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USACE / NAVFAC / AFCESA / NASA **UFGS-23 65 00 (August 2008)**

Preparing Activity: NAVFAC **Superseding**
UFGS-23 65 00.00 10 (January 2008)
UFGS-23 66 00.00 20 (July 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2012
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 65 00

COOLING TOWERS

08/08

-- End of Section Table of Contents --

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SECTION 23 65 00

COOLING TOWERS
08/08

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NOTE: This guide specification covers the requirements for induced mechanical draft cooling towers (both packaged and field-erected).

Use of electronic communication is encouraged.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information. Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.13	(2005; R 2010) Methods for the Measurement of Sound Pressure Levels in Air (ASA 118)

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2005) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2012) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A48/A48M	(2003; R 2008) Standard Specification for Gray Iron Castings
ASTM A653/A653M	(2011) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C67	(2012) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2996	(2001; R 2007e1) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2012a) Standard Test Method for Surface Burning Characteristics of Building Materials

COOLING TECHNOLOGY INSTITUTE (CTI)

CTI ATC-105	(2000) Acceptance Test Code
CTI ESG-114	(2007) Design of Cooling Towers with Douglas Fir Lumber
CTI STD-111	(2009) Gear Speed Reducers
CTI STD-134	(2007) Plywood for Use in Cooling Towers
CTI Std-103	(2007) Redwood Lumber Specifications
CTI Std-112	(2009) Pressure Preservative Treatment of Lumber
CTI Std-137	(2009) Fiberglass Pultruded Structural Products for Use in Cooling Towers
CTI Std-201	(2011) Standard for the Certification of Water Cooling Tower Thermal Performance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2011) Motors and Generators
NEMA MG 11	(1977; R 2007) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 214	(2011; Errata 2011) Standard on Water-Cooling Towers
NFPA 255	(2006) Standard Method of Test of Surface Burning Characteristics of Building Materials
NFPA 70	(2011; Errata 2 2012) National Electrical Code

REDWOOD INSPECTION SERVICE (RIS) OF THE CALIFORNIA REDWOOD ASSOCIATION (CRA)

RIS Grade Use	(1998) Redwood Lumber Grades and Uses

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J534	(2008) Lubrication Fittings

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA G-5	(1998) Western Lumber Grading Rules

1.2 SUBMITTALS

****
NOTE: Review Submittal Description (SD) definitions

in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cooling Towers[; G][; G, [_____]]

Manufacturer's standard catalog data, at least [5 weeks] [_____] prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Posted Instructions[; G][; G, [_____]]

Posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated

plastic and be posted where indicated by the Contracting Officer.

Demonstrations[; G][; G, [_____]]

A schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions[; G][; G, [_____]]
A letter, at least [2] [_____] weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

[Packaged cooling tower - installation instructions[; G][; G, [_____]]]

[Field-erected cooling tower - installation instructions[; G][; G, [_____]]]

[Packaged cooling tower - field acceptance test plan[; G][; G, [_____]]]

[Field-erected cooling tower - field acceptance test plan[; G][; G, [_____]]]

[Packaged cooling tower - field acceptance test report[; G][; G, [_____]]]

[Field-erected cooling tower - field acceptance test report[; G][; G, [_____]]]

SD-07 Certificates

Service Organization

Cooling Tower

SD-08 Manufacturer's Instructions

[Packaged cooling tower - installation instructions]

[Field-erected cooling tower - installation instructions]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 SAFETY REQUIREMENTS

****
NOTE: Catwalk, ladder and guardrail may be required. If so, select the applicable item and delete the others and indicate on drawings the selected item. If not applicable, delete the entire sentence within the brackets.
****

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1. [[Catwalk,] [ladder,] [and guardrail] shall be provided where indicated and in accordance with[Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].]

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

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NOTE: Warranties on Navy construction: Warranties for equipment, materials, or design furnished, or workmanship performed by the Contractor or any subcontractor or supplier, has a duration of one year from the date of final acceptance of the work. An exception is in normal commercial practice longer warranty period for particular construction are given.

An example of a typically longer duration period is the warranty for the chiller refrigeration compressor, is typically good for five years. The Contractor submits to the Contracting Officer all applicable warranties signed and official prior to project closeout.

If a longer than one year warranty duration is desired, it is recommended that the specifier/designer survey the chiller market to determine if the chiller industry normally provides

a longer warranty for all of the subject chiller or for any major components.

