to burn natural gas at 1050 Btu/cubic foot and 7 inches water gage inlet pressure and maintain fuel-air ratios automatically.
2. Blower shall be statically and dynamically balanced, have adequate capacity to supply combustion air to burner and be directly connected to motor.
3. Single motor shall control combustion air damper and fuel valves.

4. Gas burner shall be forced draft, high radiant multiport power burner with electric ignition and modulating main valves with low fire ignition position.
5. Natural gas burner piping shall be factory installed and shall be complete gas train including high and low gas pressure switches, plug valve, gas pressure regulator, pilot valve and modulating main valve.

E. Controls

1. Mount NEMA 250, Type 1 hinged metal panel on boiler, containing electronic combustion control, blower motor starter, low fire hold time, automatic-manual firing selection switch, and control switches.
2. Provide electronic combustion control-to-control ignition, starting and stopping of burner, and both pre-combustion purge and post combustion purge. Burner to shut down in event of ignition, pilot, or main flame failure. Interlock to shut down burner upon combustion air pressure drop.
3. Provide electronic detector to prevent primary fuel valves from opening until pilot flame is established.

F. Performance

1. Performance rating shall be in accordance with HI – Testing and Rating Standard for Cast Iron and Steel Heating Boilers.
2. Minimum Efficiency shall be 80 percent from 30 to 100 percent of full load firing rate. Efficiency and capacity shall be certified by factory. In addition to factory certified capacity and efficiency tests, the boilers shall be performance tested by the factory to check construction, controls, and operation or unit. Submit copies of inspection report to Engineer prior to shipment.

2.09 RECIRCULATION PUMPS

A. General: Provide centrifugal pumps and related accessories normally encountered in hydronics system.

1. In-Line Circulators
 - a. Type: Horizontal shaft, single stage, direct connected with resiliently mounted motor for in-line mounting, oil lubricated, for 125 psig (860 kPa) maximum working pressure.
 - b. Casing: Cast iron, with flanged pump connections.
 - c. Impeller: Cadmium plated steel, keyed to shaft.
 - d. Bearings: Two, oil lubricated bronze sleeves.
 - e. Shaft: Alloy or stainless steel with copper or bronze sleeve, integral thrust collar.

- f. Seal Carbon rotating against a stationary ceramic seat, 225 degrees F (107 degree C) maximum continuous operating temperature.
- g. Drive: Flexible coupling.
- h. Electrical Characteristics:
 - 1) Motor: 1750 rpm unless indicated otherwise.
 - 2) Wiring Terminations: Provide terminal tugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2. Base Mounted Pumps

- a. Type: Horizontal shaft, single stage, direct connected, radially or horizontally split casing, for 125 psig (860 kPa) maximum working pressure.
- b. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- c. Impeller: Bronze, fully enclosed, keyed to shaft.
- d. Bearings: Oil lubricated roller or ball bearings.
- e. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
- f. Seal: Carbon rotating against a stationary ceramic seat, 225 degrees F (107 degrees C) maximum continuous operating temperature.
- g. Drive: Flexible coupling with coupling guard.
- h. Baseplate: Cast iron or fabricated steel with integral drain rim.
- i. Electrical Characteristics:
 - 1) Motor: 1750 rpm unless specified otherwise.
 - 2) Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

3. Preparation

- a. Verify that electric power is available and or the correct characteristics.

2.10 AIR COILS

- A. General: Provide heat transfer coils for installation in air systems, where indicated in heating, ventilation, air conditioning units, ductwork, and variable air volume units. Equipment shall be

capable of both continuous operation and intermittent operation. Insulate headers located outside air flow as specified for piping.

B. Refrigerant Coils

1. Tubes: 5/8 inch (16 mm) OD seamless copper arranged in parallel or staggered pattern, expand into fins, silver brazed joints.
2. Fins: Aluminum continuous plate type with full fin collars.
3. Casing: Die formed channel frame of 16 gage (1.6 mm) galvanized steel with 3/8 inch (9.5 mm) mounting holes on 3 inch (75 mm) centers. Provide tube supports for coils longer than 36 inches (900 mm).
4. Headers: Seamless copper tubes with silver brazed joints.
5. Liquid Distributors: Brass or copper venturi type distributor with seamless copper distributor tubes. Maximum 12 circuits per distributor.
6. Testing: air test under water at 300 psig (2070 kPa) for working pressure of 250 psig (1720 Kpa); clean, dehydrate, and seal with dry nitrogen charge.
7. Configuration: Down feed with bottom suction to prevent trapping of oil.
8. Fin Spacing: 8 fins per inch (3.1 mm on center).
9. Provide sight glass in liquid line within 12 inches (300 mm) of coil.

C. Hydronic Coils:

1. Hydronic Coils: Connect water supply to leaving air side of coil counterflow arrangement.
2. Provide shut-off valve on supply line and lockshield balancing valve on return line.
3. Locate water supply at bottom of supply header and return water connection at top.
4. Provide float operated automatic air vents at high points complete with stop valve.
5. Ensure water coils are drainable and provide drain connection at low points.
6. Provide three break moisture eliminators of 24 gage (0.7 mm) galvanized steel, where air velocity exceeds 500 ft/min (2.5 m/sec).
7. Provide drain pan and drain connection; fabricate from 20 gage (1.0 mm) galvanized steel, extend 3 inches (75 mm) from face of entering air side, 6 inches (150 mm) from face of leaving air side and 4 inches (100 mm) from face of eliminators. Condensate in drain pan after condensate drain trap shall flow through flexible plastic hose to nearest floor drain.

