SECTION 236513.13 - OPEN-CIRCUIT, FORCED-DRAFT COOLING TOWERS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

See "Sustainable Design Considerations" Article in the Evaluations for a discussion of sustainable design requirements that may impact editing of this Section.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section includes factory-assembled, open-circuit, forced-draft cooling towers.
			2. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. SCCR: Short-circuit current rating.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer's installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of product.

Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.

Maximum flow rate.

Minimum flow rate.

Pressure required at cooling tower supply piping connections.

Retain first two subparagraphs below if hot-water or steam basin heater and collection basin sweeper piping are required.

Pressure required at basin heater supply piping connections.

Pressure required at collection basin sweeper supply piping connections.

Drift loss as percent of design flow rate.

Retain first subparagraph below to require other means of field-installed storage.

Volume of water in suspension for purposes of sizing remote storage.

Sound:

Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.

Retain first subparagraph below for sound-sensitive applications only. Consult manufacturers to confirm information being requested is available for product(s) specified.

Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and design speed.

Retain first subparagraph below if performance curves are required to inform optimization of system operation. Limit selections in options indicated to only information required to inform system operation because requests for extensive information can impact schedule and cost.

Performance curves for the following:

Varying entering-water temperatures from design to minimum in [**one**] [**five**] <**Insert number**>-degree temperature increments.

Varying ambient wet-bulb temperatures from design to minimum in [**one**] [**five**] <**Insert number**>-degree temperature increments.

Varying water flow rates from design to minimum in increments of [**10**] <**Insert number**> percent of flow rate difference between design and minimum flow rates.

Varying fan operation from design to minimum speed in [**5**] [**10**] <**Insert number**> percent speed increments, and with fan off.

Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percentage of brake horsepower).

Fan motor electrical characteristics, including but not limited to, speed, voltage, phase hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.

Electrical power requirements for each cooling tower component requiring power.

* + - * 1. Shop Drawings:

Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.

Assembled unit dimensions.

Diagram showing each separate piece requiring field assembly.

Shipped sub-assembly dimensions and weights for field assembly.

Assembled unit weight without water.

Operating weight and load distribution.

Unit vibration isolation[**and seismic controls**].

Required clearances for maintenance and operation.

Sizes and dimensioned locations of piping and wiring connections.

Diagrams for power, signal, and control wiring.

Retain "Coordination Drawings" paragraph below if Drawings do not include detailed plans or if Project involves unusual coordination requirements. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations.

* + - * 1. Coordination Drawings:

Drawings on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

Structural supports.

Piping roughing-in requirements.

Conduit and wiring roughing-in requirements for controls and electrical power, including spaces reserved for controls and electrical equipment.

Access requirements, including working clearances for controls and electrical equipment, and service clearances. Mark and label clearances.

Drawings showing plans, sections, and elevation views, drawn to scale of at least <**Insert scale**>.

Each view to show screened background with the following:

Structural grids.

Adjacent walls, floors, and roofs.

Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire-suppression systems, and plumbing systems.

Retain "Product Certificates" paragraph below if retaining certification in "Quality Assurance" Article.

* + - * 1. Product Certificates: For certification required in "Quality Assurance" Article.

Retain "Seismic Qualification Certificates" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC." See ASCE/SEI 7 for certification requirements for equipment and components.

Some manufacturers claim not to be able to provide the certification specified in "Seismic Qualification Data" paragraph below; however, such certification is mandated in many locations by authorities having jurisdiction. Verify availability with manufacturers. See "Seismic Considerations" Article in the Evaluations for discussion.

* + - * 1. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

* + - * 1. Source quality-control reports.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
				2. Field Test Reports: Include startup service reports.
				3. Sample Warranty: For special warranty.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
				2. Instructional Videos: Including those that are pre-recorded and those that are recorded during training.
			2. MAINTENANCE MATERIAL SUBMITTALS

Retain this article to require maintenance materials.

Retain "Belts" paragraph below to require spare belts for cooling towers with belt drives.

* + - * 1. Belts:

Furnish [**one**] <**Insert number**> set(s) of matching belts for each unique belt configuration and size furnished.

Consult Director’s Representative about cooling tower service and need for tool kit. Servicing of cooling tower by unqualified personnel is not recommended by manufacturers and may void warranty.

* + - * 1. Tool Kit:

A tool kit specially designed by cooling tower manufacturer for use in servicing cooling tower(s) furnished.

Special tools required to service components not readily available to Director’s Representative service personnel in performing routine maintenance.

Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Cooling Tower Tool Kit." Text size shall be at least 1 inch high.

A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.

* + - * 1. Touch-up Coating: [**32-oz.**] <**Insert volume**> container of paint coating used. Label outside of container with detailed description of coating to allow for procurement of a matching coating in the future.
			1. QUALITY ASSURANCE

Retain "Testing Agency Qualifications" paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article.

* + - * 1. Testing Agency Qualifications: [**Certified by CTI**] [**An NRTL**].

Retain "CTI Certification" paragraph below if CTI certification is required. Confirm that Project requirements fall within parameters of CTI STD 201RS.

* + - * 1. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

Retain "FM Global" paragraph below if required to comply with governing codes or insurance underwriter's requirements.

* + - * 1. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."
			1. DELIVERY, STORAGE, AND HANDLING
				1. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.
				2. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.

Clearly label each package with a unique designation and include assembly instructions for each complete cooling tower.

* + - 1. WARRANTY

When warranties are required, verify with Director’s Representative 's that warranties stated in this article are not less than remedies available to Director’s Representative under prevailing local laws.

* + - * 1. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:

Retain first subparagraph below if requiring warranty to cover entire cooling tower. Some manufacturers offer models with an extended warranty covering the entire cooling tower.