A warranty duration of longer than a year, and not covered normally by the industry, requires a Level III Contracting Officer's written determination documenting that the extra warranty protection is needed.

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1.6 Warranty

In addition to the warranty requirements specification in Division 00, Contract Requirements, the following major components of the cooling tower shall be covered by a warranty of a duration period of five years: [fans,] [fan drives,] [electric motors,] [cold water basin,] [basin heater].

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard commercial catalogued products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship.

The standard products shall have been in satisfactory commercial or industrial use in field service for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. This 6000 hour record shall not include any manufacturer's prototype or factory testing.

Records of satisfactory field use shall be completed by a product that had been, and presently is, sold, or offered for sale on a commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including cooling towers, cooling tower gear drive assemblies, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life. Plates shall be fixed in prominent locations.

2.3 ELECTRICAL WORK

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NOTE: Show the electrical characteristics, motor starter type(s), enclosure type, and maximum rpm on the drawings in the equipment schedules.

Where reduced-voltage motor starters are recommended by the manufacturer or required otherwise, specify

and coordinate the type(s) required in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Reduced-voltage starting is required when full voltage starting will interfere with other electrical equipment and circuits and when recommended by the manufacturer. Where adjustable speed drives (SD) are specified, reference Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS. The methods for calculating the economy of using an adjustable speed drive is described in UFC 3-520-01, "Interior Electrical Systems".

****

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

e. [Where two-speed or variable speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW 10 hp or less and adjustable frequency drives for larger motors.] [Inverter duty premium efficiency motors shall be provided for variable frequency drive applications. Motors shall have efficiency labeling in accordance with NEMA MG 1]. [Provide variable frequency drives for motors as specified in Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS.]

2.4 COOLING TOWER MATERIALS

2.4.1 Lumber

2.4.1.1 Douglas Fir

CTI ESG-114, WWPA G-5, Grade B and better, Industrial Clear. Douglas fir shall have a preservative treatment in accordance with CTI Std-112.

2.4.1.2 Plywood

CTI STD-134, Exterior Grade, type and thickness as specified for the application.

2.4.1.3 Pressure Treated Lumber

Pressure treated lumber shall be in accordance with CTI Std-112. Wood exposed as the result of notching, cutting, or drilling shall be saturated with the preservative.

2.4.1.4 Redwood

CTI Std-103, RIS Grade Use California Redwood, clear of all hearts.

2.4.2 Fiberglass Reinforced Plastic (FRP)

FRP components shall be inert, corrosion resistant, and fire-retardant with a thickness of 3.66 kg/square meter 12 ounces per square foot. FRP components shall contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3. Components manufactured of polystyrene will not be permitted.

2.4.3 Zinc-Coated Steel

Components fabricated of zinc-coated steel shall be not lighter than 16 gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153/A153M and ASTM A123/A123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square meter[2.5 ounces per square foot] [2.35 ounces per square foot] of surface. Galvanized surfaces damaged due to welding shall be coated with zinc rich coating conforming to ASTM D520, Type 1.

2.4.4 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D1784, Type I, Grade 1 with a flame spread rating of 25 or less per ASTM E84.

2.4.5 Stainless Steel Sheets

Type 304.

2.4.6 Concrete

Concrete shall conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted.

2.4.7 Hardware

Bolts shall be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt shall be provided with neoprene and cadmium-plated steel washers under the heads. Nails shall be silicon bronze, commercial bronze, or stainless steel. Hardware shall meet the salt-spray fog test as defined by ASTM B117. Angle brackets and similar parts shall be cast iron or zinc-coated steel. Zinc coatings shall conform to ASTM A153/A153M and [ASTM A123/A123M] [ASTM A653/A653M], as applicable, and shall have an extra heavy coating of not less than 2.5 ounces per square foot of surface. Nails shall be silicon bronze, commercial bronze, or stainless steel. Subject hardware to a salt-spray fog test in accordance with ASTM B117. No signs of corrosion shall be evident after 1,000 hours continuous exposure to a 5 percent salt spray.

2.5 COOLING TOWERS

2.5.1 Factory Assembled Towers

2.5.1.1 Description

The cooling tower shall be of the [induced mechanical draft][or forced mechanical draft] type. The cooling tower shall include frames and casings, louvers, drift eliminators, partitions, windbreak baffles, drift-check walls, cold water basin equipment, fans and fan walls, blowers, drives, electric motors, access doors, [working platforms,] inspection plates, and panels.