D. Electric Heating Coils

1. Electric heating coils shall be provided, where indicated, in ductwork, air handling units, and variable air volume units. Equipment shall be capable of both continuous operation and intermittent operation. Duct mounted heating coils shall be flanged type.
2. Electric heating coils and controls shall be UL listed and shall meet the requirements of the California Electrical Code and NFPA 70 grounding lugs shall be provided. Internal wiring, including step controllers and overcurrent protection of resistance steps, shall be factory installed and terminated at terminal blocks. Heater power and control terminals shall be marked.
3. Elements shall be open coil type. Wire element shall consist of 80 percent nickel and 20 percent chromium alloy. Supports for elements shall be ceramic bushings, spaced not more than 3.5 inches on centers.
4. Enclosure for heaters shall conform with NEMA 1. Insulation constructed of minimum 5/16-inch thick glass fiber shall be provided between the mounting and the terminal box.
5. Internal safety controls shall be serviceable through the terminal box without removing the heater from the duct or air handling unit, and shall be provided complete with the following:
 - a. Integral thermal cutout temperature sensing elements;
 - b. Automatic-reset thermal cutout temperature sensing elements;
 - c. Switch to de-energize circuits in the terminal box, when the terminal box is opened;
 - d. Air flow sensing device and switch;
 - e. Energizing the heaters in steps in response to signals step controller circuits.
 - f. Transformer to provide control circuit power for safety and backup contactors;
 - g. Disconnecting switch with door interlock; and
 - h. Disconnecting safety and backup contactors.

2.11 ELECTRIC CABINET CONVECTOR

- A. Provide electrical cabinet convector with voltage, phase, capacity, inlet and outlet locations, and size as indicated, UL-labeled. Provide self-contained, factory-assembled unit consisting of heating elements, casings having inlet and outlet grilles, air-flow baffles, controls, and protective devices.
- B. Provide minimum 18 gage steel cabinet with removable front not less than 16 gage and back not less than 18 gage. Convectors shall be for wall mounting installed with bottom six inches above the finished floor. Complete cabinet with inlet and outlet grilles and access to control

components. Provide enclosure with factory baked-enamel finish. Color of finish will be selected by the Engineer from manufacturer's standards.

- C. Provide heating elements consisting of nickel-chromium heating wire embedded in magnesium oxide insulating refractory and sealed in corrosion-resistant metallic sheath having fins. Seal and enclose ends of elements in terminal box and press element sheath mechanically after filling to ensure maximum magnesium oxide compaction. Provide steel sheath and fins with copper plating, high-temperature ceramic coating or high-temperature aluminized finish. Fins shall be spaced a maximum of six per inch. Heat transfer between sheath and fins shall be uniform. Free elements from expansion noise and 60 Hz hum.
- D. Provide automatic reset thermal overload line voltage protection with convector heater to protect from overheating.
- E. Provide heaters with factory-installed safety disconnect switch or circuit breaker.
- F. Provide heater with a built-in, tamper-resistant thermostat that is tool-adjustable without requiring removal of cabinet parts.

2.12 ELECTRIC BASEBOARD HEATERS

- A. Requirements: Provide electric baseboard heaters with voltage, phase, and capacity as indicated, UL-labeled. Furnish and install heaters complete with heating elements, brackets and closures, splice plates, interior and exterior corners, controls, and accessible wiring compartment.
- B. Cabinet:
 1. Provide minimum 18 gage steel cabinet at front and 20 gage at back, and reinforce and support rigidly. Provide cabinet with no sharp or rough edges, forming a strong rigid cover. Provide heavy-gage gusset plates for stiffening the enclosure to maintain uniform shape. Cabinet shall have top flat outlet.
 2. Front shall be removable. End plates and corner pieces shall be die-formed with round edges, fit flush with cabinet surface, and neat in appearance. Provide cabinet with factory baked-enamel finish. Color of finish will be selected by the Engineer from manufacturer's standards.
- C. Heating Element: Provide heating element consisting of nickel-chromium heating wire embedded in magnesium-oxide insulating refractory and sealed in corrosion-resistant metallic sheath with fins. Seal and enclose ends of elements in terminal box and press element sheath mechanically after filling to ensure maximum magnesium oxide compaction. Provide steel sheath and fins with copper plating, high-temperature ceramic coating or high-temperature aluminized finish. Fins shall be spaced a maximum of six per inch. Heat transfer between sheath and fins shall be uniform. Elements shall be free from expansion noise and 60 Hz hum.
- D. Limit Control: Provide continuous end-to-end automatic reset thermal overload line-voltage protection with each individual baseboard heater.
- E. Disconnect Means: Provide heater with either a factory-installed safety disconnect switch or circuit breaker installed in the housing or in an auxiliary matching control section.

- F. Thermostat: Provide heater with a built-in, adjustable, tamper-resistant thermostat, that shall be tool-adjustable without requiring removal of cabinet parts. Provide thermostat with an approximate range from 55 degrees F to 85 degrees F, and an operating differential of 3 degrees F or less.

2.13 ELECTRIC UNIT HEATER

- A. Requirements: Provide electric unit heater with voltage, phase, capacity, number of steps, and mounting height as indicated. Units shall be UL-labeled. Provide unit heater with terminals for control circuits and for single source of power supply. Provide factory-installed control transformer.
- B. Housing: Housing shall be not less than 18 gage steel. Housing shall be either galvanized, or bonderized and prime painted, and factory-finished with baked-enamel. Brace parts rigidly with heavy steel plates or structural steel shapes to prevent vibration and to maintain alignment. Housing shall be designed to provide ready access to interior parts without unfastening housing from mounting bracket. Furnish swivel-mounting brackets with each heater for wall and/or ceiling mounting where indicated.
- C. Heating Element: Provide heating element consisting of nickel-chromium heating wire embedded in magnesium-oxide insulating refractory and sealed in corrosion-resistant metallic sheath with fins. Seal and enclose ends of elements in terminal box and press element sheath mechanically after filling to ensure maximum magnesium oxide compaction. Provide steel sheath and fins with copper plating, high-temperature ceramic coating or high-temperature aluminized finish. Fins shall be spaced a maximum of six per inch. Heat transfer between sheath and fins shall be uniform. Elements shall be free from expansion noise and 60 Hz hum.
- D. Louvers: Provide horizontal air discharge units with individually adjustable horizontal louvers. Provide a heavy duty removable, galvanized steel louvered back, heavy grided, or chrome plated steel wire guard for inlet air. Provide vertical air discharge units with individually adjustable louvers so that air-flow pattern can be adjusted in all directions.
- E. Fans and Motors: Provide propeller type fans directly connected to fan motor, dynamically balanced, resiliently mounted to the housing, and designed specifically for unit heater application and low noise level. Provide totally enclosed fan motor, continuous duty with built-in automatic reset thermal overload protection.
- F. Limit Controls: Provide thermal overheat protection located to protect against overheating of unit from any cause.
- G. Contactor: Provide unit with factory-installed magnetic contactor for remote thermostatic operation, that disconnects all ungrounded contactors to the heater. Provide a control transformer to supply 120 V thermostat control power.

