SECTION 236500 - COOLING TOWERS

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Closed-circuit, forced-draft, counterflow cooling towers.
2. Closed-circuit, induced-draft, combined-flow cooling towers.
3. Closed-circuit, induced-draft, counterflow cooling towers.
4. Open-circuit, forced-draft, counterflow cooling towers.
5. Open-circuit, induced-draft, counterflow cooling towers.
6. Open-circuit, induced-draft, crossflow cooling towers.

1.3 DEFINITIONS

A. BMS: Building management system.

B. FRP: Fiber-reinforced polyester.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design cooling tower support structure[**and seismic restraints**] [**and wind restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to [**SEI/ASCE 7**] <**Insert requirement**>.

1. Dead Loads: <**Insert loads**>.

2. Live Loads: <**Insert loads**>.
3. Roof Loads: <**Insert loads**>.
4. Snow Loads: <**Insert loads**>.
5. Seismic Loads: <**Insert loads**>.
6. Wind Loads: <**Insert loads**>.
7. <**Insert loads or load combinations**>.
8. Deflection Limits: Design system to withstand design loads without deflections greater than the following:

    a. <**Insert deflection limits**>.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to [**SEI/ASCE 7**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, furnished specialties, and accessories.

1. Maximum flow rate.
2. Minimum flow rate.
3. Drift loss as percent of design flow rate.
4. Volume of water in suspension for purposes of sizing a remote storage tank.
5. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
6. Performance curves for the following:

    a. Varying entering-water temperatures from design to minimum.
    b. Varying ambient wet-bulb temperatures from design to minimum.
    c. Varying water flow rates from design to minimum.
    d. Varying fan operation (off, minimum, and design speed).

7. Fan airflow, brake horsepower, and drive losses.
8. Pump flow rate, head, brake horsepower, and efficiency.
9. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
10. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Sizes and locations of piping and wiring connections.

5. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] [**and wind restraints**] and for designing vibration isolation bases.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Startup service reports.

G. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: [**Certified by CTI**] [**An NRTL**].

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

F. FMG approval and listing in the latest edition of FMG's "Approval Guide."

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:

1. Fan assembly including fan, drive, and motor.
2. All components of cooling tower.
3. <**Insert components requiring extended warranty**>.
4. Warranty Period: [**Five**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CLOSED-CIRCUIT, FORCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of [**30 lbf/sq. ft. (1.44 kPa)**] <**Insert value**>.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Frame Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin: Configure tower for installation with a field-constructed collection basin.

F. Collection Basin:

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Strainer: Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Basin Sweeper Distribution Piping and Nozzles:

    a. Pipe Material: [**PVC**] <**Insert material**>.
    b. Nozzle Material: [**Plastic**] <**Insert material**>.
    c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

G. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

H. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**], controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

I. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

J. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

K. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

L. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

M. Water Distribution Piping: Main header and lateral branch piping designed for even distribution over fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [**Fiberglass**] [**PVC**] [**Galvanized steel**] <**Insert material**>.
2. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] [**PVC**] <**Insert material**>.
3. Piping Supports: Corrosion-resistant hangers and supports designed to resist movement during operation and shipment.

N. Recirculating Piping: [**PVC**] <**Insert pipe material**>[**, with connections for separately provided, remote spray pump**].

O. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.

1. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed nonventilated (TENV)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.0**] [**1.15**] <**Insert value**>.

P. Heat-Exchanger Coils:

1. Tube and Tube Sheet Materials: [**Copper tube with stainless-steel sheet**] [**Stainless-steel tube and sheet**] [**Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication**].

2. Heat-Exchanger Arrangement: [**Serpentine tubes**] [**Serpentine tubes with removable cover plate on inlet and outlet headers**] [**Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube**]; and sloped for complete drainage of fluid by gravity.
3. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
4. Field Piping Connections: Vent, supply, and return[**suitable for mating to ASME B16.5, Class 150 flange**].

Q. [**Removable**]Drift Eliminator:

1. Material: [**FRP**] [**PVC**] [**FRP or PVC**] <**Insert material**>; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

R. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

S. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.

1. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
2. Fan Wheel and Housing Materials: Galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

T. Belt Drive:

1. Belt-Drive Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load, and the other sized for [**67**] <**Insert value**> percent of full-load speed.

b. Belt Drives: Each motor shall have belt drive complying with requirements for belt drives and configured for operation when other motor fails.
c. Motor controller and wiring same as two-speed, two-winding motor.

U. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.15**] <**Insert value**>.
5. Insulation: [**Class F**] [**Class H**] <**Insert class**>.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:

   a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
   b. Double-shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)
   c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

V. Discharge Hoods:

1. Hood Configuration: [**Tapered**] [**Straight**]; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed [**insulation and**]access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.

   a. Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.

W. Capacity-Control Dampers: [**Galvanized-steel**] [**Stainless-steel**] <**Insert material**> dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

X. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable acceleration sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.

4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

Y. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

Z. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan[**and spray pump**] based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin, electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.
10. Power and controls to open discharge hood dampers when pump is energized and close dampers when pump is de-energized.
11. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

12. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
13. Visual indication of status and alarm[**with momentary test push button**] for each motor.
14. Audible alarm and silence switch.
15. Visual indication of elapsed run time, graduated in hours for each motor.
16. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Cooling tower leaving-fluid temperature.

d. Fan vibration alarm.
e. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.
f. <**Insert conditions to be monitored**>.

AA. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from [**both**]cooling tower end walls.[**Doors shall be operable from both sides of the door.**]
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard at platforms and around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

    a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.

BB. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Maximum Drift Loss: [**0.005**] <**Insert number**> percent of design water flow.
3. Heat-Exchanger Coil:

    a. Fluid Type: [**Water**] <**Insert type**>.
    b. Fluid Flow/Cell: <**Insert gpm (L/s)**>.
    c. Minimum Fluid Flow/Cell: <**Insert gpm (L/s)**>.
    d. Fluid Pressure Drop: <**Insert psig (kPa)**>.
    e. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    f. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
    g. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

4. Economizer Mode:

    a. Fluid Flow/Cell: <**Insert gpm (L/s)**>.
    b. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    c. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
    d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

5. Fan Location: [**Bottom**] [**Side**].
6. Fan Motor:

    a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
    b. Horsepower/Cell: <**Insert horsepower**>.
    c. Full-Load Ampacity: <**Insert value**>.
    d. Minimum Circuit Ampacity: <**Insert value**>.

e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
f. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.

7. Spray Pump and Motor:

a. Water Flow/Cell: <**Insert gpm (L/s)**>.
b. Horsepower/Cell: <**Insert horsepower**>.
c. Full-Load Ampacity: <**Insert value**>.
d. Minimum Circuit Ampacity: <**Insert value**>.
e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
f. Electrical Characteristics: [**120**] [**208**] [**240**] [**277**] [**480**] <**Insert value**>-V ac, [**single**] [**3**] phase, 60 Hz.

8. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
9. Basin Heater:

a. Basin Water Temperature: [**40 deg F (5 deg C)**] <**Insert deg F (deg C)**>.
b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**] <**Insert deg F (deg C)**>.
c. Capacity/Cell: <**Insert kilowatts**>.
d. Full-Load Ampacity: <**Insert value**>.
e. Minimum Circuit Ampacity: <**Insert value**>.
f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
g. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.
h. Capacity/Cell: <**Insert MBtu/h (kW)**>.
i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
k. Fluid Pressure Drop: <**Insert psig (kPa)**>.
l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
m. Steam Flow: <**Insert lb/h (L/s)**>.
n. Steam Pressure: <**Insert psig (kPa)**>.

2.2 CLOSED-CIRCUIT, INDUCED-DRAFT, COMBINED-FLOW COOLING TOWERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of [**30 lbf/sq. ft. (1.44 kPa)**] <**Insert value**>.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Frame Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.

4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin: Configure tower for installation with a field-constructed collection basin.

F. Collection Basin:

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Strainer: Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Basin Sweeper Distribution Piping and Nozzles:

    a. Pipe Material: [**PVC**] <**Insert material**>.
    b. Nozzle Material: [**Plastic**] <**Insert material**>.
    c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

G. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

H. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**], controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

I. Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal[**for connection to BMS**].
3. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
4. Solenoid Valve: Slow closing[**with stainless-steel body**], controlled and powered through level controller in response to water-level set point.
5. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

J. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

K. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

L. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

M. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

N. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Location: Over each bank of fill with easily replaceable [**plastic**] <**Insert material**> spray nozzles mounted in bottom of basin.
3. Joints and Seams: Sealed watertight.
4. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
5. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable [**corrosion-resistant**] [**stainless-steel**] hardware.
6. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity water distribution basin.

O. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [**PVC**] [**Galvanized steel**] <**Insert material**>.
2. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] <**Insert material**>.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

P. Recirculating Piping: [**PVC**] <**Insert pipe material**>[**, with connections for separately provided, remote spray pump**].

Q. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.

1. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed nonventilated (TENV)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.0**] [**1.15**] <**Insert value**>.

R. Fill:

1. Materials: [**PVC**] <**Insert material**>, with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. Minimum Thickness: [**15 mils (0.4 mm)**] [**20 mils (0.5 mm)**] <**Insert value**>, before forming.
3. Fabrication: Fill-type sheets fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F (49 deg C)**] <**Insert temperature**>.

S. Heat-Exchanger Coils:

1. Tube and Tube Sheet Materials: [**Copper tube with stainless-steel sheet**] [**Stainless-steel tube and sheet**] [**Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication**].
2. Heat-Exchanger Arrangement: [**Serpentine tubes**] [**Serpentine tubes with removable cover plate on inlet and outlet headers**] [**Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube**]; and sloped for complete drainage of fluid by gravity.
3. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
4. Field Piping Connections: Vent, supply, and return[**suitable for mating to ASME B16.5, Class 150 flange**].

T. Drift Eliminator:

1. Material: [**FRP**] [**PVC**] [**FRP or PVC**] <**Insert material**>; with maximum flame-spread index of [**5**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
4. Fill Drift Eliminators: [**Integral to**] [**Separate and removable from**] fill.
5. Heat-Exchanger Coil Drift Eliminators: Located on discharge side and removable.

U. Air-Intake Louvers:

1. Material: [**FRP**] [**PVC**] [**Matching casing**].

2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
4. Location: [**Integral to**] [**Separate from**] fill.

V. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

W. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**Aluminum**] [**FRP**].
2. Hub Material: [**Aluminum**] [**FRP**].
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

X. Belt Drive:

1. Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for [**67**] <**Insert value**> percent of full-load speed.
    b. Each motor with belt drive and configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

Y. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: [**2.0**] <**Insert value**> based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.

5. Drive-to-Motor Connection: [**Close coupled to motor using a flexible coupling**] [**Connected to motor located outside of cooling tower casing by a full-floating drive shaft**].
6. Drive Shaft Material: [**Corrosion resistant**] [**Stainless steel**], and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
7. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

Z. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.15**] <**Insert value**>.
5. Insulation: [**Class F**] [**Class H**] <**Insert class**>.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
8. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)
    c. Internal heater automatically energized when motor is de-energized.

9. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

AA. Fan Discharge Stack: Material shall match casing, [**manufacturer's standard**] [**velocity recovery**] design.

1. Stack Extension: Fabricated to extend above fan deck <**Insert distance**> unless otherwise indicated.
2. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

BB. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.

4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

CC. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to a BMS**].

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm[**through the BMS**].

DD. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

EE. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan[**and spray pump**] based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin level controller complying with requirements in [**"Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve"**] [**"Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve"**] Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
10. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

11. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm[**with momentary test push button**] for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

a. Operational status of each motor.
b. Position of dampers.
c. Cooling tower leaving-fluid temperature.
d. Fan vibration alarm.
e. Oil-level alarm.
f. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.
g. <**Insert conditions to be monitored**>.

FF. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

GG. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Air-Inlet Arrangement: [**Single side**] [**Two sides**] [**Sides and top**].
3. Maximum Drift Loss: [**0.005**] <**Insert number**> percent of design water flow.
4. Heat-Exchanger Coil:

a. Fluid Type: [**Water**] <**Insert type**>.
b. Fluid Flow/Cell: <**Insert gpm (L/s)**>.
c. Minimum Fluid Flow/Cell: <**Insert gpm (L/s)**>.
d. Fluid Pressure Drop: <**Insert psig (kPa)**>.
e. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
f. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
g. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

5. Economizer Mode:

a. Fluid Flow/Cell: <**Insert gpm (L/s)**>.
b. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
c. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

6. Fan Drive: Belt or gear.

7. Fan Motor:

   a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
   b. Horsepower/Cell: <**Insert horsepower**>.
   c. Full-Load Ampacity: <**Insert value**>.
   d. Minimum Circuit Ampacity: <**Insert value**>.
   e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
   f. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.

