SECTION 236514.17 - CLOSED-CIRCUIT, INDUCED-DRAFT, COMBINED-FLOW 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, closed-circuit, induced-draft, combined-flow 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.

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 percent 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.

Retain first two subparagraphs below if pump is integral to closed-circuit cooling tower.

Pump flow rate, head, brake horsepower, and efficiency.

Pump 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 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 "Seismic Qualification Data" 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.

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

* + - * 1. Product Certificates: For certification required in "Quality Assurance" Article.
        2. Field Test Reports: Include startup service reports.
        3. 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. 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 prerecorded 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. Touchup 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 "ASME Compliance" paragraph below if heat-exchanger coil of closed-circuit cooling towers requires ASME Boiler and Pressure Vessel Code construction. See the Evaluations for discussion.

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

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

Retain subparagraph below for cooling towers with gear drives.

Install seals on gear-drive assemblies to eliminate oil leakage during shipment if shipped with oil.

* + - 1. WARRANTY

When warranties are required, verify with Director’s Representative's counsel 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=12758) 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=123457139986).

[EVAPCO, Inc](http://www.specagent.com/Lookup?uid=123457139988).

[Marley Cooling Technologies; SPX Cooling Technologies](http://www.specagent.com/Lookup?uid=123457139987).

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**] [**the 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 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 application.

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 on-line.

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 of three paragraphs below. Consult listed manufacturers for availability.

* + - * 1. Combined flow with airflow from one side and induced-draft, top-mounted, axial fan; and with pressurized pipe distribution.
        2. Combined flow with airflow from two sides and induced-draft, top-mounted, axial fan; and with pressurized pipe distribution.
        3. Combined flow with airflow from all (four) sides and induced-draft, top-mounted, axial fan; and with pressurized pipe distribution.
      1. CASING AND FRAME
         1. Casing Material: [**Galvanized steel, ASTM A653, G235 coating**] [**Polymer-coated galvanized steel**] [**Stainless steel, Grade 304**] [**Stainless steel, Grade 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: [**Galvanized steel, ASTM A653, G235 coating**] [**polymer-coated galvanized steel**] [**stainless steel, Grade 304**] [**stainless steel, Grade 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

Retain one of two paragraphs below. Retain "Field-Constructed Collection Basin" paragraph to require collection basins to be provided separate from cooling tower. The basinless feature described in first paragraph is not available from all manufacturers on all products. Consult listed manufacturers for limited availability.

* + - * 1. Field-Constructed Collection Basin: Configure tower without a factory-assembled collection basin for installation and operation with a field-constructed collection basin.
        2. Factory-Assembled Collection Basin:

Material: [**Galvanized steel, ASTM A653, G235 coating**] [**Polymer-coated galvanized steel**] [**Stainless steel, Grade 304**] [**Stainless steel, Grade 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.

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" or "Electric/Electronic, 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 on 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, while other options are limiting.

Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel, Grade 304**] [**Stainless steel, Grade 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 setpoint.

Signal adjustable level alarm through relay closure[**for connection to control system**].

Signal 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, while other options are limiting.

Water Stilling Chamber: [**Corrosion-resistant material**] [**FRP**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel, Grade 304**] [**Stainless steel, Grade 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" paragraph below to require basin heaters for projects subject to freezing conditions. See the Evaluations.

* + - * 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 make connections to each electric basin heater with liquid tight conduit.

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

* + - 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
         1. Materials: PVC, with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E84.

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

* + - * 1. Minimum Thickness: [**15 mils**] [**20 mils**] <**Insert value**>, before forming.
        2. 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.

* + - * 1. Fill Material Operating Temperature: Suitable for entering-water temperatures up through [**120 deg F**] <**Insert temperature**>.
        2. Hardware: [**Galvanized**] [**or**] [**stainless**] steel.
      1. HEAT-EXCHANGER COILS

Some material options in "Tube and Tube Sheet Materials" paragraph below are limited to specific manufacturers. Consult listed manufacturers if Project requires specific materials. See "Heat Exchanger" Article in the Evaluations for a discussion about feature options and choices.

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

Some options in "Heat-Exchanger Arrangement" paragraph below are limited to specific manufacturers. Consult listed manufacturers if Project requires specific arrangement. See the Evaluations for discussion.

* + - * 1. Heat-Exchanger Arrangement:

[**Serpentine tubes**] [**serpentine tubes with removable cover plate on inlet and outlet headers**] [**or**] [**straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube**]; sloped for complete drainage of fluid by gravity.

