

COOLING TECHNOLOGY INSTITUTE

Performance Rating of Evaporative Heat Rejection Equipment



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STD-201RS (17)

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and has been approved for publication by the CTI Board of Directors

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This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Approved by the CTI Executive Board.



To assure CTI Standard STD-201, *Standard for Thermal Performance Certification of Evaporative Heat Rejection Equipment*, remains current with advancing technologies and to quickly address newly recognized concerns, it has been placed under continuous maintenance by the standing CTI Task Group on STD-201. Such designation provides for timely consideration of requests for change to any part of the standard and, as may be necessary, publication of addenda or revisions adapted by the Task Group as the result of such a request.

Approved by the
CTI Executive Board

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Performance Rating of Evaporative Heat Rejection Equipment

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Performance Rating of Evaporative Heat Rejection Equipment

1. Purpose

- 1.1 This Standard sets forth a program whereby the Cooling Technology Institute will certify that all models of a line of evaporative heat rejection equipment offered for sale by a specific Manufacturer will perform thermally in accordance with the Manufacturer's published ratings, as limited in Paragraph 5.3.

2. Scope

- 2.1 This Standard applies to Mechanical Draft Evaporative Heat Rejection Equipment such as Cooling Towers, Closed Circuit Coolers and Evaporative Refrigerant Condensers where the thermal capacity is selected from published ratings.

3. Definitions

3.1 Evaporative Heat Rejection Equipment

3.1.1 Open Circuit Cooling Towers. Direct heat rejection whereby heat is removed from exposed water directly to the atmosphere

3.1.2 Closed Circuit Cooling Towers. Indirect heat rejection whereby heat is removed from a process liquid in a closed circuit by an external fluid circuit(s) through a heat exchanger in forms including but not limited to:

3.1.2.1 An external circuit in which recirculating evaporative water is exposed to atmospheric air flow and cascades in direct contact with the outside surface of a coil bundle heat exchanger and in which the process fluid to be cooled is circulated inside the tubes of the coil bundle.

3.1.2.2 A factory standard open cooling tower coupled to a heat exchanger integrally packaged on a common skid containing two separate fluid circuits: an external circuit in which recirculating evaporative water is exposed to atmospheric air flow in the factory standard tower and which passes through one side of the heat exchanger and

the process fluid is circulated in the alternate side of the heat exchanger.

3.1.3 Evaporative Condensers. Indirect heat rejection whereby heat is removed from a condensing refrigerant vapor in a closed circuit of a condensing coil that is continually wetted on the outside surface while air is simultaneously directed over the coil causing a small portion of the water to evaporate

- 3.2 Published Rating. The term "Published Ratings," as used in this Standard, pertains to the thermal performance ratings for the certified product line (presented in printed form or as computer output) available upon request to contractors, distributors, consultants, engineers, and owners for selecting equipment for applications. Preferably such ratings will permit the selection of models for specific duties over the full range of certified operating conditions claimed by the Manufacturer. For Closed Circuit Cooling Towers, this further includes corresponding process fluid pressure drop values.

3.2.1 Standard Rating. A rating at a Standard Operating Condition listed in Table 1.

3.2.2 Application Rating. A rating at conditions other than Standard Rating Conditions.

- 3.3 Rating Conditions. Any set of operating conditions within the limitations of certification as defined in the appendices under which a single level of performance results and which causes only that level of performance to occur.

3.3.1 Standard Rating Conditions. Rating Conditions listed in Table 1 that can be used as a basis of comparison for performance characteristics. The conditions listed below are widely recognized as industry "standard conditions".

Table 1. Standard Rating Conditions

Parameter	Open Circuit Cooling Tower		Closed Circuit Cooling Tower		Evaporative Refrigerant Condenser	
	°C	°F	°C	°F	°C	°F
Fluid	Water		Water		Ammonia	
Inlet Fluid Temperature	35.0	95.0	38.9	102.0		
Outlet Fluid Temperature	29.4	85.0	32.2	90.0	35.7	96.3
Wet Bulb Temperature	25.6	78.0	25.6	78.0	25.6	78.0

- 3.4 Rated Power.** Power of the fan driver or pump driver utilized to determine unit thermal performance rating
- 3.5 Nameplate Power.** Power indicated on fan driver or pump driver nameplate.
- 3.6 “Shall” or “Should”.** “Shall” or “Should” shall be interpreted as follows:
- 3.6.1 Shall.** Where “shall” or “shall not” is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.
- 3.6.2 Should.** “Should” is used to indicate provisions which are not mandatory but which are desirable as good practice.
- 3.7 Heat Rejection Capability.** Capability, expressed in terms of process fluid flowrate or heat rejection, at specified rating condition and rated power.
- 3.8 Entering Air Wet-Bulb Temperature.** Average inlet wet-bulb temperature of the air entering the equipment, including any effects of recirculation.