2.5.1.2 Construction

Tower shall be constructed to withstand a wind pressure of not less than 1.44 kilopascal (kPa) 30 psf on any external surface. Fan deck shall be constructed to withstand a live load of not less than 2.87 kPa 60 psf in addition to the concentrated or distributed loads of equipment mounted on the fan deck. [A 15 percent increased loading shall be included for ice or snow load.]

The hot water distribution system shall be of the open basin gravity feed type or the pressurized spray header type design.

2.5.1.3 Tower Frame and Louvers

Provide frame constructed from [galvanized steel][_____]. Intermediate structural members shall be provided for rigidity and support of casings, louvers, fill, distribution systems, fan decks, and other equipment. Inlet air louvers shall permit free air passage but no splashout, and shall be designed to prevent debris and sunlight from entering the cold water basin.

[2.5.1.4 Air Inlet And Discharge Connections

On forced draft centrifugal type units, the air inlet and discharge connections shall have flanged or lipped projections for connecting to ductwork.]

2.5.1.5 Fill

The fill shall support expected loads without sag or failure and arranged to effectively break up the water. The fill shall be manufactured and performance tested by the cooling tower manufacturer. The fill shall be of

the materials as specified. Polyvinyl chloride fill is suitable for inlet temperatures to 51.7 degrees C 125 degrees F on cross flow type units and temperatures to 54.4 degrees C 130 degrees F on counterflow type units. Chlorinated polyvinyl chloride(CPVC) fill shall be used for applications where inlet temperatures are greater than 54.4 degrees C 130 degrees F.

2.5.1.6 Drift Eliminators

Provide drift eliminator sections designed and arranged to effectively trap water droplets entrained in the discharge airstream. Sections shall be assembled in easily removable sections for [forced mechanical drift tower][and][counterflow induced mechanical draft tower].

2.5.1.7 Cold Water Basin Equipment.

Include sump with removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 13 mm 1/2 inch pipe size shall be the balanced piston type. Valve seats and disks shall be replaceable. [Electric water level control shall be provided.]

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.1.8 Fans, Blowers, and Drives.

The towers shall have propeller-type fans having not less than four metal blades or squirrel-cage, centrifugal-type blowers, as applicable. Fans and blowers shall be designed and constructed to withstand 50 percent overspeed above normal maximum operating speeds.

If belt drives are utilized, multi-grooved solid back single belt design shall be used to avoid uneven belt stretch. Adjustment shall be provided for belt tension and drive centers. Belt drives shall be designed and constructed for 150 percent overload.

Sheaves located in the airstream shall be corrosion-resistant material. Shafting for gear drives shall have flexible-type couplings requiring no lubrication.

The gear assemblies shall be enclosed in an oil filled housing provided with fill and drain plugs.

2.5.1.9 Tower Piping

Plastic piping shall be not less than schedule 40 and conform to ASTM D2996. Fittings for other piping materials shall be of the same material or equal and of the same class and grade as the pipe.

2.5.1.10 Electric Motors

Requirements are specified in paragraph ELECTRICAL WORK.

[2.5.1.11 Vibration Cutout Switch.

Provide [vibration cutout switch] [electronic vibration cutout switch with auxiliary contacts] in a protected position and most effective location, interlocked with the fan wiring to electrically open the motor circuit under excessive fan vibration.]

2.5.1.12 Performance

The factory assembled tower shall have Cooling Tower Institute certification that, in accordance with CTI Std-201, the cooling tower will perform thermally at the rating published by the tower manufacturer in his copyrighted literature.

2.5.1.13 Sound Power Level

Sound power levels, in decibels (dB)with a reference pressure of 0.0002 microbars, of the cooling tower shall be not greater than the maximum permitted dB levels for the designated octave band as set forth in Table I or Table II. The sound power level data for the cooling tower shall have been verified in tests conducted in accordance with ASA S1.13.

Table I. Sound Power Level For Induced Mechanical Draft Type								
Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

Table II. Sound Power Level For Forced Mechanical Draft Type								
Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

****

NOTE: The numbers shown in Table 1 are ranges of acceptable/recommended sound power levels.

****

2.5.1.14 Drift Loss

Drift loss shall be not greater than 0.005 percent of the water circulated.