2.14 HOT WATER UNIT HEATER

- A. General: Provide hot water unit heaters as indicated.
 - 1. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

2. Casing: 18 gage (1.2) steel with threaded pipe connections for hanger rods.
3. Finish: Factory applied baked primer coat as suggested.
4. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve gearings; vertical models with grease-lubricated ball bearings.
5. Air Outlet: Adjustable pattern diffuser on projection model and four way louvers on horizontal throw models.
6. Motor: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models.
7. Control: Local multi-speed disconnect switch.
8. Capacity: As scheduled, based on 60 degree F (18 degree C) entering air temperature.

2.15 GAS FIRED UNIT HEATER

A. Requirements: Provide gas fired unit heaters as indicated.

1. Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, burner, controls, and accessories:
 - a. Heating: Natural gas fired.
 - b. Discharge Louver: Individually adjustable horizontal louvers to match cabinet finish.
 - c. Downtown Nozzle: 30 degree nozzle to match outlet and cabinet finish.
2. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner.
3. Supply Fan: Propeller type with direct drive.
4. Gas Burner:
 - a. Atmospheric type with adjustable combustion air supply.
 - b. Gas Valve: Provide 100 percent safety gas shut-off, 24 volt combining pressure regulation, safety pilot, manual set on-off, pilot filtration, automatic electric valve.
 - c. Electronic pilot ignition: With electric spark igniter.
 - d. Combustion air damper: With synchronous spring return damper motor.
 - e. Non-corrosive combustion air blower with permanently lubricated motor.
5. Gas Burner Safety Control:

- a. Thermocouple Sensor: Prevents opening of gas valve until pilot flame is prove and stops gas flow on ignition failure.
 - b. Flame Rollout Switch: Installed on burner box and prevents operation.
 - c. Vent Safety Shutoff Sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.
 - d. Limit Control: Fixed stop at maximum permissible setting, de-energizes burner on excessive bonnet temperature, automatic resets.
6. Operation Controls:
- a. Room Thermostat: Cycles burner to maintain room temperature setting.
 - b. Supply Fan Control: Energized from bonnet temperature independent of burner controls, with adjustable time delay and fixed time on delay, with manual switch for continuous fan operation.

2.16 INFRA-RED TUBE HEATERS

A. Heater Parameters:

- 1. Two stage infra-red tube heaters shall be RE-VERBER-RAY HL SERIES, as manufactured by Detroit Radiant Products Company, Warren, MI 48089; Reznor Inreal-Rez Model TR/TR-H, Mercer, PA 16137; or equal.
- 2. Two stage infrared tube heaters shall be Design Certified by the American Gas Association (AGA) and comply with current Occupational Safety and Health Act (OSHA) Requirements.
- 3. The Contractor shall provide a manufacturer's published warranty covering the heater's stainless steel burner for a period of 10 years, combustion and radiant emitter tube assembly for a period of 5 years, and all components utilized in the heater control assembly for a period of 1 year.
- 4. Two stage infra-red tube heaters shall be designed to operate when burning natural gas having a heat value of 100 MBH/75 MBH per cubic foot.

B. Two Stage Infra-red Tube Heater Burner Controls:

- 1. The two-stage infra-red tube heater shall be AGA Design Certified to operate at an input differential of at least 30% between the low-fire and high fire modes.
- 2. Heaters shall equip with a direct silicon carbide ignition system. Power supplied to each burner shall be 120 VAC, 60HZ, and single phase.
- 3. Heater controls shall include two safety differential pressure switches.

4. Heater control assembly shall include staging indicator lights that define the units operation input ranges.
5. The heater controls shall provide a 60 second post purge as an integral part of the control assembly.

C. Two stage Infra-red Tube Heater Construction:

1. Heater's control housing shall be totally enclosed with an enameled steel exterior.
2. The main burner assembly shall be constructed of stainless steel.
3. Heater's combustion chamber shall be 4 inch O.D. 16 gage titanium alloy or aluminized steel finished with a high emissivity rated, corrosion resistant, black coating.
4. Heater's radiant emitter tube shall be 4 inch O.D. 16 gage aluminized steel finished with a high emissivity rated, corrosion resistant, black coating.
5. The heater's combustion chamber and radiant emitter tube shall incorporate a 4 inch slip fit connection held by a bolted clamp.
6. The silicon carbide igniter shall be readily accessible and serviceable without the use of tools.
7. Reflectors shall be of 0.025 polished aluminum with reflector end caps. Reflectors shall be rotatable from 0 to 45 degrees when required.
8. The heaters shall utilize a downstream turbulator baffle for thermal efficiency.
9. The two stage infrared tube heaters shall be designed such that, at the District's option, outside combustion air may be supplied, an air intake collar shall be supplied.

2.17 INFRA-RED HI INTENSITY HEATERS

A. Heater Parameters:

1. High intensity heaters shall be RE-VERBER-RAY DR SERIES, as manufactured by Detroit Radiant Products Company, Warren, MI 48089; Reznor Infra-Rez Model RIH/RIHV, Mercer, PA 16137; or equal.
2. High intensity heaters shall be Design Certified by the American Gas Association (AGA), approved by Underwriter's Laboratories, Inc. (UL), and shall comply with current Occupational Safety and Health Act (OSHA) Requirements, and accepted by Factory Insurance Association (FIA) and Mutual Fire Insurance Companies (FM).
3. The Contractor shall provide a manufacturer's published warranty covering the heater's ceramic burner for a period 10 years and all the components utilized in the heater control assembly for a period of 1 year.
4. High intensity heaters shall be designed to operate when burning natural gas having a heat value of 50 MBH per cubic foot.