4. Test Requirements

- 4.1 Test Requirements.** Published Ratings of Evaporative Heat Rejection Equipment shall be verified by tests conducted in accordance with the limitations and methods outlined in the Appendix B, C, or D for the particular type of Evaporative Heat Rejection Equipment.

4.1.1 All regularly furnished equipment that will affect performance shall be in place and in operation during the test.

4.1.2 The fluid used during the test shall be one that is published for use with the Evaporative Heat Rejection Equipment.

4.1.3 Instrumentation Requirements. Test Instrumentation employed on certification qualification or re-verification tests shall be as specified in the appropriate test code, except as hereinafter provided:

4.1.3.1 Calibration. All measuring instruments and instrument systems (e.g. data acquisition coupled to temperature, pressure, or flow sensors) shall be calibrated by comparison to primary or secondary standards with calibrations traceable to National Institute of Standards and Technology (NIST) measurements, other recognized national laboratories, or derived from accepted values of natural physical constants. All test instruments shall be calibrated tri-annually, whenever damaged, or when the accuracy is called into question.

4.1.3.1.1 Pitot Tubes shall be checked at least twice annually against concurrent measurements made with an approved and calibrated, magnetic flow meter. Deviations

of more than +/- 4% shall be cause for recalibration of both devices.

4.1.3.2 Wet Bulb Temperature Measurement. Psychrometers used to measure wet bulb temperatures shall be as specified in the applicable test code specified in Appendix B, C, or D.

4.1.3.3 Non-volatile Fluid Flow Measurement. Appropriately sized Pitot tubes or magnetic flow meters shall be used for measuring the flow rates of non-volatile process fluids such as water and aqueous solutions of glycols.

Instruments approved for use in this program shall have National Institute of Standards and Technology (NIST) traceable flow calibrations, performed on a tri-annual basis, across the full range of their intended application. Laboratory calibration shall include a minimum of six (6) data points, spaced across the application range of the instrument. The calibration coefficient shall be expressed as a 2nd order polynomial, fit to the calibration data set, and expressed as a function of Reynolds number.

Non-Prandtl Pitot tube designs (such as the Simplex type) shall be subject to the following limitations:

4.1.3.3.1 The Pitot tube shall be calibrated over a range of Reynolds Numbers (expressed in terms of probe diameter or width) extending from 1.5E+04 to 6.5E+04. Calibrations shall be reported in the form of Pitot Coefficient versus Probe Tip Reynolds Number:

$$Re_{PT} = \frac{D \cdot V \cdot \rho}{\mu_e} \quad [\text{Eqn.1}]$$

Where:

D = Probe tip diameter (or width perpendicular to the axis of the pipe) in m (ft).

V = Process fluid velocity at the Pitot station in m/sec (ft/sec).

ρ = Density of process fluid for conditions at the Pitot station in kg/m³ (lb_m/ft³).

μ_e = Absolute viscosity of process fluid for conditions at the Pitot station in Pa·s (lb_m/ft·sec).

4.1.3.3.2 Due to the relative physical size of such Pitot Tubes, they shall not be used in pipes with a diameter less than 150 mm (6”).

4.1.3.3.3 To limit measurement uncertainty, the Reynolds Number of the fluid at the Pitot Station, expressed in terms of tip size, shall

be neither greater nor less than the limits of calibration.

4.1.3.3.4 During Pitot traverses, the pressure shall be sufficiently positive to bleed the pressure sensing device on all ports.

4.1.3.4 Volatile Fluid Flow Measurement. For volatile process fluids (refrigerants), a Coriolis flow meter shall be employed. Flow measurement devices shall be calibrated at least once every three years by a recognized hydraulics laboratory.

4.1.3.5 Pressure Measurement. A mercury manometer, calibrated pressure differential meter/transducer, and/or calibrated pressure gauges/transducers shall be used to measure pressures and the pressure differential of the process fluid across the heat exchanger.