8. Spray Pump and Motor:

   a. Water Flow/Cell: <**Insert gpm (L/s)**>.
   b. Horsepower/Cell: <**Insert horsepower**>.
   c. Full-Load Ampacity: <**Insert value**>.
   d. Minimum Circuit Ampacity: <**Insert value**>.
   e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
   f. Electrical Characteristics: [**120**] [**208**] [**240**] [**277**] [**480**] <**Insert value**>-V ac, [**single**] [**3**] phase, 60 Hz.

9. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
10. Basin Heater:

    a. Basin Water Temperature: [**40 deg F (5 deg C)**] <**Insert deg F (deg C)**>.
    b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**] <**Insert deg F (deg C)**>.
    c. Capacity/Cell: <**Insert kilowatts**>.
    d. Full-Load Ampacity: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    g. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.
    h. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
    k. Fluid Pressure Drop: <**Insert psig (kPa)**>.
    l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    m. Steam Flow: <**Insert lb/h (L/s)**>.
    n. Steam Pressure: <**Insert psig (kPa)**>.

2.3 CLOSED-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of [**30 lbf/sq. ft. (1.44 kPa)**] <**Insert value**>.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Stainless steel**].
2. Frame Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin: Configure tower for installation with a field-constructed collection basin.

F. Collection Basin:

1. Material: [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Stainless steel**].
2. Overflow and drain connections.
3. Makeup water connection.

G. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

H. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**]; controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

I. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.

8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

J. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

K. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

L. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

M. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [**Fiberglass**] [**PVC**] [**Galvanized steel**] <**Insert material**>.
2. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] [**PVC**] <**Insert material**>.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

N. Recirculating Piping: [**PVC**] <**Insert pipe material**>[**, with connections for separately provided, remote spray pump**].

O. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.

P. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.

1. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed nonventilated (TENV)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
2. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
3. Service Factor: [**1.0**] [**1.15**] <**Insert value**>.

Q. Heat-Exchanger Coils:

1. Tube and Tube Sheet Materials: [**Copper tube with stainless-steel sheet**] [**Stainless-steel tube and sheet**] [**Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication**].
2. Heat-Exchanger Arrangement: [**Serpentine tubes**] [**Serpentine tubes with removable cover plate on inlet and outlet headers**] [**Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube**]; and sloped for complete drainage of fluid by gravity.
3. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
4. Field Piping Connections: Vent, supply, and return[**suitable for mating to ASME B16.5, Class 150 flange**].

R. [**Removable**]Drift Eliminator:

1. Material: [**FRP**] [**PVC**] [**FRP or PVC**] <**Insert material**>; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

S. Air-Intake Louvers:

1. Material: [**FRP**] [**PVC**] [**Matching casing**].
2. UV Treatment: Treat louvers with inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out during all modes of operation including operation with fans off.

T. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**Aluminum**] [**FRP**] [**Galvanized steel**].
2. Hub Material: [**Aluminum**] [**FRP**] [**Galvanized steel**].
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

U. Belt Drive:

1. Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for [**67**] <**Insert value**> percent of full-load speed.
    b. Each motor with belt drive and configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

V. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.

2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.15**] <**Insert value**>.
5. Insulation: [**Class F**] [**Class H**] <**Insert class**>.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F ((minus 29 and plus 149 deg C).)
    c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

W. Fan Discharge Stack: Material shall match casing, [**manufacturer's standard**] [**velocity recovery**] design.

1. Stack Extension: Fabricated to extend above fan deck <**Insert distance**> unless otherwise indicated.
2. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

X. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

Y. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

Z. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

4. Microprocessor-based controller for automatic control of fan[**and spray pump**] based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

10. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
11. Visual indication of status and alarm[**with momentary test push button**] for each motor.
12. Audible alarm and silence switch.
13. Visual indication of elapsed run time, graduated in hours for each motor.
14. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Cooling tower leaving-fluid temperature.
    c. Fan vibration alarm.
    d. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.
    e. <**Insert conditions to be monitored**>.