B. High Intensity Infrared Heater Burner Controls:

1. High intensity heaters shall be AGA Design Certified to operate at the designed input rating of 50 MBH per cubic foot.
2. Heaters shall be equipped with a Spark Pilot Ignition System (NSPI-8) with automatic (re) ignition via solid-state spark ignition. Loss of gas shall cause shut-off of main burners and loss of power shall cause 100% shut-off of main burners and pilot burners. Power supplied to each burner shall be 120 VAC, 60 HZ, single phase or 24 VAC with a transformer for a sufficient VA rating.

C. High Intensity Infrared Heater Construction:

1. The heater reflector housing and plenum chamber shall be constructed of bright polished aluminum.
2. The Venturi shall be constructed of stainless/aluminized steel.
3. The rods shall be constructed of high temperature stainless steel alloy with ceramic infrared generators.
4. Parabolic reflectors shall be used when units are installed in high mounting applications or to direct the infrared rays in a more focused pattern.
5. Protective screens shall be used in facilities where debris may damage the heater.

2.18 ROOFTOP INDIRECT EVAPORATIVE AIR COOLER

- A. General Description: Units shall be factory-assembled and tested designed for roof installation and connecting of gas-fired furnace section, blower section, indirect evaporative cooling section, filter, damper and temperature controls. Capacities and electrical characteristics shall be as indicated on the Contract Drawings.
- B. Casing: All side and roof panels shall utilize standing seam modular panel construction and shall be assembled with bolts such that they are removable. Casing shall be of not less than 16 gage galvanized, painting grip steel sheets reinforced as required with structural steel to provide structural integrity and prevent breathing drumming.
- C. Access doors: Provide hinged, double-wall, insulated man-size access doors for regular maintenance or inspection. Door frames shall be one piece, welded, 14 gage galvanized steel with integral gutter lips, Access doors shall be fully gasketed around entire perimeter with easily replaceable gaskets.
- D. Insulation: Insulation shall be neoprene coated NFPA-90A approved glass fiber. Seal all insulation seams with formed steel angles such that all edges are rendered smooth to airflow. Insulation for the bottom of the unit shall be glued and pinned to the under side of the unit so the floor of the unit will be a walk-work area.
- E. Fans: Unit fan assemblies shall be of type as indicated on the drawings and schedules. Plug type fans shall be arranged with both fan bearings on the same side of the wheel. No obstruction will be permitted in the fan inlet.

- F. Filter Section: Filter section shall be factory fabricated as part of air handling unit. Filters shall be arranged for face loading into positive sealing manufacturer's filter frames. Frames shall be bolted or welded into filter section by air handling unit manufacturer.
- G. Gas Fire Furnace Section: Provide factory installed outdoor, weatherproof, AGA certified indirect fired furnace for capacity as shown on the schedule. Minimum efficiency shall be 80%. Provide 409 stainless steel heat exchanger and burner. Include 2-stage gas valve, spark ignition; electronic flame supervision, high limit safety control, redundant gas valve and fan switch.
- H. Dampers: Dampers shall be low leak construction. Frames shall be 7.0" wide with double flanges for structural rigidity. Damper blades shall be enclosed in frame. Damper frame shall be minimum 16.0 gauge galvanized steel welded continuously at all corners and shall be coated with 2 coats of polyurethane paint.
- I. Indirect Evaporative Cooling Sections: The indirect evaporative cooling sections shall be factory assembled packages complete with indirect evaporative heat exchangers, wetside fans, water pumps, intake weatherhood, filter section, discharge supply air duct connections, water distribution manifold and nozzles moisture eliminators, float valve, overflow and drain.
- J. Indirect Evaporative Heat Exchanger: The indirect evaporative heat exchanger shall be the air-to-air type, constructed with non-corrosive, non-metallic vertical tubes to eliminate stress and protect from calcium deposits. The header shall be solvent welded to the tubes to insure and airtight and watertight seal. The water shall be evaporated on the inside of the tubes to insure only sensible cooling; the minimum heat exchanger efficiency shall be as scheduled in the Contract Drawings.
- K. Roof Curbs: Manufacturer's standard construction, 14 inch high minimum, insulated and having a corrosive protective coating, complete with factory installed wood nailer and drain nipple. Roof curbs shall be tapered to math roof slope.

2.19 GAS FIRED FURNACE

- A. General Product Requirements:
 1. Built-in thermostats furnished with equipment shall meet requirements of the California Energy Code, Subchapter 2, All Occupancies-Mandatory Requirements for the Manufacture, Construction and Installation of Systems, Equipment and Building Components.
 2. Minimum efficiency of equipment shall meet or exceed requirements of the California Energy Code, Subchapter 2, Mandatory Requirements for Space-Conditioning Equipment and Table 1-C, Efficiency Requirements for space-Conditioning Equipment.
 3. Equipment shall be listed on the California Energy Commission's (CEC) list of approved equipment and shall be certified, by the manufacturer, as complying with the CEC Appliance Efficiency Standards.
 4. Air conditioners shall be designed for and charged with non-ozone-depleting refrigerant.

5. Disconnect switches, where provided, shall be accessible from outside control panel with control circuit transformer wired on disconnected side of the switch.
6. Provide smoke detectors to automatically shutdown the system upon detecting the presence of smoke as required by NFPA 90A.