All components of cooling tower.

Retain any of three subparagraphs below if not retaining subparagraph above.

Fan assembly, including fan, drive, and motor.

<**Insert components requiring extended warranty**>.

Verify available warranties and warranty periods for units and components.

Warranty Period: [**Five**] <**Insert number**> years from date of Substantial Completion.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. MANUFACTURERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=12753) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Baltimore Aircoil Company](http://www.specagent.com/Lookup?uid=123457139312).

[Delta Cooling Towers, Inc](http://www.specagent.com/Lookup?uid=123457139309).

[EVAPCO, Inc](http://www.specagent.com/Lookup?uid=123457139310).

[Marley Cooling Technologies; SPX Cooling Technologies](http://www.specagent.com/Lookup?uid=123457139313).

[Recold](http://www.specagent.com/Lookup?uid=123457139314).

[Tower Tech, Inc](http://www.specagent.com/Lookup?uid=123457139311).

Approved equivalent.

* + - 1. PERFORMANCE REQUIREMENTS
				1. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to [**ASCE/SEI 7**] [**IBC**] [**governing code**] <**Insert requirement**>.

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Verify requirements of authorities having jurisdiction. Coordinate requirements with Structural Engineer.

* + - * 1. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

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**]."

For life-safety components required to function after an earthquake (such as fire-sprinkler systems, components that contain hazardous content, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

Component Importance Factor: [**1.5**] [**1.0**].

See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in "Component Amplification Factor" and "Component Response Modification Factor" subparagraphs below.

Component Amplification Factor: <**Insert value**>.

Component Response Modification Factor: <**Insert value**>.

Retain "ASHRAE/IES 90.1 Compliance" paragraph below to require compliance with ASHRAE/IES 90.1.

* + - * 1. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
				2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

Retain "Operation Following Loss of Normal Power" paragraph below if uninterrupted cooling tower operation is required without operator intervention.

* + - * 1. Operation Following Loss of Normal Power:

Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.

Include means and methods required to satisfy requirement even if not explicitly indicated.

* + - * 1. Vibration:

Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.

Critical speed shall be at least 115 percent of design speed.

* + - 1. DESIGN ARRANGEMENT

Retain this article if design arrangement is not indicated on Drawings.

Retain one or more of three paragraphs below as applicable. Design arrangement described in first paragraph is not available from all manufacturers. Consult listed manufacturers for availability.

* + - * 1. Counterflow pattern with inlet airflow from bottom and forced-draft, bottom-mounted axial fans; and with pressurized pipe distribution near top.
				2. Counterflow pattern with inlet airflow from one side and forced-draft, bottom-mounted centrifugal fans; and with pressurized pipe distribution near top.
				3. Low-profile design with counterflow pattern, with inlet airflow from one side and forced-draft, side-mounted centrifugal fans to reduce overall height; and with pressurized pipe distribution near top.
			1. CASING AND FRAME
				1. Casing Material: [**FRP with UV inhibitors**] [**HDPE with UV inhibitors**] [**galvanized steel, ASTM A653, G210 coating**] [**galvanized steel, ASTM A653, G235 coating**] [**polymer-coated galvanized steel**] [**stainless steel, Type 304**] [**or**] [**stainless steel, Type 316**] <**Insert material**>.

Some manufacturers use different materials for casing and frame on some products. Confirm product availability with listed manufacturers if retaining "materials to match casing" option in "Frame Material" paragraph below.

* + - * 1. Frame Material: [**FRP with UV inhibitors**] [**HDPE with UV inhibitors**] [**galvanized steel, ASTM A653, G210 coating**] [**galvanized steel, ASTM A653, G235 coating**] [**polymer-coated galvanized steel**] [**stainless steel, Type 304**] [**stainless steel, Type 316**] [**or**] [**materials to match casing**] <**Insert material**>.
				2. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
				3. Joints and Seams: Sealed watertight.
				4. Welded Connections: Sealed watertight[**by continuous welds**].
			1. COLLECTION BASIN
				1. Factory-Assembled Collection Basin:

Material: [**FRP with UV inhibitors**] [**HDPE with UV inhibitors**] [**Galvanized steel, ASTM A653, G210 coating**] [**Galvanized steel, ASTM A653, G235 coating**] [**Polymer-coated galvanized steel**] [**Stainless steel, Type 304**] [**Stainless steel, Type 316**] <**Insert material**>.

Hardware: [**Galvanized**] [**or**] [**stainless**] steel.

Joints and Seams: Sealed watertight.

Welded Connections: Sealed watertight[**by continuous welds**].

Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.

Overflow and drain connections.

Makeup-water connection.

Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.

If Project has a multiple-cell cooling tower or multiple cooling towers, retain one of first two subparagraphs below.

Removable equalization flume plate between adjacent cells of multiple-cell towers.

Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.

Retain "Basin Sweeper Distribution Piping and Nozzles" subparagraph below for factory-installed basin sweeper distribution piping for field connection to field-installed filtration system to minimize sediment from collecting in the collection basin. Not all listed manufacturers offer basin sweeper distribution piping. Consult listed manufacturers for availability.

Basin Sweeper Distribution Piping and Nozzles:

Pipe Material: [**PVC**] <**Insert material**>, Schedule 40 or heavier, treated with UV inhibitors and intended for continuous exposure to direct sunlight with degradation.

Nozzle Material: [**Plastic**] <**Insert material**>.

Configure piping and nozzles to minimize sediment from collecting in the collection basin.

Basin penetrations sealed watertight.

Field Connections: Threaded or flanged, depending on pipe size. Threaded for sizes through <**Insert pipe size**> and flanged for larger sizes.