2.5.2 Lubrication

The lubricating points shall be extended to the outside of the unit for easy accessibility. Hydraulic lubrication fittings shall be in accordance with SAE J534. Where use of high pressure lubricating equipment, 6894 kPa 1000 psi or higher, will damage grease seals or other parts, a suitable warning shall be affixed to the equipment in a conspicuous location.

2.5.3 Factory Finish System

Manufacturer's standard factory finish system shall be provided.

****

NOTE: Galvanized metal is the standard finish for most manufacturers.

****

[Factory painting system] [Galvanized metal] shall have been proven to withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117.

For that salt-spray fog test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C 120 degrees F, the factory painting system be designed for the temperature service and shall have been proven to pass the specified salt-spray test.

2.5.4 [Field-Assembled Cooling Towers

Factory fabricated, factory-assembled towers which are shipped to the job site in separate cells or modules shall be provided with all appropriate manufacturer's hardware for assembly in the field. Factory fabricated, field-assembled towers shall be assembled and adjusted at the job site by a factory representative.]

2.5.4.1 Framework, Casing, and Supports

****

NOTE: Packaged type cooling towers are typically constructed to withstand a 1.4 kPa (30 psf) windload.

****

Towers shall be designed and constructed to withstand a wind pressure of not less than [1.4] [_____] kPa [30] [_____] pound-force per square foot (psf) on external surfaces. [A 15 percent increased loading shall be included for ice or snow load.] [Air inlet and discharge terminations shall have flanged or lipped projections for connecting ductwork.] Framework, structural supports, and equipment supports shall be [zinc-coated steel,] [Type 304 stainless steel,] [air-entrained concrete] [FRP,] [or] [lumber]. Casing (exterior enclosing walls) shall be constructed of [zinc-coated steel] [Type 304 stainless steel] [air-entrained concrete] [FRP] [or] [lumber]. Framework design for wood towers shall conform to requirements of CTI Std-103 for redwood construction and CTI ESG-114 for Douglas fir construction. Notching structural wood members may be permissible only if the members are increased proportionately in size to provide equivalent strength. Materials provided for framework, casings and equipment supports shall be compatible. Structural supports shall be provided in accordance with the recommendations of the manufacturer of the tower unless otherwise indicated. [Cold-pour concrete joints in vertical walls shall have a continuous water-stop stripping of molded polyvinyl plastic (150 mm 6 inch dumbbell).]

2.5.4.2 Foundations

****

NOTE: For the design of a tower foundation, indicate the location, the size, the reinforcement requirements, etc. necessary for a cooling tower available from three commonly known manufacturers. For small retrofit type jobs the designer may choose to show the general layout of the foundation and rely on the Contractor to design and construct the foundation based on the cooling tower to be provided. Delete the last two sentences of the paragraph if the foundation is not to be designed by the Contractor.

****

Cooling tower foundations shall meet the requirements of the cooling tower manufacturer and wind and seismic loads, wind and seismic loads and be as indicated. Foundation design shall be based on the load conditions and soil bearing value indicated. Foundation calculations shall be submitted with the equipment drawings.

2.5.4.3 Stairways and Ladders

Provide stairs, 60-degree ship ladders or straight-rung ladders of standard design, starting at [ground] [roof] level and extending as high as required to gain access to fan decks and water distribution systems. Stairways and ladders shall be hot-dip, zinc-coated steel. Ladders higher than 3.66 meters 12 feet shall have a safety cage.

2.5.4.4 Handrailings

Steel handrailings shall be not less than 1067 mm 42 inches high around the exterior of each working surface that is 3.66 m 12 feet or more above the ground, roof, or other supporting construction. Railings shall be not smaller than 32 mm 1-1/4 inch zinc-coated steel pipe with standard zinc-coated steel railing.

2.5.4.5 Access Doors

Each tower shall be provided with access doors at grade level to provide entry to the interior for service maintenance without removal of the fill. Doors shall be provided on each endwall of each cooling tower cell. Frame and brace access doors to prevent damage when opening and closing. Doors shall be located adjacent to float controls.

2.5.4.6 Louvers

Air inlets for each cooling tower shall be provided with individually removable louvers arranged to prevent the escape of water. Louvers shall be zinc-coated steel, [Type 304 stainless steel,] [FRP,] or lumber. Materials provided for casings and louvers shall be compatible; one material shall not produce stains upon the other. Louvers constructed of lumber shall be of a thickness to withstand alternate wetting and drying without cracking or splitting. Air intakes shall be provided with 25 mm 1 inch zinc-coated steel mesh.