B. Furnace:

1. Requirements: Provide furnace consisting of indoor unit and remote air-to-air outdoor unit rated in accordance with ANSI A21.47 and ARI 210/240. Design separate units to be used together, and base ratings on the use of the matched assemblies. Provide units complete with air filters, control dampers, base, factory installed internal insulation, controls, wiring, and internal refrigerant piping.
2. Indoor Unit:
 - a. Indoor unit shall be completely assembled to form an integral unit in which all components are properly matched. Unit shall be located indoor as indicated. Unit shall be capable of both continuous 24-hour per day operation, and intermittent operation.
 - b. Indoor unit shall consist of cabinet type centrifugal fan section, gas burner, heat exchanger, direct expansion cooling coil section, and air filter and mixing box with dampers where indicated. Each section shall be constructed of a steel frame with removable steel panels. Section shall be bolted together to make up a single unit. Bolting flanges shall be sealed to prevent leakages. Steel transition pieces or flexible connections shall be provided where shown or required.
 - c. Access panels shall be provided for each section and both faces of the coils.
 - d. Inlet and outlet section of the unit for ducted air delivery shall have flanges or collars for attachment of flexible connections or ducts.
 - e. Blower shall be centrifugal fan suitable for cabinet type design. Fan section shall consist of one or more fan wheels as required. Fan housing shall be constructed of steel members and plates reinforced for maximum rigidity. Shaft bearings shall be supported independently from the fan section panels. Blower shall be statically and dynamically balanced. Belt drives shall be designed for 50 percent overload capacity and shall be provided with adjustable pulleys. Blower-motor assembly shall be resiliently mounted on spring vibration isolators.
 - f. Coil section shall consist of a cooling coil where indicated. Cooling coils shall be direct expansion type constructed of aluminum fins mechanically bonded to seamless copper tubes. Coil section shall be arranged to allow removal of the coils from either side of the housing, unless otherwise indicated. The coil section shall be provided with a waterproofed and insulated galvanized steel drain pan with a drain connection.
 - g. Indoor unit cabinet shall be insulated with one-inch thick 1.5 pounds per cubic foot density glass fiber insulation. Unit cabinet shall be coated with baked enamel finish.

- h. Filter: Provide either integral or remote filters, as indicated. Integral filters shall be 1 inch deep low efficiency filters as specified in this section. The remote filters shall include 2 inches deep low efficiency filters and high efficiency bag filters in side servicing housing as specified in this section.
 - i. Fan motors shall conform to NEMA MG 1. Motor starters shall conform to NEMA ICS 1. Motors shall be totally enclosed fan cooled. Motor starters shall be magnetic across-the-line type. Floor mounted indoor unit starters and controls shall be enclosed in NEMA 4X enclosure. Ceiling suspended indoor unit starters and controls shall be enclosed in NEMA 12 general purpose enclosure. All starter panels shall be furnished with circuit breaker main disconnect switch.
 - j. Heat exchanger shall be of aluminized steel. Burners shall be single-port non-linting, providing even heat distribution.
 - k. Gas controls shall provide for automatic shut-off if flame goes out. Burner ignition shall be via spark-ignition. Continuous burning pilots shall not be allowed.
3. Outdoor Unit:
- a. Unit and components shall be completely factory assembled, pre-wired, tested, and ready to operate. Unit shall be capable of operating at rated capacity at the specified ambient air temperature and conditions. Equipment shall be suitable for outdoor installation at rooftop or ground level locations as shown. Unit shall be capable of both continuous operation and intermittent operation.
 - b. Each unit shall have either one or two completely independent refrigeration circuits as shown. Where two circuits are shown for an individual unit, each circuit shall be suitable for load sharing and/or standby duty.
 - c. Each unit shall be provided with either one or two compressors as required by the specified refrigeration circuits. Compressors shall be reciprocating, serviceable semi-hermetic, or hermetic type with crankcase heater, with entire running gear assembly internally suspended, and externally mounted on resilient rubber mounts. Suction and discharge valves shall have hardened seats. Unit shall have multiple step capacity control, spring-loaded relief valve, and removable heads with unloader timers. Compressor motor shall be provided with heat sensing elements embedded in the motor winding.
 - d. Condenser coils shall be air-cooled type with minimum 3/8-inch outside diameter seamless copper tubing. Coil shall have aluminum plate fins mechanically bonded to copper tubes.
 - e. Condenser fans shall be statically and dynamically balanced propeller type, direct driven and discharging upward.
 - f. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with baked enamel. Cabinet panels shall be removable for service access to all operating components.

- g. Integral refrigerant piping shall be hard-drawn type ACR copper tubing with wrought-copper fittings and brazed joints.
 - h. Compressor motor shall be rated for electric power characteristics as indicated. Motor shall conform to NEMA MG 1. Starters shall conform to NEMA ICS1. Motor shall be constant speed, low-starting current and high-torque squirrel-cage induction type, and shall have a magnetic across-the-line motor starter.
 - i. Provide each outdoor unit with unit mounted disconnect switch.
4. Unit Controls:
- a. Unit controls shall be housed in a NEMA 4Z, for outdoor units and floor mounted indoor units, and NEMA 12 for other indoor units integral with the unit cabinet. The following control devices shall be provided:
 - 1) Compressor motor magnetic starters.
 - 2) Condenser fan motor magnetic starters.
 - 3) Control power transformers.
 - 4) Occupied/ Unoccupied program relay.
 - 5) Override timer.
 - b. Protective devices shall be designed to control operation under the following conditions:
 - 1) Motor overload.
 - 2) Under-voltage.
 - 3) Locked rotor.
 - 4) Excessive winding temperature.
 - 5) High and low operating pressures.
 - 6) Loss of refrigeration.
 - 7) Compressor rapid cycling.
 - c. Where two compressors per unit are required, switch for alternating lead compressor timer shall be provided.