* + - 1. COLLECTION BASIN MAKEUP-WATER ASSEMBLY

Retain "Mechanically Operated, Collection Basin Water-Level Control," "Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve," or "Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve" paragraph below to require water-level control with cooling tower. Consult listed manufacturers for availability of different methods of water-level control and options.

* + - * 1. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
				2. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

Enclosures: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert Type**>.

Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to [**control makeup-water valve**] [**control makeup-water valve and low-level alarm**] [**control makeup-water valve and low- and high-level alarms**] [**control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level**].

Electrode Probes: Stainless steel.

First option in "Water-Stilling Chamber" subparagraph below is less restrictive, whereas other options are limiting.

Water-Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**galvanized steel**] [**PVC pipe**] [**stainless steel, Type 304**] [**or**] [**stainless steel, Type 316**] <**Insert material**>.

Makeup-Water Valve:

Slow closing[**with stainless-steel body**].

Valve actuator controlled and powered through level controller in response to water-level set point.

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

Fail Position: [**Closed**] [**Open**] [**Last**].

Action: [**Two position**] [**or**] [**modulating**].

Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

* + - * 1. Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve:

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

Controller:

Ultrasonic level sensor/transmitter with local display of measured value.

Factory wired to terminal strip.

Control makeup-water valve in response to water-level set point.

Adjustable-level, alarm signal through relay closure[**for connection to control system**].

Continuous-level indication through a 4- to 20-mA signal[**for connection to control system**].

First option in "Water-Stilling Chamber" subparagraph below is less restrictive, whereas other options are limiting.

Water-Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**galvanized steel**] [**PVC pipe**] [**stainless steel, Type 304**] [**or**] [**stainless steel, Type 316**] <**Insert material**>.

Makeup-Water Valve:

Slow closing[**with stainless-steel body**].

Valve actuator controlled and powered through level controller in response to water-level set point.

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

Fail Position: [**Closed**] [**Open**] [**Last**].

Action: [**Two position**] [**or**] [**modulating**].

Electrical Connection Requirements: 120 V ac, single phase, 60 Hz.

* + - 1. COLLECTION BASIN HEATER

Retain "Electric Heater," "Hot-Water-Coil Heater," "Steam-Coil Heater," or "Steam-Injector Heater" paragraph below to require basin heaters for projects subject to freezing conditions. See the Evaluations for discussion.

* + - * 1. Electric Heater:

Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.

Heater Control Panel: Mounted on the side of each cooling tower cell.

Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] <**Insert Type**>.

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.

Control-circuit transformer with primary and secondary side fuses.

Terminal blocks with numbered and color-coded wiring to match wiring diagram.

Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.

Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures; except, connections to each electric basin heater shall be liquid tight conduit.

Raceway shall be corrosion-resistant [**stainless steel**] [**or**] [**PVC-coated steel**].

* + - * 1. Hot-Water-Coil Heater: Manufacturer's standard heater with indicated capacity.
				2. Steam-Coil Heater: Manufacturer's standard heater with indicated capacity.
				3. Steam-Injector Heater: Manufacturer's standard offering heater with indicated capacity.
			1. PRESSURIZED DISTRIBUTION NETWORK
				1. Main header and lateral branch piping designed for even distribution over fill and heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.
				2. Pipe Material: [**Schedule 40 PVC**] <**Insert material**>.
				3. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] [**or**] [**PVC**] <**Insert material**>.
				4. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
			2. FILL

Retain "PVC" paragraph below if PVC fill is required. PVC is most commonly used fill material and suitable for most HVAC applications.

* + - * 1. PVC:

Flame-Spread Index: [**5**] [**25**] <**Insert value**> according to ASTM E84.

Retain "Minimum Thickness" subparagraph below if other than manufacturer's standard fill is required. Thicker fill is used primarily in applications with elevated water temperatures.

Minimum Thickness: [**15 mils**] [**20 mils**] <**Insert value**>, before forming.

Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

Consult manufacturers for fill options at elevated temperatures.

Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F**] <**Insert temperature**>.

Retain first paragraph below for special applications. Consult listed manufacturers for availability. See the Evaluations for discussion.

* + - * 1. [**Galvanized**] [**or**] [**stainless**] steel:

Retain "Minimum Material Thickness" subparagraph below if other than manufacturer's standard fill is required.

Minimum Material Thickness: <**Insert thickness**>, before forming.

Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**170 deg F**] <**Insert temperature**>.

* + - * 1. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
			1. DRIFT ELIMINATORS
				1. Material: [**PVC**] <**Insert material**>, with maximum flame-spread index of [**5**] [**25**] <**Insert number**> according to ASTM E84.
				2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
				3. Arrangement: Multiple, easily removable sections.
				4. Configuration: Multipass, designed and tested to reduce water carryover to [**0.001**] <**Insert number**> percent of design flow rate indicated.
				5. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
			2. AIR INLET

Retain "(Removable) Air-Intake Screens" paragraph below to require screens. Screens are optional and sometimes included in applications where there is a high risk of entraining debris.

* + - * 1. [**Removable**]Air-Intake Screens:

[**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh, with openings of size sufficient to not restrict airflow or impact performance.

Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

* + - * 1. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
			1. FAN AND DRIVE ASSEMBLY

Retain "Axial Fans" paragraph below to equip cooling towers with axial fans. Axial fans are not available from all manufacturers. Consult listed manufacturers for availability.

* + - * 1. Axial Fans: Factory balanced[**after assembly**].

Blade Material: [**Aluminum**] [**galvanized steel**] [**or**] [**thermoplastic**] <**Insert material**>.

Hub Material: [**Aluminum**] [**or**] [**galvanized steel**] <**Insert material**>.