2.5.4.7 Fan Deck and Cylinder

Each fan shall be mounted in a fan cylinder (or stack) to elevate the fan discharge air. Total extension height shall not exceed the fan diameter. Each fan cylinder shall be provided with a zinc-coated steel 2.75 mm 12 gauge wire mesh securely mounted to the top of the cylinder in accordance with manufacturer's recommendations. Fan decks shall be designed to withstand a live load of not less than [1.9] [2.9] kPa [40] [60] psf in addition to the concentrated or distributed loads of equipment mounted on the fan decks. [Fan deck and cylinders shall be constructed of zinc-coated steel, lumber, Type 304 stainless steel, or FRP and be compatible with the entire tower construction.] [Fan deck shall be constructed of precast, reinforced lightweight concrete, in multiple sections, forming a complete, vibration-free base for mounting fan, speed reducer, drive shaft, motor, and fan stacks. Fan cylinders (or stacks) shall be constructed of precast, reinforced lightweight concrete in multiple sections, constrained with bands of zinc-coated steel conforming to ASTM A123/A123M, not less than 3 by 75 mm 1/8 by 3 inches, and bolted to form a compressive load on stack perimeter. Fan cylinder shall be secured in place on the fan deck with Class A mortar.]

2.5.4.8 Fans

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NOTE: When the density of the ambient air to be handled by the fans differs substantially from the density of the standard air value of 1.2 kg per cubic m (0.075 pound per cubic foot) at 21 degrees C (70 degrees F) and 101 kPa (29.92 inches mercury), the density of the air and/or the elevation above mean sea level will be shown on the drawings.
****

Fans shall be the [centrifugal] [or] [adjustable-pitch propeller] type, constructed of zinc-coated steel, Type 304 stainless steel, aluminum or an aluminum alloy, or FRP. Propeller type shall have a maximum tip speed of 330 m/minute 10,800 fpm. Fan blade assembly shall be both statically and dynamically balanced after assembly of the cooling tower. Fan hub shall be constructed of [zinc-coated steel] [stainless steel] [cast aluminum] with adequate surface protection against corrosion. Complete fan assembly (fan and mounting) shall be designed to give maximum fan efficiency and long life when handling saturated air at high velocities. Each cooling tower fan shall be provided with a ball and pedestal type vibration limit switch which shall stop the corresponding fan motor in the event of sensing excessive fan vibration.

2.5.4.9 Speed Reducers Gears and Drive Shaft

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NOTE: Double reduction gear reducer should be considered where low noise requirement is a factor.
****

Speed reducer gears shall be rated in accordance with CTI STD-111. Gear reducers shall be of the [spiral bevel, single reduction] [spiral or helical, double reduction] type. Reducer shall be mounted in accordance with manufacturer's recommendations. Each reducer shall be provided with an oil level cutoff switch interlocked to the fan motor. Each reducer shall be provided with an oil level sight glass, fill, drain, and vent

lines located in a readily accessible position. Drive shafts shall be the full floating type with flexible couplings at both ends and have a service factor of 1.0 or greater. Drive shafts shall be of stainless steel, fitted each end with flexible couplings (stainless steel plate type). Each drive shaft shall be provided with a galvanized steel guard, to prevent damage to surrounding equipment in case of shaft failure. Provision shall be made for lubrication of all bearings. Bearings shall be accessible to the extent that each bearing can be lubricated without dismantling fan.

2.5.4.10 Electric Motors

****
NOTE: Delete the last sentence if inapplicable.

Consider the following for energy efficiency in cooling towers:

Induced draft fans, VFD's and designing to 0.4 percent wet bulb temperature.
****

Each motor shall be a [single speed] [two speed], totally enclosed, insulation Class B, NEMA Design B, continuous-rated type which conforms to NEMA MG 1. Motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures and be located outside the discharge airstream. Motors shall be mounted according to manufacturer's recommendations. [Two-speed motors shall have a single winding with variable torque characteristics.] [Motors shall be provided specifically for either pump or fan application and shall comply with the requirements of paragraph ELECTRICAL WORK.]