2.20 COOLING TOWERS

- A. Fabricated package cooling towers using manufacturer's standard design, materials, and construction in accordance with published product information, except as otherwise indicated in the Contract Documents.
- B. Structural Design Requirements: Design structural system for the following live loading in addition to tower dead-loads and operating-loads:
 - 1. Wind Loading: 100 MPH on exposed vertical surfaces.
 - 2. Earthquake Resistance: Per CBC Seismic Zone 4 requirements.
- C. Other Design Requirements: The cooling towers total drift shall not exceed 0.02 percent of the maximum water flow.
- D. Steel panel and structural elements shall be constructed from heavy gauge type 304 stainless steel.
- E. Casings: Provide fiberglass-reinforced polyester (FRP) panels fabricated and installed by manufacturer to make tower watertight, and ensure access to all components that require cleaning by providing large hinged doors on both sides of the tower. Provide interior doors between cells and galvanized steel internal walkways.
- F. Collecting Basin and Sump: Provide stainless steel integral type collecting basin and sump with lift-out strainer with openings smaller than nozzle orifices, and with connections for drain, overflow, and water make-up. Design and install to support water and to ensure water tightness. All cells to have connections for independent cell operation. Provide flume box with gate in each cell. Provide walkway, ladder, and working platform in each cooling tower basin and door for each cell. Provide door between cells.
- G. Wetted-Surface Fill: Provide vertical sheets of polyvinyl chloride plastic having flame spread rating of no greater than 5 per ASTM E 84. Fabricate into wave-formed configurations installed by manufacturer to ensure break-up of water into droplets.
- H. Drift Eliminators: Provide polyvinyl chloride plastic, having flame spread rating of 5 per ASTM E 84. Fabricate by manufacturer into three-pass configuration to limit drift-loss to indicated maximum percentage of circulating-water flow-rate.
- I. Louvers: Provide FRP louvers designed and installed by manufacturer, and of sufficient thickness and rigidity to prevent visible sagging:
- J. Provide a single water inlet connection with a chamber that automatically balances the flow to the hot water basins or provide two inlets with butterfly valves for balancing flow to each distribution basin and for shut off during servicing.
- K. Water Distribution System: The following materials designed and installed by manufacturer to ensure even distribution of water over wetted- surface-fill.
 - 1. Schedule 40 PVC pipe header and removable schedule 40 PVC pipe branches with balancing chamber, access door, and removable strainer.

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2. Nozzles: Provide removable plastic, brass, or ceramic nozzles. Pressure Drop: Maximum pressure drop of 1 PSI.
 3. Provide flow control valves for balancing flow to each distribution basin and for shut-off during servicing, or provide accessible balancing chamber with strainer and internal risers for gravity water distribution.
- L. Basin Covers: Provide high density polyethylene covers, removable and with handles, installed by manufacturer to prevent debris from entering basin and to inhibit algae growth by eliminating sunlight.
- M. Handrails: Provide galvanized steel pipe rails of required height above or inside tower. Include knee and toe rails of required diameter and heights if required by code. (Required only with top inlet towers where access is required at top of unit.)
- N. Ladders: Provide galvanized steel or aluminum ladder, to top of cooling tower internally or externally as required to access all working surfaces on two sides including working platform.
1. Safety Cage: Include safety cage of galvanized steel or aluminum. (Only required where access to top of tower is required.)
- O. Water Level Control: Provide plastic mechanical float ball with adjustable linkage.
- P. Fans and Drives: Provide cast-aluminum propeller fan of adjustable-pitch (factory adjusted) type with gear-drive (or power band NJ-drive) including speed reducer, designed for single-speed operation installed by manufacturer. Provide low oil level alarm and wiring (only with gear drive) for each cell.
- Q. Fan Bearings: Provide tapered roller or ball bearings installed by manufacturer.
- R. Vibration Cutout Switch: Provide switch (for each cell), wired by contractor to de-energize fan motors if excessive vibration occurs due to fan imbalance.
- S. Assemble components by one of the following methods:
1. Use stainless fasteners and accessories to assemble components, except for cold water basin. Hot and cold water basin shall be welded stainless steel.
 2. Weld metal seams and joints.
- T. Finishes:
1. Apply phosphatized pretreatment on zinc coated surfaces which have not been mill-phosphatized or polymer-coated. Apply gasoline-soluble rust preventative compound on ferrous parts which cannot be galvanized, including shafts and machined parts.
 2. Finish components with zinc-coated metal surfaces by one of the following methods:
 - a. Coat abraded areas and welded areas with galvanizing repair paint. Finish-paint exposed surfaces with zinc chromated paint.

- b. Provide 2-1/4 oz. (per sq. ft. of sheet) zinc coating on basin and sump, after fabrication, by hot-dip galvanizing process. Coat abraded areas and welded areas of work with galvanizing repair paint.
 - c. Apply to metal surfaces which are not galvanized, a zinc-rich paint equivalent to hot-dipped galvanized steel.
- U. Provide removable standpipe overflow for flush-out basin cleaning.
 - V. The cooling towers fill materials thickness shall not be less than 13 mils.
 - W. The support structure, fan deck, and fan cylinder shall be protected with the corrosion protection system, applied by the cooling tower manufacturer at the manufacturing plant.

2.21 AIR FILTERS

- A. Filter Type: Type and capacity of filters and type of filter holding system shall be as indicated.
- B. Low Efficiency Filters: Replaceable, throwaway, panel filters, 2 inches deep, 24 inches by 24 inches face or as required, fiberglass, heavy duty, with laminated backing and sprayed with non-flammable adhesive, UL Class II, framed in throwaway fiberglass casing, and sandwiched between perforated metal grilles. Provide filters with rated maximum face velocity of 500 fpm, initial resistance of not greater than 0.30 inch water gage (w.g.), final rated resistance of 0.50 inch w.g., and average arrestance of 80 percent.
- C. High Efficiency Bag Filters: Replaceable, throwaway, fiberglass media, with 10 pleats, bags, 22 inches deep, thread stitched, 24 inches by 24 inches face or as required, with corrosion resistant frame, and minimum of 70 square feet of filter media. Provide filters with rated maximum face velocity of 500 fpm, initial resistance of 0.40 inch w.g. with 80 percent to 85 percent ASHRAE 52.1 dustspot efficiency, and final rated resistance of 1.0 inch w.g.
- D. Front and Rear Access Filter Frames: Provide filter bank framing system, constructed of aluminum framing members having minimum thickness of 0.09 inch. Provide for either upstream (front) or downstream (rear) filter servicing. Cut to size and pre-punch members for each assembly into modules of size and capacity as indicated. Provide permanently gasketed framing members to prevent bypass of unfiltered air. If vertical support members are required to prevent deflection of horizontal members, install so as not to interfere with either installation or operation of filters. Incorporate separate track for pre-filters, removable from front, or removable from back after removal of after-filters. Provide factory-installed positive sealing device for each row of filters, to insure seal between gasketed filter elements. Provide hardware necessary for field assembly.
- E. Side Servicing Housings: Provide factory-assembled side servicing housings with flanges for insertion into ductwork system as indicated: housing shall be constructed of 16 gage galvanized steel. Provide integral pre-filter tracks to accommodate 2 inches pre-filters. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass. Arrange so filter cartridge can be loaded from either access door.
- F. Spare Media and Filters:

1. In the original installation of filters and filtering equipment, two replacements of filters as herein specified shall be provide for each filter.
2. Mark each media carton with a code number applying to the series of tests that have been carried out by the manufacturer in accordance with ASHRAE and ARI requirements; AFI Performance Test, Test for Uniformity of Resistance, Media Compressibility and Strength Test, Weight Test for Quantity of Adhesive, and Weight Test for Quantity of Fiber.
3. Any filter media installed in air handling systems used to provide temporary service shall not be considered a part of the final installation at Substantial Completion.