Tubes with extended surface fins if required to achieve performance indicated.

Retain "Multiple Separate Circuits" subparagraph below only in unique applications. Coordinate with requirements indicated on Drawings.

Multiple Separate Circuits: Separate circuits to achieve multiple isolated loops as required by application.

"ASME Compliance" paragraph below is only available with hot-dip galvanized-steel tubes and only required in some applications. Coordinate with "Tube and Tube Sheet Materials" paragraph and "Quality Assurance" Article.

* + - * 1. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; sloped for complete drainage of fluid by gravity.
        2. Field Piping Connections: Vent, supply, and return[**suitable for mating to ASME B16.5, Class 150 flange**].
      1. DRIFT ELIMINATORS
         1. Material: [**PVC**] <**Insert material**>; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> 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
         1. Air-Intake Louvers:

Material: [**PVC**] <**Insert material**>.

UV Treatment: Inhibitors to protect against damage caused by UV radiation.

Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

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

See the Evaluations for discussions on fan drive types.

* + - * 1. Axial Fan: Balanced at the factory[**after assembly**].

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

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

Retain "Blade Pitch" subparagraph below to require this sometimes optional feature. Feature is not available from all manufacturers on all products. Consult listed manufacturers for availability.

Blade Pitch: Field adjustable.

Fan Shaft: [**Corrosion resistant**] [**Stainless steel**] <**Insert material**>.

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.

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

Retain "Automatic Bearing Greasing System" subparagraph below to reduce bearing maintenance intervals. Feature is limited to only some manufacturers on some models. Consult listed manufacturers for availability.

Automatic Bearing Greasing System:

Manufacturer-designed system to provide an as-needed supply of new grease to bearings while reducing the need for periodic bearing maintenance and associated greasing problems.

Easily replaceable storage container filled with recommended grease and located in an easily accessible location on cooling tower exterior. Container capacity of sufficient size to provide grease for [**one year**] <**Insert time**>.

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

* + - * 1. Belt Drive:

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 with two motors. Feature is proprietary. See the Evaluations for discussion.

Two-Motor, Single-Fan Drive:

Two single-speed motors per fan, one sized for full speed and load and the other sized for [**67**] <**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 Drive" paragraph below to require direct drive.

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

Retain "Gear Drive" paragraph below to require gear drive.

* + - * 1. 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.

Gear Drive and Coupling Service Factor: [**2.0**] <**Insert value**> based on motor nameplate horsepower.

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.

Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.

Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to [**10**] [**20**] <**Insert value**> of design speed.

Retain one of two "Drive-to-Motor Connection" subparagraphs below. Coordinate with motor requirements.

Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.

Drive-to-Motor Connection: Connected to motor located outside of cooling tower casing by a full-floating drive shaft.

Retain "Drive Shaft Material" subparagraph below with retained "Drive-to-Motor Connection" subparagraph above.

Drive Shaft Material: [**Corrosion resistant**] [**Stainless steel**], and fitted with flexible couplings on both ends.

Drive Guards: Provide exposed shaft and couplings with guards according to OSHA regulations.

Extend oil fill, drain, and vent to outside of cooling tower casing using [**galvanized-steel**] [**or**] [**stainless-steel**] piping. Provide installation with oil-level sight glass.

* + - * 1. Fan Motor:

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 either TEAO or TEFC option. Epoxy or polyurethane finish option may achieve added corrosion protection.

Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air-over (TEAO)**] [**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 per 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 my manufacturer and product. Consult listed manufacturers for availability.

Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.

Retain "Severe-Duty Rating" subparagraph below to require additional protection. Coordinate with "Motor Enclosure" subparagraph. Severe-duty rating is not available with open dripproof option.

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 provision[**for adjusting belt tension**].

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 number**> percent of motor nameplate horsepower.

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

Retain "Fan Discharge Stack" or "Discharge Hood" paragraph below. Retain "Fan Discharge Stack" Paragraph for projects with height restrictions, lower initial cost, and less emphasis on energy efficiency. Retain "Discharge Hood" paragraph for projects with emphasis on energy efficiency.

* + - * 1. Fan Discharge Stack:

Manufacturer's standard low-profile design.

Material: [**Material to match casing**] <**Insert material**>.

Retain "Stack Extension" subparagraph below if Project requires a minimum stack height to clear an obstruction.

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

Stack Termination: Wire-mesh, [**galvanized-steel**] [**polymer-coated, galvanized-steel**] [**or**] [**stainless-steel**] <**Insert material**> screens; segmented into multiple removable pie sections and complying with OSHA regulations.