Retain "Blade Pitch" subparagraph below to require this feature. Consult listed manufacturers for availability.

Blade Pitch: Field adjustable.

Fan Shaft: Steel, coated to resist corrosion.

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. Bearings designed for an L-10 life of [**40,000**] [**50,000**] [**100,000**] <**Insert value**> hours.

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

Retain "Centrifugal Fans" paragraph below to equip cooling towers with centrifugal fans. Centrifugal fans are more common than axial fans for use with this type of cooling tower.

* + - * 1. Centrifugal Fans: Double-width, double-inlet, forward-curved blades; statically and dynamically balanced at the factory[**after assembly**].

Cooling Tower Cell Fan Assembly: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.

Fan Wheel and Housing Materials: Hot-dip galvanized steel.

Fan Shaft: Steel, coated to resist corrosion.

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. Bearings designed for an L-10 life of [**40,000**] [**50,000**] [**100,000**] <**Insert value**> hours.

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

Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.

Retain "Belt Drives" paragraph below to require belt drive.

* + - * 1. Belt Drives:

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

Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.

Retain one of first two "Belt" subparagraphs below. Second "Belt" subparagraph may achieve better performance.

Belt: Multiple V-belt design with a matched set of[**cogged**] belts.

Belt: One-piece, multigrooved, solid-back belt.

Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.

Belt-Drive Guard: Comply with OSHA regulations.

Retain "Two-Motor, Single-Fan Drive" subparagraph below if requiring functionality of a single-fan assembly with two motors.

Two-Motor, Single-Fan Drive:

Two single-speed motors per cooling tower cell fan assembly; one sized for full speed and load and the other sized for [**67**] [**100**] <**Insert number**> percent of full-load speed.

Each motor shall have belt drive and be configured for operation when other motor fails.

Controls and wiring same as two-speed, two-winding motor.

Retain "Direct Drives" paragraph below to require direct drive. Drive direct is only available with axial fans. Consult listed manufacturers for availability.

* + - * 1. Direct Drives: Fan hub directly connected, and properly secured, to motor shaft.
				2. Fan Motors:

Comply with NEMA MG 1 unless otherwise indicated.

Description: NEMA MG 1, [**Design B**] <**Insert design**>, as required to comply with capacity and torque characteristics; medium induction motor.

Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

Retaining "Totally enclosed" option in "Motor Enclosure" subparagraph below is less restrictive and allows manufacturer to choose "TEAO" or "TEFC" option. "And with epoxy or polyurethane finish" option may achieve added corrosion protection.

Motor Enclosure: [**Totally enclosed**] [**totally enclosed air-over (TEAO)**] [**or**] [**totally enclosed fan cooled (TEFC)**] [**and with epoxy or polyurethane finish**].

Rotor: Random wound, squirrel cage.

Energy Efficiency: [**Comply with ASHRAE/IES 90.1**] [**NEMA Premium Efficient**].

Service Factor: [**1.15**] <**Insert value**>.

Temperature Rise: [**Match**] [**One class lower than**] <**Insert requirements**> insulation rating.

Insulation: [**Class F**] [**Class H**] <**Insert class**>.

Variable-Speed Motors: Inverter-duty rated according to NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."

Retain "Motor Location" subparagraph below for enhanced protection. Standard offering varies by manufacturer and product. Consult listed manufacturers for availability.

Motor Location: Mounted outside of cooling tower airstream.

Retain "Severe-Duty Rating" subparagraph below to require additional protection. Coordinate with "Motor Enclosure" subparagraph above.

Severe-Duty Rating:

Rotor and stator protected with corrosion-inhibiting epoxy resin.

Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F.

"Internal Heater" subparagraph below may require a separate, single-phase, field-power connection for heater operation.

Internal Heater: Automatically energized when motor is de-energized.

Complying with IEEE 841.

Retain "Motor Base" subparagraph below for belt-drive units or other drive applications as applicable.

Motor Base: Adjustable, or other suitable belt-tensioning provisions.

Retain "Motor Shaft Grounding" subparagraph below for variable-speed motors.

Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than [**0.5**] <**Insert value**> percent of motor nameplate horsepower.

* + - * 1. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
			1. AIR DISCHARGE

Retain "Discharge Hood" paragraph to equip cooling tower with a discharge hood. Paragraph describes features that are not available from all manufacturers. Consult listed manufacturers for availability.

* + - * 1. Discharge Hood:

Hood Configuration: [**Tapered**] [**Straight**]; totally surrounding heat exchanger; pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed [**insulation and**]access doors.

Retain "Discharge Dampers" or "Capacity-Control Dampers" subparagraph below.

Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of [**aluminum**] [**galvanized steel**] [**stainless steel**] <**Insert material**>, with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.

Retain first subparagraph below if cooling towers are not provided with factory-installed and -wired control package.

If not provided with factory controls, field-connect provisions for electrical power and controls to open dampers when pump is energized, and close dampers when pump is de-energized.

Retain "Capacity-Control Dampers" subparagraph below to require capacity-control dampers to improve leaving-water temperature control.

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

Retain subparagraph below if cooling towers are not provided with factory-installed and -wired control package.

If not provided with factory controls, provide field power and controls to operate dampers when pump is energized, and close dampers when pump and fan is de-energized.

* + - * 1. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
			1. ELECTRICAL POWER

Retain this article to require factory-furnished or -installed electrical power options for cooling tower fan motors. Not all manufacturers offer the options indicated. Consult listed manufacturers for availability.

Retain "Factory Furnish for Field Installation" or "Factory Install" paragraph below. Retain "Factory Furnish for Field Installation" paragraph to require manufacturer to furnish, but not factory install, electrical devices. Retain "Factory Install" paragraph to require manufacturer to furnish and install electrical devices.