2.22 BOILER STACK

- A. Boiler stack and fittings shall be factory fabricated fuel chimney, double wall, air insulated, all metal construction and shall include straight section stack, elbows if required, roof support, flashing, storm collar, and vent cap.
- B. Inner Pipe: Fabricated of Type 304 stainless steel with nominal 1 inch air space between walls.
- C. Outer Jacket: Aluminum coated steel.
- D. Joints: Stack and vents shall have snap-lock joints or compression band joints that provide tight sealing and rigid joints.
- E. Mechanical Boiler Stack Vent System
 1. Provide boiler stack vent system for multiple boiler arrangements where indicated. Otherwise, stacks shall not be manifolded to one single stack.
 2. Mechanical boiler stack vent system shall consist of two variable speed flue exhaust fans on a factory fabricated steel plenum mounted on the roof at the top of the boiler stack system. System shall be controlled maintaining a pre-set negative draft pressure.
 3. Fans:
 - a. Provide tow fans with a total capacity equal to or greater than the maximum flue gas capacity and at the required pressure to ensure a negative pressure in the entire boiler stack system.
 - b. Chimney fans shall handle a flue gas temperature up to 640 degrees F measured at the flue exit point.
 - c. Fans shall be ETL listed to UL 378 for installation at the boiler stack termination point.
 - d. Fans shall provide full modulation from minimum load to maximum load.
 - e. The entire mechanical boiler stack vent system shall be manufactured at an ISO 9001 certified and audited plant.

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- f. Fans shall be manufactured in cast aluminum, type SAE331, with a minimum thickness of 3/16 inch.
 - g. Housings shall be corrosion resistant and protected by factory applied paint finish.
 - h. The impellers shall be made of cast aluminum and be completely balanced.
 - i. The discharge area design shall insure minimum soot buildup and provide easy access for cleaning and servicing.
4. Motors:
- a. Use maintenance free split capacitor motors, completely enclosed, with pro-lubricated and sealed ball bearings requiring no further maintenance.
 - b. Motors shall be variable speed, Class H.
5. Exhaust Fan Plenum: A factory fabricated 12 gage galvanized steel plenum of welded construction shall be provided for the system installation. Welded seams shall be coated with a zinc primer.
6. Constant Pressure Regulator: A constant pressure regulator shall be furnished for automatic modulation of boiler stack fan speed. Controls shall maintain a pre-set negative draft pressure. Control box shall have dial settings between zero and 1.0 inch water column with indicator lights. Control shall include a sensor and boiler stack probe.
7. Fan Proving Switch:
- a. A fan proving switch shall be provided with sensing probe and tubing. Switch shall have an adjustable set point between 0.07 inch and 0.15 inch water column. Switch shall be rated at 1 x 120 V, 15 A.
 - b. If fan proving switch indicates boiler stack exhaust fans are inoperative, hot water boilers shall be shut down.
8. Warranty:
- a. Mechanical boiler stack vent system shall be provided with a two-year warranty against corrosion perforation.
 - b. The system shall be designed by the manufacturer in accordance with the terms of the manufacturer's warranty.
9. Structural Support: Mechanical boiler stack vent assembly shall be seismically braced at the roof, using steel guy wires.
10. Expansion Joints: Provide an expansion joint section on the boiler stack immediately below the mechanical boiler stack vent system.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Install unitary air-conditioning equipment, heat pumps, heating and ventilating units, Boilers, pumps, unit heaters, coils and electric heating equipment as indicated, plumb and level, firmly anchored, in accordance with the respective manufacturer's installation instructions.
- B. Install accessories, appurtenances, piping and controls, including supports, vibration isolators, stands, guides, anchors, clamps, and brackets as indicated.
- C. Anchor bolt heads shall have welded-on plates, and shall be embedded in the concrete. Equipment bases shall be leveled and grouted-in with non-shrink grout. Anchor plates shall be hot-dip galvanized as specified in Section 05 50 00 - Metal Fabrications.
- D. Locate equipment as indicated, having manufacturers' recommended working space available for servicing. Provide electric isolation between dissimilar metals.
- E. Install pumps according to manufacturer's written installation and alignment instructions.
- F. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.
- G. Support pumps and piping separately so that piping is not supported by pumps.
- H. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.
- I. Support pump base plate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4-inch to 1-1/2 inches between pump base and foundation for grouting. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- J. Install furnace and air-conditioning units as indicated, plumb and level, firmly anchored, in accordance with the respective manufacturer's installation instructions. Install accessories, appurtenances, piping and controls, including supports, vibration isolators, stands, guides, anchors, clamps, and brackets as indicated.
- K. Anchor bolt heads shall have welded-on plates, and shall be embedded in the concrete. Equipment bases shall be leveled and grouted-in with non-shrink grout. Anchor plated shall be hot-dip galvanized as specified in Contract Specifications Section 05 50 00 - Metal Fabrications.
- L. Locate equipment as indicated, having manufacturer's recommended working space available for servicing. Provide electric isolation between dissimilar metals.
- M. Boiler Stack and Gas Vent Installation: Comply with manufacturer's recommendations, Uniform Mechanical Code, and local code requirements. Fasten and support the stack and vent system securely to building structure. Maintain required clearance from combustible materials. Keep offsets and lengths of horizontal pipe to minimum unless indicated otherwise.