AA. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

BB. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Maximum Drift Loss: [**0.005**] <**Insert number**> percent of design water flow.
3. Heat-Exchanger Coil:

a. Fluid Type: [**Water**] <**Insert type**>.
b. Fluid Flow/Cell: <**Insert gpm (L/s)**>.
c. Minimum Fluid Flow/Cell: <**Insert gpm (L/s)**>.
d. Fluid Pressure Drop: <**Insert psig (kPa)**>.
e. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
f. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
g. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

4. Economizer Mode:

a. Fluid Flow/Cell: <**Insert gpm (L/s)**>.
b. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
c. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

5. Fan Motor:

a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
b. Horsepower/Cell: <**Insert horsepower**>.
c. Full-Load Ampacity: <**Insert value**>.
d. Minimum Circuit Ampacity: <**Insert value**>.
e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
f. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.

6. Spray Pump and Motor:

a. Water Flow/Cell: <**Insert gpm (L/s)**>.
b. Horsepower/Cell: <**Insert horsepower**> .
c. Full-Load Ampacity: <**Insert value**>.
d. Minimum Circuit Ampacity: <**Insert value**>.
e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
f. Electrical Characteristics: [**120**] [**208**] [**240**] [**277**] [**480**] <**Insert value**>-V ac, [**single**] [**3**] phase, 60 Hz.

7. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
8. Basin Heater:

a. Basin Water Temperature: [**40 deg F (5 deg C)**] <**Insert deg F (deg C)**>.
b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**] <**Insert deg F (deg C)**>.
c. Capacity/Cell: <**Insert kilowatts**>.
d. Full-Load Ampacity: <**Insert value**>.
e. Minimum Circuit Ampacity: <**Insert value**>.
f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
g. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.
h. Capacity/Cell: <**Insert MBtu/h (kW)**>.
i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
k. Fluid Pressure Drop: <**Insert psig (kPa)**>.
l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
m. Steam Flow: <**Insert lb/h (L/s)**>.
n. Steam Pressure: <**Insert psig (kPa)**>.

2.4 OPEN-CIRCUIT, FORCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of [**30 lbf/sq. ft. (1.44 kPa)**] <**Insert value**>.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Frame Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin: Configure tower for installation with a field-constructed collection basin.

F. Collection Basin:

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Strainer: Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Basin Sweeper Distribution Piping and Nozzles:

a. Pipe Material: [**PVC**] <**Insert material**>.
b. Nozzle Material: [**Plastic**] <**Insert material**>.
c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

G. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

H. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**], controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

I. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

J. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

K. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

L. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

M. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [**Fiberglass**] [**PVC**] [**Galvanized steel**] <**Insert material**>.

2. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] [**PVC**] <**Insert material**>.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

N. Fill:

1. Materials: [**PVC**] <**Insert material**>, with maximum flame-spread index of 5 according to ASTM E 84.
2. Minimum Thickness: [**15 mils (0.4 mm)**] [**20 mils (0.5 mm)**] <**Insert value**>, before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F (49 deg C)**] <**Insert temperature**>.

O. [**Removable**]Drift Eliminator:

1. Material: [**FRP**] [**PVC**] [**FRP or PVC**] <**Insert material**>; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

P. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

Q. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.

1. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
2. Fan Wheel and Housing Materials: Galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

R. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**FRP**] <**Insert material**>.
2. Hub Material: [**Aluminum**] [**FRP**] <**Insert material**>.
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus

300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.

6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

S. Belt Drive:

1. Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for [**67**] <**Insert value**> percent of full-load speed.
    b. Each motor with belt drive and configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

T. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

U. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.15**] <**Insert value**>.
5. Insulation: [**Class F**] [**Class H**] <**Insert class**>.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and 300 deg F (minus 29 and 149 deg C.)
    c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

V. Discharge Hoods:

1. Hood Configuration: [**Tapered**] [**Straight**]; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed [**insulation and**] access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.

    a. Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.

W. Capacity-Control Dampers: [**Galvanized-steel**] [**Stainless-steel**] <**Insert material**> dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

X. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

Y. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

Z. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Factory-installed and -wired, collection basin electric/electronic level controller.
7. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
8. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
9. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
10. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.

11. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

12. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
13. Visual indication of status and alarm[**with momentary test push button**] for each motor.
14. Audible alarm and silence switch.
15. Visual indication of elapsed run time, graduated in hours for each motor.
16. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Cooling tower leaving-fluid temperature.
    d. Fan vibration alarm.
    e. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.
    f. <**Insert conditions to be monitored**>.