* + - * 1. Factory Furnish for Field Installation: A [**disconnect switch**] [**motor controller**] [**variable-frequency controller**] for each fan motor.
				2. Factory Install: A [**disconnect switch**] [**motor controller**] [**variable-frequency controller**] for each fan motor.

Locate in a convenient and field-accessible location within sight of motor.

Installation shall comply with NFPA 70.

Wire, Conduit, and Enclosures:

Minimum Conduit Size: [**0.75 inch**] <**Insert size**>.

Materials: Corrosion resistant[**and constructed of stainless steel or PVC-coated steel**].

Motor Termination: Liquid tight conduit, not to exceed 36 inches long.

Supports: Support, conduits boxes, and enclosures using corrosion-resistant fastening hardware[**constructed of stainless steel**].

Wire:

Copper, rated for 600-V solid wire for size [**No. 10 AWG**] <**Insert wire size**> and smaller and stranded wire for larger sizes.

Minimum Wire Size: [**No. 12 AWG**] <**Insert wire size**>.

Each circuit shall have a ground wire.

Install wire in conduit.

Boxes, Condulets, and Enclosures: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].

Retain "Disconnect Switches" paragraph below to require factory-installed disconnect switches for each cooling tower.

* + - * 1. Disconnect Switches:

Specification Grade; "Heavy-Duty Type," "quick-make," "quick-break" construction.

Three pole [**fused**] [**or**] [**nonfused**].

600-V rated.

Minimum SCCR: As required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.

Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] [**or**] [**Type 4X stainless steel**] <**Insert Type**>.

Operating handle shall be of box-mounted type that directly drives switch mechanism.

Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.

Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.

Include a solid neutral as required by authorities having jurisdiction.

Include a ground lug for ground wire termination.

Operating handle shall be lockable in open position.

Horsepower rated.

Feed through or double lugged.

Retain "Motor Controllers" paragraph below to require factory-installed motor controllers on cooling tower.

* + - * 1. Motor Controllers:

NEMA ICS 2, Class A, full-voltage, non-reversing motor-rated controller.

Configured for control of single- or multi-speed motors.

Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] [**or**] [**Type 4X stainless steel**] <**Insert Type**>, with hinged full-front access door with lock and key.

Externally Operated[**, Door-Interlocked**] Disconnect: [**Fused disconnect switch**] [**Nonfused disconnect switch**] [**Circuit breaker**] with lockable handle.

SCCR: As required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.

Hand-Off-Auto Switch: Mounted on face of enclosure.

Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.

Control Relays: Time-delay relays.

Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.

Retain "Elapsed-Time Meters" subparagraph below to add local display of operating hours.

Elapsed-Time Meters: Numerical readout in hours on face of enclosure.

Retain "Number-of-Starts Counter" subparagraph below to add local display of fan motor starts.

Number-of-Starts Counter: Numerical readout on face of enclosure.

Retain "Variable-Frequency Controllers" paragraph below to require factory-installed variable-frequency controllers on cooling tower.

* + - * 1. Variable-Frequency Controllers:

Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.

Enclosure: Unit mounted, NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] [**or**] [**Type 4X stainless steel**] <**Insert Type**>, with hinged full-front access door with lock and key.

Externally Operated[**, Door-Interlocked**] Disconnect: [**Fused disconnect switch**] [**Nonfused disconnect switch**] [**Circuit breaker**] with lockable handle.

Minimum SCCR: As required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.

Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBTs); suitable for variable-torque loads.

Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.

Operating Requirements:

Input AC Voltage Tolerance: [**10**] <**Insert number**> percent.

Input frequency tolerance of 60 Hz, plus or minus 2 Hz.

Capable of driving full motor load, without derating.

Minimum Efficiency: 96 percent at 60 Hz, full load.

Minimum Displacement Primary-Side Power Factor: 95 percent.

Overload Capability: 1.05 times the full-load current for seven seconds.

Starting Torque: As required by fan and motor drive assembly.

Speed Regulation: 1 percent.

Speed Range: 10:1 speed range.

To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.

Capable of being restarted into a motor, coasting in either the forward or reverse direction without tripping.

Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.

Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

Overtemperature.

Short circuit at controller output.

Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.

Open circuit at controller output.

Input undervoltage.

Input overvoltage.

Loss of input phase.

Reverse phase.

AC line-switching transients.

Instantaneous overload, line to line or line to ground.

Sustained overload exceeding 100 percent of controller-rated current.

Starting a rotating motor.

<**Insert features**>.

Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

Automatic Reset and Restart:

Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.

Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

Visual Indication: On face of controller; indicating the following conditions:

Retain any of 14 subparagraphs below as required by application. Some requirements may not be available from all listed manufacturers. Consult listed manufacturers to confirm availability.

Power on.

Run.

Overcurrent and overvoltage.

Motor speed (percent).

Various faults with alarm status.

Input kilovolt amperes.

Power factor.

Input kilowatts and kilowatt-hours.

Three-phase input and output voltage.

Three-phase input and output current.

Output frequency.

Elapsed operating time (hours).

Diagnostic and service parameters.

<**Insert conditions**>.

Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.

Control Signal Interface: A minimum of [**two**] <**Insert number**> analog inputs (0 to 10 V or 0/4 to 20 mA) and [**four**] <**Insert number**> programmable digital inputs.

Retain "Bypass Controller" subparagraph below to require variable-frequency controller with added operational reliability.

Bypass Controller:

Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.

Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller, for safe servicing of variable-frequency controller.

Include "Bypass/VFC" manual selector switch on face of enclosure to provide for local operator control of preferred controller.

Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.