2.5.4.11 Cold Water Basin

****
NOTE: Delete the bracketed sentences at the end of the paragraph if a field-erected type tower is not specified.
****

Basin shall be completely watertight and constructed of [zinc-coated steel] [Type 304 stainless steel] [high density, air-entrained concrete] [FRP] [36 mm 1-1/2 inch tongue and groove lumber]. Basin shall be constructed and installed to ensure that air will not be entrained in outlets when operating and no water will overflow on shutdown. Each individual sump shall be provided with an individual outlet. Each outlet shall be provided with a 1/2 inch mesh, zinc-coated steel wire securely mounted to prevent trash from entering the outlet. Each basin shall be provided with overflow and valved drain connections. Each basin shall be provided with a float-controlled, makeup water valve as indicated. The makeup water shall discharge not less than 50 mm 2 inches or two pipe diameters, whichever is greater, above the top of the basin. [Basin floor slab shall be made in a continuous pour. A continuous water-stop stripping of molded polyvinyl plastic (150 mm 6 inch dumbbell) shall be located on the centerline position of the basin wall section/floor slab intersection, and at all other cold pour joints. Basin wall sections shall be made in a second continuous pour, contain the necessary reinforcing steel as submitted by the manufacturer and approved, and be arranged to interlock with the water-stop seal in the floor slab, forming a completely waterproof basin.]

2.5.4.12 Electric Basin Heater

Heater shall be the electric immersion type with water-tight junction boxes mounted in the basin with sufficient capacity to maintain the basin water temperature above 4.4 degrees C 40 degrees F at an ambient temperature of [_____] degrees C degrees F. Heater shall be complete with control thermostat, transformer, contactor, and low water level heater protection.

2.5.4.13 Hot Water Distribution System

****
NOTE: The gravity-flow type distribution system will be the system of choice. Pressurized-flow type systems will typically only be specified for field-erected, counterflow type towers

Piping connecting to a cooling tower will be externally supported, independent of the tower structure and piping.
****

Water distribution shall be the [gravity-flow] [pressurized-flow] type system which distributes waters evenly over the entire fill surface. Each tower cell shall be designed so that a water flow of 140 percent capacity will not cause overflowing or splashing. The distribution system for each cell shall include adjustable flow control valves. The entire distribution system shall be self-draining and nonclogging. Piping shall be either cast iron, ductile iron, threaded-glass-fiber reinforced epoxy pipe, polypropylene, PVC or Schedule 80 black steel.

a. Gravity-Flow System: System shall be provided with open basins which include a splash box or baffles to minimize splashing of incoming hot water and holes that evenly distribute the water over the entire decking area. Holes used in a water basin shall be provided with ceramic or plastic orifice inserts.

b. Pressurized-Flow System: System shall include piping, fittings, branches, and spray nozzles. Spray nozzles shall be stainless steel, bronze, polypropylene, or high-impact plastic. Nozzles shall be cleanable, nonclogging, removable, and spaced for even distribution.

c. Basin Cover: Hot water distribution basins shall be provided with the tower manufacturer's standard removable, [wood] [zinc-coated steel] [stainless steel] [FRP] covers. Covers shall prevent airborne debris from entering the basin.

2.5.5 Drift Eliminators

****
NOTE: For small, packaged type towers, the expected drift loss can be specified as low as 0.02 percent of the circulating water rate. In larger, field-erected type towers, the expected drift loss can be specified as low as 0.005 percent of the circulating water rate.

Delete the last set of bracketed sentences if a field-erected type tower is not specified.
****

Eliminators shall be provided in the tower outlet to limit drift loss to not over [0.02] [0.005] percent of the circulating water rate. Eliminators shall be constructed of not less than 10 mm 3/8 inch lumber or polyvinyl chloride (PVC). [Eliminators shall be of the multi-pass zigzag type, assembled into sections making a strong, stable unit. Eliminators sections shall be supported on PVC or FRP tee sections. Tee sections shall be suspended with 6.35 mm 1/4 inch brass rods connected to stainless steel clips embedded in the bottom side of the roof deck at the time of casting. Stainless steel clips shall be supplied by cooling tower manufacturer for installation by Contractor at time of roof deck pour. Eliminators may be supported by brass or stainless steel suspension rods from the fan deck or supported directly on concrete beams.]

2.5.6 Cold Water Basin Equipment.

Include sump with removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 13 mm 1/2 inch pipe size shall be the balanced piston type. Valve seats and disks shall be replaceable. [Electric water level control shall be provided.]