AA. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

    a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
    b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

BB. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Air-Inlet Arrangement: [**Single side**] [**Four sides**].
3. Maximum Drift Loss: [**0.005**] <**Insert number**> percent of design water flow.
4. Water Flow/Cell: <**Insert gpm (L/s)**>.

5. Minimum Water Flow/Cell: <**Insert gpm (L/s)**>.
6. Water Pressure Drop: <**Insert psig (kPa)**>.
7. Entering-Water Temperature: <**Insert deg F (deg C)**>.
8. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
9. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
10. Economizer Mode:

    a. Water Flow/Cell: <**Insert gpm (L/s)**>.
    b. Entering-Water Temperature: <**Insert deg F (deg C)**>.
    c. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
    d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

11. Fan Location: [**Bottom**] [**Side**] [**Bottom or side**].
12. Fan and Drive Type: Axial with direct drive or centrifugal with belt drive.
13. Fan Motor:

    a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
    b. Horsepower/Cell: <**Insert horsepower**>.
    c. Full-Load Ampacity: <**Insert value**>.
    d. Minimum Circuit Ampacity: <**Insert value**>.
    e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    f. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.

14. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
15. Basin Heater:

    a. Basin Water Temperature: [**40 deg F (5 deg C)**] <**Insert deg F (deg C)**>.
    b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**] <**Insert deg F (deg C)**>.
    c. Capacity/Cell: <**Insert kilowatts**>.
    d. Full-Load Ampacity: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    g. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.
    h. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
    k. Fluid Pressure Drop: <**Insert psig (kPa)**>.
    l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    m. Steam Flow: <**Insert lb/h (L/s)**>.
    n. Steam Pressure: <**Insert psig (kPa)**>.

2.5 OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of [**30 lbf/sq. ft. (1.44 kPa)**] <**Insert value**>.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Stainless steel**].
2. Frame Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin: Configure tower for installation with a field-constructed collection basin.

F. Collection Basin:

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Strainer: Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.5, Class 150 flange.
6. Removable equalization flume plate between adjacent cells of multiple-cell towers.
7. Equalizer connection for field-installed equalizer piping.
8. Basin Sweeper Distribution Piping and Nozzles:

    a. Pipe Material: [**PVC**] <**Insert material**>.
    b. Nozzle Material: [**Plastic**] <**Insert material**>.
    c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

G. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

H. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**]; controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

I. Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal[**for connection to BMS**].
3. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
4. Solenoid Valve: Slow closing[**with stainless-steel body**]; controlled and powered through level controller in response to water-level set point.
5. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

J. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

K. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

L. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

M. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

N. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [**Fiberglass**] [**PVC**] [**Galvanized steel**] <**Insert material**>.
2. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] [**PVC**] <**Insert material**>.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

O. Fill:

1. Materials: [**CPVC**] [**PVC**] <**Insert material**>, resistant to rot, decay, and biological attack; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. Minimum Thickness: [**15 mils (0.4 mm)**] [**20 mils (0.5 mm)**] <**Insert value**> before forming.

3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F (49 deg C)**] <**Insert temperature**>.

P. [**Removable**]Drift Eliminator:

1. Material: [**FRP**] [**PVC**] [**FRP or PVC**] <**Insert material**>; resistant to rot, decay, and biological attack; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

Q. Air-Intake Louvers:

1. Material: [**FRP**] [**PVC**] [**Matching casing**].
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

R. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

S. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**Aluminum**] [**FRP**] [**Galvanized steel**].
2. Hub Material: [**Aluminum**] [**FRP**] [**Galvanized steel**].
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

T. Belt Drive:

1. Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.

    a. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
    b. Belt: One-piece, multigrooved, solid-back belt.
    c. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    d. Belt-Drive Guard: Comply with OSHA regulations.

U. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

V. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: [**2.0**] <**Insert value**> based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.
5. Drive-to-Motor Connection: [**Close coupled to motor using a flexible coupling**] [**Connected to motor located outside of cooling tower casing by a full-floating drive shaft**].
6. Drive Shaft Material: [**Corrosion resistant**] [**Stainless steel**], and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
7. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

W. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.15**] <**Insert value**>.
5. Insulation: [**Class F**] [**Class H**] <**Insert class**>.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
8. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)
    c. Internal heater automatically energized when motor is de-energized.

9. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

X. Fan Discharge Stack: Material shall match casing, [**manufacturer's standard**] [**velocity recovery**] design.

1. Stack Extension: Fabricated to extend above fan deck <**Insert distance**> unless otherwise indicated.

2. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

Y. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

Z. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to a BMS**].