Install bypass controller in same enclosure as variable-frequency controller.

* + - 1. CONTROLS

Retain "Vibration Switch" paragraph below to require a vibration switch furnished with cooling tower.

* + - * 1. Vibration Switch: For each fan drive.

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

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.

Retain one or both of first two subparagraphs below.

Switch shall have manual-reset button with hardwired connection to fan motor electrical circuit.

Switch shall have field connection for hardwired connection to control system.

Switch shall, on sensing excessive vibration,[**signal an alarm for connection to control system and**] shut down the fan.

Retain "Control Package" paragraph below to require cooling tower to be equipped with factory-installed controls. Not all manufacturers offer factory-installed control packages; those that do offer control packages have limited features available with the package. Consult listed manufacturers for additional information. Subparagraphs list optional features. Retain applicable subparagraphs, based on Project conditions, to correspond with other components.

* + - * 1. Control Package:

Factory installed and wired, and functionally tested at factory before shipment.

NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable, internally mounted backplate.

Control-circuit transformer with primary and secondary side fuses.

Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

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.

Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.

If retaining "Mechanically Operated, Collection Basin Water-Level Control" paragraph in "Collection Basin Makeup-Water Assembly" Article, delete first subparagraph below.

Collection basin water-level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve" Paragraph.

Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Collection Basin Heater" Article.

Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph in "Controls" Article.

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

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

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.

Factory-installed wiring outside of enclosures shall be in metal raceway; except, make connections to each motor and electric basin heater with liquid tight conduit.

Visual indication of status and alarm[**with momentary test push button**] for each motor.

Retain first subparagraph below for audible alarm. Coordinate with control sequence.

Audible alarm and silence switch.

Visual indication of elapsed run time, graduated in hours for each motor.

Retain first subparagraph below if unit controls interface with remote-control system.

Cooling tower shall have hardware to enable control system to remotely monitor and display the following:

Five subparagraphs below are optional features. Retain applicable subparagraphs, based on Project conditions, to require these features.

Operational status of each motor.

Cooling tower leaving-fluid temperature.

Fan vibration alarm.

Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.

<**Insert conditions to be monitored**>.

* + - 1. WATER TREATMENT

Retain this article to require an automated water treatment system that is furnished with cooling tower. Factory-furnished water treatment is limited to only some manufacturers and product offerings. Consult listed manufacturers for availability.

"Chemical-Free Water Treatment System" paragraph below describes system that is offered by Evapco Inc.

* + - * 1. Chemical-Free Water Treatment System: Complete factory-installed system consisting of the following:

Pulsed-power technology emitting high-frequency bursts of low-energy electromagnetic fields to the recirculated water to control corrosion, bacteria, and scale.

Conductivity control of electrically operated valve designed to control totally dissolved solids levels and bleed rates.

Piping associated with system.

Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

* + - 1. SERVICE ACCESS

This article specifies optional service access devices. Retain devices desired for Project. See the Evaluations for discussion.

* + - * 1. Doors:

Large enough for personnel to access cooling tower internal components.

Doors shall be hinged with handles operable from both sides of the door.

Door materials shall match casing.

Hinges and handles shall be [**corrosion resistant**] [**stainless steel**] <**Insert material**>.

* + - * 1. External Ladders with Safety Cages: [**Aluminum**] [**galvanized-steel**] [**or**] [**stainless-steel**] <**Insert material**> 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.
				2. External Platforms with Handrails: [**Aluminum**] [**galvanized-steel**] [**or**] [**stainless-steel**] <**Insert material**> bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
				3. Handrail: [**Aluminum**] [**galvanized steel**] [**or**] [**stainless steel**] <**Insert material**> complete with knee rail and toe board, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.
				4. Hardware: Galvanized steel when connecting galvanized-steel components and stainless steel when connecting other materials.
			1. CAPACITIES AND CHARACTERISTICS

If Project has more than one type or configuration of cooling tower, delete this article and schedule cooling towers on Drawings.

* + - * 1. Number of Cells: <**Insert quantity**>.
				2. Air-Inlet Arrangement: [**One side**] [**or**] [**bottom**].
				3. Maximum Drift Loss: [**0.001**] <**Insert number**> percent of design water flow.
				4. Waterside:

Design Water Flow per Cell: <**Insert gpm**>.

Minimum Water Flow per Cell: <**Insert gpm**>.

Water Pressure Drop: <**Insert psig**>.

Entering-Water Temperature: <**Insert deg F**>.

Leaving-Water Temperature: <**Insert deg F**>.

* + - * 1. Airside:

Entering-Air, Wet-Bulb Temperature: <**Insert deg F**>.

Altitude: <**Insert value**>.

Air Flow per Cell: <**Insert cfm**>.

Retain "Economizer Mode Performance" paragraph below to indicate performance required when operating in economizer mode. See the Evaluations for discussion.

* + - * 1. Economizer Mode Performance:

Fluid Flow per Cell: <**Insert gpm**>.

Entering-Fluid Temperature: <**Insert deg F**>.

Leaving-Fluid Temperature: <**Insert deg F**>.

Entering-Air, Wet-Bulb Temperature: <**Insert deg F**>.

* + - * 1. Fan Drive Assembly:

Retain "or" option in "Type" subparagraph below to allow choice of drive type. Coordinate with "Belt Drive" and "Gear Drive" paragraphs in "Fan and Drive Assembly" Article.

Type: [**Belt**] [**or**] [**direct**].

Fan Motor:

Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].

Motor Size per Cell: <**Insert number**> hp.

Full-Load Ampacity: <**Insert number**> A.

Minimum Circuit Ampacity: <**Insert number**> A.

Maximum Overcurrent Protection Device: <**Insert number**> A.

Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert number**> V ac, 3 phase, 60 Hz.

* + - * 1. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet**> [**when measured according to CTI ATC 128**].

Retain "Collection Basin Heater" paragraph below to have heaters furnished with cooling tower by manufacturer.

* + - * 1. Collection Basin Heater:

Basin Water Temperature: [**40 deg F**] <**Insert temperature**>.

Outdoor Ambient Temperature: [**0 deg F**] [**Minus 20 deg F**] <**Insert temperature**>.

Retain first five subparagraphs below for electric basin heaters.

Capacity per Cell: <**Insert number**> kW.

Full-Load Ampacity: <**Insert number**> A.

Minimum Circuit Ampacity: <**Insert number**> A.

Maximum Overcurrent Protection Device: <**Insert number**> A.

Electrical Characteristics: [**208**] [**240**] [**480**] <**Insert number**> V ac, 3 phase, 60 Hz.

Retain first six subparagraphs below for hot-water-coil basin heaters.

Capacity/Cell: <**Insert MBtu/h**>.

Coil fluid Type: [**Water**] <**Insert fluid type**>.

Entering-Fluid Temperature: <**Insert deg F**>.

Leaving-Fluid Temperature: <**Insert deg F**>.

Fluid Flow Rate: <**Insert gpm**>.

Fluid Pressure Drop: <**Insert psig**>.

Retain three subparagraphs below for steam-coil or -injection basin heaters.

Capacity/Cell: <**Insert MBtu/h**>.

Steam Flow: <**Insert lb/h**>.

Steam Pressure: <**Insert psig**>.

* + - 1. SOURCE QUALITY CONTROL

Retain "Performance Test" paragraph below as a method of verifying performance. Verify that Project requirements are within parameters of CTI STD 201RS and that listed manufacturers can comply with requirements. See "Testing and Inspecting" Article in the Evaluations for a discussion on factory tests.

Factory performance tests add cost. Consult Director’s Representative to confirm need for performance testing. Consult listed manufacturers for estimated cost of testing.

* + - * 1. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS.

Retain first subparagraph below to witness testing.

Allow [Director’s Representative] <**Insert entity**> access to place where cooling towers are being tested. Notify Director’s Representative in writing at least [**30**] <**Insert number**> days in advance of testing.

Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

Retain "Seismic Performance Testing" paragraph below to certify performance through testing. Consult manufacturer for additional information related to availability, cost, and schedule impact.

* + - * 1. Seismic Performance Testing: Shake table tested by an independent [**or a factory-certified**] laboratory to certify performance complies with seismic requirements indicated.

Retain first subparagraph below to witness testing.

Allow [Director’s Representative] <**Insert entity**> access to place where cooling towers are being tested. Notify Director’s Representative in writing at least [**30**] <**Insert number**> days in advance of testing.

Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

Retain "Factory Functional Tests" paragraph below to require factory testing. Consult listed manufacturers for availability of factory tests.

* + - * 1. Factory Functional Tests:

Retain any of first seven subparagraphs below as applicable. Coordinate with applicable component requirements specified in this Section.

Test collection and distribution basins after assembly, and prove free of leaks.

Test factory-installed electric/electronic water-level controls for proper operation.

Test factory-installed electric basin heaters for proper operation.

Test factory-installed fan and drive assemblies for proper operation.

Test factory-installed control package for proper operation.

Test access doors to ensure smooth operation and proper fit.

<**Insert additional functional test requirements**>.

Retain first subparagraph below to witness testing.

Allow [Director’s Representative] <**Insert entity**> access to place where cooling towers are being tested. Notify Director’s Representative in writing at least [**30**] <**Insert number**> days in advance of testing.

Submit report documenting tests performed and results within one week of test date.

Retain " Director’s Representative Travel Expenses" paragraph below if travel expenses are to be included. Consult Director’s Representative.

* + - * 1. Director’s Representative Travel Expenses:

Include cost associated with Director’s Representative travel expenses to witness testing. Total value attributed to travel expenses shall be clearly indicated.

Expenses shall include round-trip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.

Exclude other incidental expenses not indicated.

Include travel expenses for [**one**] [**two**] <**Insert number**> Director’s Representative representatives with origin of <**Insert city, state, and country**>.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine cooling towers before installation. Reject cooling towers that are damaged.
				2. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation.

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

Retain first subparagraph below for mounting cooling towers on concrete bases and support structure.

Verify sizes and locations of concrete bases and support structure with actual equipment.

Retain first subparagraph below for mounting cooling towers on a structural-steel support structure.

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

Retain subparagraph below for mounting cooling towers on the roof.

Verify sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment.

* + - * 1. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. INSTALLATION

Retain first paragraph below if cooling towers are to be installed on a support structure other than a concrete base. Indicate design of support structure on Drawings.

* + - * 1. Install cooling towers on support structure.
				2. Equipment Mounting:

Retain first subparagraph below to require equipment to be installed on cast-in-place concrete equipment bases.

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."

Retain one of two subparagraphs below if vibration and seismic control is required. Retain first for projects in seismic areas; retain second for projects not in seismic areas. Indicate vibration isolation and seismic-control device type and minimum deflection in supported equipment schedule on Drawings.

Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

* + - * 1. Install anchor bolts to elevations required for proper attachment to supported equipment.
				2. Maintain manufacturer's recommended clearances for service and maintenance.
				3. Maintain clearances required by governing code.
				4. Loose Components: Install components, devices, and accessories furnished by manufacturer with cooling tower, that are not factory mounted.

Retain subparagraph below to require involvement of manufacturer's factory-trained service personnel's in installation of field-installed components.