"Discharge Hood" paragraph describes feature that is 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. Retain "Discharge Dampers" subparagraph below to require discharge dampers.

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, provide field 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. RECIRCULATING WATER DISTRIBUTION SYSTEM

Retain "Pump" and "Pump Motor" paragraphs below to require pump to be integral to cooling tower. Coordinate with "Piping" paragraph.

* + - * 1. Pump: Close-coupled, single-stage, [**bronze-fitted**]centrifugal pump; with mechanical seal and suitable for outdoor service. Factory install pump with the following:

Retain "Redundant Pump" subparagraph below if requiring an increased level of reliability. Feature is not available from all manufacturers. Consult listed manufacturers for availability.

Redundant Pump: Same performance as required for primary pump; easily switched and maintained while cooling tower remains operating.

Flanges at pump connections to piping.

Strainer[**, with blowdown isolation valve,**] installed in piping on suction side of pump.

Flow balancing valve in piping on discharge side of pump.

* + - * 1. Pump Motor:

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 "with epoxy or polyurethane finish" option in "Motor Enclosure" subparagraph below provides added corrosion protection.

Motor Enclosure: Totally enclosed[**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**>.

Retain "Severe-Duty Rating" subparagraph below to require additional protection. Coordinate with "Motor Enclosure" subparagraph. Severe-duty rating is not available with open dripproof option.

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 one of two "Piping" paragraphs below. Retain first paragraph if piping is integral to cooling tower. Retain second paragraph if field piping connects to remote pump and tank.

* + - * 1. Piping: Interconnecting collection basin to pump and pressurization distribution system.

Design delegated to manufacturer.

External to and supported from cooling tower casing and frame.

Material: [**Corrosion resistant**] [**PVC**] <**Insert material**>.

Install flanges at connections to collection basin and pressurized distribution system.

Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.

* + - * 1. Piping: Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.
      1. ELECTRICAL POWER

Retain this article for factory-furnished or -installed electrical power options for cooling tower fan motors. Not all manufacturers offer 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 and a [**disconnect switch**] [**motor controller**] for each pump motor.
        2. Factory Install: A [**disconnect switch**] [**motor controller**] [**variable-frequency controller**] for each fan motor and a [**disconnect switch**] [**motor controller**] for each pump 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 short-circuit current rating (SCCR) shall be 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 multispeed motors as indicated.

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 shall be 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 (IGBT); 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 7 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 first 13 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 value**> analog inputs (0 to 10 V or 0/4 to 20 mA) and [**four**] <**Insert value**> 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 of first two subparagraphs below, or both.

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 "Vibration Transmitter with Switch" paragraph below to require a vibration transmitter with switch furnished with cooling tower. Transmitters can provide trending of vibration levels to take corrective action before reaching alarm conditions.

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

Enclosure: NEMA 250, Type 4X.

Retain "Display" subparagraph to require a local display.

Display: Local display of measured value, power, and alarm.

Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.

Cooling tower manufacturer shall select range that is suitable for cooling tower provided and recommend switch set point for proper operation and protection.

Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.

Switch:

Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.

Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible[**and where display is easily viewable**].

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

Retain "Gear-Drive, Oil-Level Switch" paragraph below for cooling towers with fan gear drives to require an oil-level switch furnished with cooling tower.

* + - * 1. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to control system**].

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

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.

* + - * 1. Control Package:

Subparagraphs below list optional features. Retain applicable subparagraphs, based on Project conditions, and to correspond with other components.

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

NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount 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 level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve" Paragraph in "Collection Basin Makeup-Water Assembly" Article.

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.

Oil-level switch for each fan with a gear drive, complying with requirements in "Gear-Drive, Oil-Level Switch" Paragraph.

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 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.

* + - * 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.

"Chemical Water Treatment System" paragraph below describes system that is offered by EVAPCO.

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

Microprocessor-controlled conductivity controller housed in a NEMA 250, Type 4X enclosure.

Chemical metering pump housed in a NEMA 250, Type 4X enclosure.

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 required 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. External Motor Platforms with Handrails: [**Aluminum**] [**galvanized-steel**] [**or**] [**stainless-steel**] <**Insert material**> bar grating.
        4. Fan Deck Floor between Cooling Tower Cells:

Factory furnish reinforced fan deck floor panels between cooling tower cells for field installation.

Floor materials shall match adjacent cooling tower cell fan deck.