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.7 Fill (Heat Transfer Surface)

****

NOTE: Typically, both the splash or film type tower fill will be allowed. Film type fill will not be allowed where there is a highly likely possibility that the circulating water will become contaminated with debris (leaves, etc.). Debris in the circulating water will significantly impact the efficiency of a tower with film type fill because of the close spacing of the film material. Note that hot water distribution basin covers will typically prevent most debris from every getting to the fill material.

The most predominant fill material is PVC formed sheets. PVC formed sheets, zinc-coated steel, or lumber will be the typical choices for fill material. Aluminum and/or stainless steel fill will only be specified where either high inlet water temperatures or fireproof construction are concerns. PVC formed sheets will not be provided when the inlet water temperature exceeds 125 degrees F. Tile file will only be considered on field-erected type towers where economically justified.

Delete the bracketed sentences at the end of the paragraph if tile type fill material is not specified.

****

Tower fill shall be the [splash] [or] [film] type. Fill material shall be free to expand or contract without warping or cracking. No plasticized

wood cellulose shall be provided for fill material. Fill shall be removable or otherwise made accessible for cleaning. Space supports shall be corrosion resistant and shall prevent warping, sagging, misalignment, or vibration of the fill material. Fill material and supports shall be designed to provide for an even mixing of air and water. Fill material shall be constructed of [aluminum] [stainless steel] [tile of multi-cell design, set without mortar] [PVC formed sheets, zinc-coated steel, or lumber] in a pattern, and of sufficient height to meet the performance specifications. [Tile fill shall be vitreous, with a low water absorption that will pass a freeze-thaw test conducted in accordance with ASTM C67. Tile fill shall have a minimum crushing strength of 13.8 MPa 2,000 psi over the gross area of the tile when the load is applied parallel to the cells as tested in accordance with ASTM C67. Cast iron tee section lintels supporting the tile fill shall conform to ASTM A48/A48M, Class 25, 3.2 mm 1/8 inch additional thickness for corrosion. Lintels shall be designed with a safety factor of 2 minimum.]

2.5.8 Fire Safety

****
NOTE: Locate the tower in accordance with NFPA 214, and determine the extent and type of fire protection required for all size towers using the factors indicated in NFPA 214.
****

Towers shall conform to NFPA 214. Fire hazard rating for plastic impregnated materials shall not exceed 25. Plastics shall not drip or run during combustion. Fire hazard ratings shall be in accordance with ASTM E84 or NFPA 255.

2.6 FABRICATION

****
NOTE: For equipment to be installed outdoors, adequate protection will be specified. Manufacturers must submit evidence that unit specimen have passed the specified salt spray fog test. A 125 hour test will be specified in a noncorrosive environment and a 500 hour test will be specified in a corrosive environment.
****

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand [125] [500] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.7 SUPPLEMENTAL COMPONENTS/SERVICES

2.7.1 Condenser Water Piping and Accessories

Condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.7.2 Cooling Tower Water Treatment Systems

Cooling tower water treatment systems shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT AND CONDENSER WATER PIPING SYSTEMS.

PART 3 EXECUTION

3.1 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.2 INSTALLATION

Installation of cooling tower systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with NFPA 70, and in compliance with the manufacturer's written installation instructions, including the following:

[(1) Packaged cooling tower - installation instructions]

[(2) Field-erected cooling tower - installation instructions]

3.2.1 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

[3.3 RELATED FIELD TESTING

3.3.1 Test Plans

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the following plans:

[(1) Packaged cooling tower - field acceptance test plan]

[(2) Field-erected cooling tower - field acceptance test plan]

Field acceptance test plans shall developed by the cooling tower manufacturer detailing recommended field test procedures for that

particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance test plans shall be the plan and procedures followed for the field acceptance tests of the cooling towers and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls factory prewired or external controls for the equipment provided under [SECTION 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][SECTION 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS] [SECTION 23 09 23.13 20, BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC].

c. Prerequisite testing: Cooling towers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Tower manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

Tower manufacturer shall identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

f. Job specific: Each test plan shall be job specific and shall address the particular cooling towers and particular conditions which exist

with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

]3.4 Testing

a. Each cooling tower system shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

[1. Packaged cooling tower - field acceptance test report]

[2. Field-erected cooling tower- field acceptance test report]

b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

g. Towers with thermal performance not CTI certified to CTI Std-201 shall have their thermal performance verified by field testing that meets the requirements of CTI ATC-105

-- End of Section --