Loose components shall be installed by [**manufacturer's factory-trained service personnel**] [**Contractor under supervision of manufacturer's factory-trained service personnel**].

* + - 1. DUCT CONNECTIONS

Retain this article for applications with cooling tower inlet or discharge to be ducted. See the Evaluations for discussion.

* + - * 1. Duct installation requirements are specified in other Sections. Drawings indicate general arrangement of ductwork and accessories.
				2. Where installing duct adjacent to cooling towers, allow space for service and maintenance.
				3. Install flexible connectors at duct connections to cooling towers.
			1. PIPING CONNECTIONS

Coordinate piping installation and specialty arrangements with Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be omitted.

* + - * 1. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
				2. Where installing piping adjacent to cooling towers, allow space for service and maintenance.
				3. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
				4. Install drain piping with valve at cooling tower drain connections and at low points in piping.
				5. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
				6. Makeup-Water Piping:

Comply with applicable requirements in Section 221116 "Domestic Water Piping."

Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

* + - * 1. 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, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.

Connect to leaving-cooling-tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.

Make connections to cooling tower with a flange.

Retain "Equalizer Piping" paragraph below if external equalizer piping is required.

* + - * 1. 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 and drain connection with valve.

Make connections to cooling tower with a flange.

Retain "Basin Heater Hot-Water Piping" or "Basin Heater Steam and Condensate Piping" paragraph below. Retain "Basin Heater Hot-Water Piping" paragraph below if hot-water basin heater is retained.

* + - * 1. Basin Heater Hot-Water Piping:

Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.

Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.

Make connections with a flange, union, or mechanical coupling.

Retain "Basin Heater Steam and Condensate Piping" paragraph below if steam basin heater is retained.

* + - * 1. Basin Heater Steam and Condensate Piping:

Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage, and flow meter.

Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.

Make connections with a flange or union.

Retain "Basin Sweeper Piping" paragraph below if basin sweeper piping is retained.

* + - * 1. Basin Sweeper Piping:

Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

Connect to supply connections with shutoff valve, flow meter, and drain connection with valve.

Connect to return connections with shutoff valve, balancing valve, flow meter, and drain connection with valve.

Make connections with a flange or union.

* + - 1. ELECTRICAL POWER CONNECTIONS
				1. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
				2. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
				3. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
				4. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.
			2. CONTROLS CONNECTIONS
				1. Install control and electrical power wiring to field-mounted control devices.
				2. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

Retain first paragraph below to connect cooling towers to control system for remote monitoring and control.

* + - * 1. Connect control wiring between cooling tower control interface and control system for HVAC for remote monitoring and control of cooling towers. Comply with requirements in [**Section 230923 "Direct Digital Control (DDC) System for HVAC"**] <**Insert Section**>.
				2. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labeling and identifying products and installations.
			1. FIELD-TESTING PROVISIONS

Retain this article to require future field performance testing.

* + - * 1. Include provisions to include pressure and temperature test ports for cooling tower future field performance testing complying with [**ASME PTC 23**] [**CTI ATC 105**].
				2. Include provisions in field piping to include pressure and temperature test ports for future field performance testing complying with [**ASME PTC 23**] [**CTI ATC 105**].
			1. FIELD QUALITY CONTROL

Retain one of first three paragraphs below.

Retain "Testing Agency" paragraph below to require Contractor to hire an independent testing agency.

* + - * 1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

Retain "Manufacturer's Field Service" paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a Company Field Advisor per OGS Spec Section 014216 to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform tests and inspections" paragraph below to require Contractor to perform tests and inspections and retain option to require Contractor to arrange for the assistance of a factory-authorized service agent.

* + - * 1. Perform tests and inspections[**with the assistance of a Company Field Advisor per OGS Spec Section 014216**].

Retain "Tests and Inspections" paragraph below to describe tests and inspections to be performed.

* + - * 1. Tests and Inspections: Comply with [**ASME PTC 23**] [**CTI ATC 105**].
				2. Cooling towers will be considered defective if they do not pass tests and inspections.
				3. Prepare test and inspection reports.
			1. STARTUP SERVICE
				1. [**Engage a Company Field Advisor per OGS Spec Section 014216 to perform**] [**Perform**] startup service.
				2. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
				3. Obtain performance data from manufacturer.

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

Clean entire unit, including basins.

Verify that accessories are properly installed.

Verify clearances for airflow and for cooling tower servicing.

Check for vibration isolation and structural support.

Lubricate bearings.

Verify fan rotation for correct direction and for vibration or binding, and correct problems.

Adjust belts to proper alignment and tension.

Retain first subparagraph below for cooling towers with variable-speed fans.

Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.

Retain first subparagraph below for cooling towers with vibration switches.

Check vibration switch setting. Verify operation.

Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.

Retain first subparagraph below for cooling towers with basin heaters.

Verify operation of basin heater and control.

Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.

Replace defective and malfunctioning units.

* + - * 1. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
				2. Prepare a written startup report that records the results of tests and inspections.
			1. ADJUSTING
				1. Set and balance water flow to each tower inlet.
				2. Adjust water-level control for proper operating level.

Retain paragraph below for cooling towers with basin heaters.

* + - * 1. Adjust basin heater control for proper operating set point.
			1. DEMONSTRATION
				1. [**Engage a Company Field Advisor per OGS Spec Section 014216 to train**] [**Train**] Facility’s maintenance personnel to adjust, operate, and maintain cooling towers.

Video record the training sessions.

Instructor shall be factory trained and certified.

Perform not less than [**eight**] <**Insert number**> hours of training.

Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.

Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

Obtain Director’s Representative sign-off that training is complete.

Director’s Representative training shall be held at Project site.

END OF SECTION 236513.13