Fan deck floor shall fasten to and be supported by framing that is attached to cooling tower cells.

Frame shall be constructed of same materials as cooling tower frame.

* + - * 1. Handrail: [**Aluminum**] [**galvanized steel**] [**or**] [**stainless steel**] <**Insert material**> complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.
        2. Internal Platforms: [**Aluminum**] [**FRP**] [**galvanized-steel**] [**or**] [**stainless-steel**] <**Insert material**> bar grating.

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

Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach.

<**Insert platform locations**>.

* + - * 1. Hardware: Galvanized steel when connecting galvanized-steel components; stainless steel when connecting other materials.
      1. HOISTING ASSEMBLY

Retain this article for applications with special service requirements. See the Evaluations for discussion.

* + - * 1. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.

Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.

Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of [**1.5**] <**Insert value**>.

Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load with safety factor.

* + - * 1. Pedestal Base:

Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.

Position pedestal base at a location on cooling tower for hoisting assembly coverage to fan, fan motor, and fan drive assembly.

Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.

Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.

Fasten pedestal base to cooling tower using threaded hardware.

Construct pedestal base of [**hot-dip galvanized steel**] [**or**] [**300L series stainless steel**].

* + - * 1. Davit Arm:

Each cooling tower [**cell**]shall have a davit arm.

Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.

Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.

Construct davit arm of [**hot-dip galvanized steel**] [**or**] [**300L series stainless steel**].

* + - * 1. Winch:

Each davit arm shall have [**a electric-**] [**or**] [**an hand-**] operated winch.

Retain one or both subparagraphs below depending on which option (electric, hand, or both) is retained in subparagraph above.

Electric winch shall include a power cord and plug for connection to a field-installed, weatherproof, 20-A receptacle with 120-V, single-phase, 60-Hz field power supply.

Hand-operated winch with gear mechanism to limit force on handle to not more than 80 lb when lifting the heaviest component.

Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.

Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.

* + - * 1. Hardware: [**304**] [**or**] [**316**] series stainless steel.
        2. Nameplate:

Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.

Letter size legible from a distance of 60 inches and not less than 1/2 inch.

Fasten nameplate at multiple points with stainless-steel rivets or screws.

* + - 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**] [**two**] [**or**] [**all**] sides.
        3. Maximum Drift Loss: [**0.001**] <**Insert number**> percent of design water flow.
        4. Heat Exchanger:

Fluid Type: [**Water**] <**Insert type**>.

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

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

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

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

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

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

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

Airflow 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**] [**direct**] [**or**] [**gear**].

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 value**>.

Minimum Circuit Ampacity: <**Insert value**>.

Maximum Overcurrent Protection Device: <**Insert amperage**>.

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

* + - * 1. Pump and Motor:

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

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

Full-Load Ampacity: <**Insert value**>.

Minimum Circuit Ampacity: <**Insert value**>.

Maximum Overcurrent Protection Device: <**Insert amperage**>.

Electrical Characteristics: [**120**] [**208**] [**240**] [**277**] [**480**] <**Insert value**>-V ac, [**single**] [**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**>.

Capacity per Cell: <**Insert kilowatts**>.

Full-Load Ampacity: <**Insert value**>.

Minimum Circuit Ampacity: <**Insert value**>.

Maximum Overcurrent Protection Device: <**Insert amperage**>.

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

* + - 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, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

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.

* + - * 1. Heat-Exchanger Factory Pressure and Leak Tests:

Pneumatically test heat-exchanger assembly while submerged underwater and prove to be free of leaks.

Test pressure equal to [**1.5**] <**Insert value**> times rated pressured, but not less than <**Insert psig**>.

Submit report documenting test and results.

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 value**> Director’s Representative representative(s) 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 the cooling tower that are not factory mounted.

Retain subparagraph below to require involvement of manufacturer's factory-trained service personnel 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. 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 "Basin Sweeper Piping" paragraph below if basin sweeper piping is installed.

* + - * 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 [**DDC system**] <**Insert system description**> 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 identification products and installations.
      1. FIELD TESTING PROVISIONS

Retain this article if there is requirement for future field-performance testing.

* + - * 1. Include provisions to include temperature and pressure 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 temperature and pressure 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 pre 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.

Retain first subparagraph below if pump is an integral part of cooling tower.

Verify pump rotation for correct direction, vibration, cavitation and flow and correct problems.

Retain first subparagraph below for cooling towers with belt drives.

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 [**8**] <**Insert value**> 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 236514.17