- N. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring-diagram submittal to electrical installer. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer. Install control, alarm, and other required wiring.
- O. Refrigeration Piping: Refer to Section 23 23 00 - Refrigerant Piping, for applicable requirements. Connect refrigeration piping to split type units, as indicated.
- P. Drain Piping: Connect unit drain to nearest indirect waste connection. Provide trap at drain pan; construct trap at least 1 inch deeper than fan pressure in inches of water.
- Q. Ductwork: Refer to Section 23 31 00 - HVAC Ducts and Casings, for applicable requirements. Connect supply and return ducts to unit with flexible duct connections where duct connections are indicated. Provide transitions to exactly match unit duct connection size.
- R. Heating and Ventilating Unit Installation
1. Section 01 45 00 – Quality Control: Manufacturer's instructions.
 2. Install in accordance with ARI 430.
 3. Bolt sections together with gaskets. Isolate fan section with flexible duct connections.
 4. Install flexible connections between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch (25 mm) flex between ductwork and fan while running.
 5. Install assembled unit on vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
 6. Provide sheaves required for final air balance.
 7. Make connections to coils with unions or flanges.
- S. Hot Water Boiler Installation
1. Install in accordance with manufacturer's instructions.
 2. Install in accordance with NFPA 54.
 3. Install boiler on existing concrete housekeeping base.
 4. Provide connection of natural gas service in accordance with NFPA 54.
 5. Provide piping connections and accessories as indicated on Reference Drawings to duplicate and integrate with existing system.
 6. Pipe relief valves to nearest floor drain.

7. Connect to electrical service.
8. Mount thermometer in boiler breeching within 12 inches (300 mm) of flue nozzle.
9. Reconnect boiler to existing expansion tank and complete related existing accessories.
10. Install new recirculation pumps and piping. Piping shall replicate existing accessories.

T. Recirculating Pump Installation:

1. Install in accordance with manufacturer's instructions.
2. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
3. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches (102 mm) and over.
4. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
5. Provide air cock and drain connection on horizontal pump casings.
6. Provide drains for bases and seals, piped to and discharging into floor drains.
7. Check, align and certify alignment of base mounted pumps prior to start-up.
8. Install base mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to Section 03 61 11 - Non-Shrink Grout.
 - a. Lubricate pumps before start-up.

U Air Coils: Install air coils in accordance with manufacturers written instructions.

1. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - a. Support coil sections independent of piping on steel channel or double angle frames and secure to casings.
 - b. Provide frames for maximum three coil sections.
 - c. Arrange supports to avoid piercing drain pans.
 - d. Provide airtight seal between coil and duct or casing.
2. Protect coils to prevent damage to fins and flanges. Comb out bent fins.
3. Install coils level. Install cleanable tube coils with 1:50 pitch.

4. Make connection to coils with unions and flanges.

3.02 COOLING TOWER INSPECTION

- A. Examine areas and conditions under which packaged cooling towers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.03 COOLING TOWER INSTALLATION

- A. General: Install cooling towers where indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices, to ensure that cooling towers comply with requirements and serve intended purposes.
- B. Access: Provide access and service space around and over cooling towers as indicated, but in no case less than that recommended by manufacturer.
- C. Placement: Mount unit on structural steel. Install gaskets or sealants between cooling tower cells. Level units to tolerance of 1/8 inch in 10 feet -0 inch, in both directions. Multiple cells shall be at equal elevations. Provide and install bolts per manufacturer's recommendations.
- D. Cooling towers pipe connections: Coordinate the pipe connections at the bottom of the unit with the steel supports: ""Provide adequate clearance and space for all of the piping. The contractor shall modify the pipe connections or supports if required without and additional cost to the university. The contractor shall provide shop drawing for piping and supporting structure before ordering the cooling towers and building the support structure.
- E. Condenser Water Piping: Provide flanged connections to cooling tower. Pitch lines so water will drain into sump. Connect inlets to cooling tower with shutoff valve, and balancing valve (if 2 or more inlets). Connect outlets with shutoff valves.
- F. Make-up and Water Piping: Provide flanged connections to cooling tower. Pitch lines so water will drain into sump.
- G. Drain Piping: Connect drain, overflow, and bleed lines to cooling tower as indicated, full size of connection on cooling tower.

3.04 PAINTING

- A. Unless otherwise indicated, paint outdoor equipment in accordance with Section 09 91 00 - Painting. Indoor equipment shall be touched up with factory-supplied paint applied in accordance with the manufacturer's instructions.

3.05 COOLING TOWER CLEANING, ADJUSTING AND TESTING

- A. Cleaning: Clean inside of cooling tower thoroughly before filling for start-up. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- B. Start-up: Comply with manufacturer's instructions for filling and start-up of operation, but not less than the following:

1. Verify lubrication of rotating parts; lubricate as needed.
 2. Verify fan rotation direction.
 3. Verify that motor amperage is in accordance with manufacturer's data.
 4. Balance condenser water flow to each tower and to each inlet for multiple inlet towers.
 5. Adjust water level control for proper operating level.
 6. Adjust bleed valve for indicated percentage of circulated water volume.
 7. Adjust temperature controls and verify operation.
- C. Operation Test: Test each cooling tower to show that it will operate in accordance with indicated requirements. Perform field test in accordance with CTI ATC-105. This test not required if towers are already CTI certified.

3.06 START-UP SERVICE

- A. Provide the services of a factory-authorized service representative to inspect the installation and connections and to provide initial start-up service. Services shall include a complete operational check and demonstration of the system to ensure proper operation.
- B. Provide instructions to the District's maintenance personnel on proper operation and maintenance procedures in accordance with the requirements of Section 01 79 00 - Demonstration and Training.
- C. Hot Water Boiler Manufacturer's Field Services
1. Prepare and start systems.
 2. Provide field representative for starting unit and training operator.

3.07 FIELD QUALITY CONTROL

- A. Perform start-up tests in conformance with Section 23 05 93 - Testing, Adjusting and Balancing for HVAC, of all heating and air-conditioning equipment. Perform tests in accordance with respective manufacturer's instructions and referenced codes and standards.
- B. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment. Retest replaced controls and equipment.

END OF SECTION 23 81 00