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm[**through the BMS**].

AA. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

BB. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin level controller complying with requirements in [**"Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve"**] [**"Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve"**] Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
10. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].

b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

11. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm[**with momentary test push button**] for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

a. Operational status of each motor.
b. Position of dampers.
c. Cooling tower leaving-fluid temperature.
d. Fan vibration alarm.
e. Oil-level alarm.
f. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.
g. <**Insert conditions to be monitored**>.

CC. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

DD. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Air-Inlet Arrangement: All sides.
3. Maximum Drift Loss: [**0.005**] <**Insert number**> percent of design water flow.
4. Water Flow/Cell: <**Insert gpm (L/s)**>.
5. Minimum Water Flow/Cell: <**Insert gpm (L/s)**>.
6. Water Pressure Drop: <**Insert psig (kPa)**>.
7. Entering-Water Temperature: <**Insert deg F (deg C)**>.
8. Leaving-Water Temperature: <**Insert deg F (deg C)**>.

9. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
10. Economizer Mode:

    a. Water Flow/Cell: <**Insert gpm (L/s)**>.
    b. Entering-Water Temperature: <**Insert deg F (deg C)**>.
    c. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
    d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

11. Fan Drive: Belt, direct, or gear.
12. Fan Motor:

    a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
    b. Horsepower/Cell: <**Insert horsepower**>.
    c. Full-Load Ampacity: <**Insert value**>.
    d. Minimum Circuit Ampacity: <**Insert value**>.
    e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    f. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.

13. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
14. Basin Heater:

    a. Basin Water Temperature: [**40 deg F (5 deg C)**] <**Insert deg F (deg C)**>.
    b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**] <**Insert deg F (deg C)**>.
    c. Capacity/Cell: <**Insert kilowatts**>.
    d. Full-Load Ampacity: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    g. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.
    h. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
    k. Fluid Pressure Drop: <**Insert psig (kPa)**>.
    l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    m. Steam Flow: <**Insert lb/h (L/s)**>.
    n. Steam Pressure: <**Insert psig (kPa)**>.

2.6 OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of [**30 lbf/sq. ft. (1.44 kPa)**] <**Insert value**>.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Frame Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin: Configure tower for installation with a field-constructed collection basin.

F. Collection Basin:

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.5, Class 150 flange.
6. Removable equalization flume plate between adjacent cells of multiple-cell towers.
7. Equalizer connection for field-installed equalizer piping.
8. Basin Sweeper Distribution Piping and Nozzles:

    a. Pipe Material: [**PVC**] <**Insert material**>.
    b. Nozzle Material: [**Plastic**] <**Insert material**>.
    c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

G. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

H. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosures: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**], controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

I. Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.

2. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal[**for connection to BMS**].
3. Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
4. Solenoid Valve: Slow closing[**with stainless-steel body**]; controlled and powered through level controller in response to water-level set point.
5. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

J. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

K. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

L. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

M. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

N. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.

1. Material: [**FRP with UV inhibitors**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Location: Over each bank of fill with easily replaceable [**plastic**] <**Insert material**> spray nozzles mounted in bottom of basin.
3. Inlet Connection: ASME B16.5, Class 150 flange.
4. Joints and Seams: Sealed watertight.
5. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
6. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable [**corrosion-resistant**] [**stainless-steel**] hardware.
7. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
8. Single-Inlet, Field Pipe Connection: [**Galvanized-steel**] [**PVC**] pipe arranged to provide balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for

mating to ASME B16.5, Class 150 flange and located on the [**bottom**] [**side**] unless otherwise indicated.

O. Fill:

1. Materials: PVC, with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. Minimum Thickness: [**15 mils (0.4 mm)**] [**20 mils (0.5 mm)**] <**Insert value**>, before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F (49 deg C)**] <**Insert temperature**>.

P. Drift Eliminator:

1. Material: [**FRP**] [**PVC**] [**FRP or PVC**] <**Insert material**>; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
4. Location: [**Integral to**] [**Separate and removable from**] fill.

Q. Air-Intake Louvers:

1. Material: [**FRP**] [**PVC**] [**Matching casing**].
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
4. Location: [**Integral to**] [**Separate from**] fill.

R. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

S. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**Aluminum**] [**FRP**] [**Galvanized steel**].
2. Hub Material: [**Aluminum**] [**FRP**] [**Galvanized steel**].
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

T. Belt Drive:

1. Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.

2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for [**67**] <**Insert value**> percent of full-load speed.
    b. Each motor with belt drive and configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

U. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: [**2.0**] <**Insert value**> based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.
5. Drive-to-Motor Connection: [**Close coupled to motor using a flexible coupling**] [**Connected to motor located outside of cooling tower casing by a full-floating drive shaft**].
6. Drive Shaft Material: [**Corrosion resistant**] [**Stainless steel**], and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
7. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

V. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: [**1.15**] <**Insert value**>.
5. Insulation: [**Class F**] [**Class H**] <**Insert class**>.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
8. Severe-duty rating with the following features:

a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)
c. Internal heater automatically energized when motor is de-energized.

9. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

W. Fan Discharge Stack: Material shall match casing, [**manufacturer's standard**] [**velocity recovery**] design.

1. Stack Extension: Fabricated to extend above fan deck <**Insert distance**> unless otherwise indicated.
2. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

X. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

Y. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to a BMS**].

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm[**through the BMS**].

Z. Capacity-Control Dampers: [**Galvanized-steel**] [**Stainless-steel**] <**Insert material**> dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

AA. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

BB. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.

5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin level controller complying with requirements in [**"Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve"**] [**"Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve"**] Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
10. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

11. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm[**with momentary test push button**] for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Cooling tower leaving-fluid temperature.
    d. Fan vibration alarm.
    e. Oil-level alarm.
    f. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.
    g. <**Insert conditions to be monitored**>.

CC. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

DD. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Air-Inlet Arrangement: [**Single side**] [**Two sides**].
3. Maximum Drift Loss: [**0.005**] <**Insert number**> percent of design water flow.
4. Water Flow/Cell: <**Insert gpm (L/s)**>.
5. Minimum Water Flow/Cell: <**Insert gpm (L/s)**>.
6. Water Pressure Drop: <**Insert psig (kPa)**>.
7. Entering-Water Temperature: <**Insert deg F (deg C)**>.
8. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
9. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
10. Economizer Mode:

    a. Water Flow/Cell: <**Insert gpm (L/s)**>.
    b. Entering-Water Temperature: <**Insert deg F (deg C)**>.
    c. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
    d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

11. Fan Drive: Belt or gear.
12. Fan Motor:

    a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
    b. Horsepower/Cell: <**Insert horsepower**>.
    c. Full-Load Ampacity: <**Insert value**>.
    d. Minimum Circuit Ampacity: <**Insert value**>.
    e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    f. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.

13. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
14. Basin Heater:

    a. Basin Water Temperature: [**40 deg F (5 deg C)**] <**Insert deg F (deg C)**>.
    b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**] <**Insert deg F (deg C)**>.
    c. Capacity/Cell: <**Insert kilowatts**> .
    d. Full-Load Ampacity: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    g. Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert value**>-V ac, 3 phase, 60 Hz.
    h. Capacity/Cell: <**Insert MBtu/h (kW)**>.
    i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
    k. Fluid Pressure Drop: <**Insert psig (kPa)**>.

l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
m. Steam Flow: <**Insert lb/h (L/s)**>.
n. Steam Pressure: <**Insert psig (kPa)**>.

2.7 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

B. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.

1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install cooling towers on support structure indicated.

B. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to cooling towers to allow service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Provide drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

F. Domestic Water Piping: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.

G. Supply and Return Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage,[**flow meter,**] and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].

H. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

I. Hot-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect to supply and return basin heater with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection. Provide supply and return piping with pressure gage and thermometer.

J. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 Steam and Condensate Piping Specialties." Connect steam supply to basin heater with shutoff valve, strainer, control valve, and union or flange and condensate piping with union or flange, shutoff valve, strainer, and an appropriate steam trap.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform field tests and inspections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections: Comply with [**ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment**] [**CTI ATC 105, "Acceptance Test Code for Water Cooling Towers**]."

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. [**Engage a factory-authorized service representative to perform**] [**Perform**] startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Clean entire unit including basins.
b. Verify that accessories are properly installed.
c. Verify clearances for airflow and for cooling tower servicing.
d. Check for vibration isolation and structural support.
e. Lubricate bearings.
f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
g. Adjust belts to proper alignment and tension.
h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.6 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.7 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236500