4.1.3.6 Selection and Accuracy. All measuring instruments shall be selected to meet or exceed the accuracy criteria listed in Table 2 for each type of measurement.

Table 2. Instrumentation Accuracy

Measurement	Medium	Minimum Accuracy		Instrument Examples
		S-I	I-P	
Temperature	Air Wet-Bulb Temperature	±0.05 °C	±0.10 °F	RTD, Thermistor
	Air Dry-Bulb Temperature			
	Hot Water Temperature			
	Cold Water Temperature			
	Make-up Water Temperature			
	Blow-down Water Temperature			
	Recirculating Water Temperature			
	Refrigerant Vapor	±0.05 °C	±0.10 °F	RTD (in thermowell)
	Refrigerant Liquid			
Flow	Circulating Liquid Flow	±2.0%		Magnetic Flowmeter
	Circulating Liquid Flow	±3.0 %		Pitot Tube
	Refrigerant Mass Flow	±2.0%		Coriolis Flowmeter
	Make-up Flow Rate	±5.0%		Per STD-146
	Blow-down Flow Rate	±5.0 %		Per STD-146
Electrical	Fan Driver Input Power	±3.0%		Power Meter
	Pump Driver Input Power			
Pressure	Refrigerants	Pressure corresponding to		Transducers
		±0.10 °C	±0.20 °F	
	Air	0.03 kPa	±0.01 “Hg	Barometer
	Water	±1.0 %		Transducer, Manometer
Velocity	Air Wind Speed	0.5 m/s	1 mph	

5. Ratings Requirements

5.1 Standard Ratings.

5.2 Application Ratings.

5.3 Certified Ratings. Certified ratings are established on the basis of entering wet bulb temperature for products located in a free and unobstructed environment and circulating fresh water over the fill or heat exchanger. The Manufacturer shall make available published criteria defining a free and unobstructed environment.

5.4 Certification shall also apply to multiple cell arrangements of certified models provided the physical configuration and airflow through each cell remains unaltered.

5.5 Tolerances. To comply with this standard, any representative production unit selected at random, when tested at any Rating Conditions, shall have a thermal capability not less than 100% of its published Standard Rating at its Rated Power. The thermal performance

test tolerance on individual tests shall be less than or equal to -5%. For Closed Circuit Cooling Towers, the corresponding process fluid pressure drop shall not be more than 100% of its published Standard Pressure Drop at the test flow. The pressure drop test tolerance on individual tests shall be less than or equal to +15%.

6. Minimum Data Requirements for Published Ratings

6.1 Minimum Data Requirements for Thermal Published Ratings. As a minimum, Published Ratings available to the general public shall include at least the listed operating conditions in either IP or SI units, defined by Tables 3-5 below, for each process fluid or refrigerant included in the certification. When certifying thermal performance for closed circuit coolers with aqueous glycol solutions, Published Ratings shall also include at least the listed operating conditions in either IP or SI units as defined in Tables 4a and 4b at 30% glycol concentration by volume,

for each glycol type covered under the certification. Data can be published in IP units, SI units or both per the manufacturer's preference. All claims to ratings for products within the scope of this standard shall be accompanied by the statement "Rated in accordance with CTI Standard 201 RS". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of CTI Standard 201 RS". Wherever Application

Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

6.1.1 The scope of the certification shall be clearly stated adjacent to the table in terms of design parameters as referenced in Appendices "B" for Cooling Towers, "C" for Closed Circuit Coolers and "D" for Evaporative Refrigerant Condensers.

Table 3a. Cooling Towers (CT) Heat Rejection Capacity Conditions, IP Units (gpm)

Range °F		9	9	9	10	10	10	10	15	15
Approach °F		7.2	9	10.8	7	7	10	12	7	12
Wet Bulb Temperature °F	50					#1	#2	#3	#4	#5
	55					#6	#7	#8	#9	#10
	60					#11	#12	#13	#14	#15
	65					#16	#17	#18	#19	#20
	69.8			* #46						
	70					#21	#22	#23	#24	#25
	75					#26	#27	#28	#29	#30
	78				* #47					
	80					#31	#32	#33	#34	#35
	80.6		* #48							
	82.4	* #49								
	85					#36	#37	#38	#39	#40
	90					#41	#42	#43	#44	#45

* Widely recognized international "standard" design conditions to be included in selection table.

Capacity condition reference number for values required in selection table.

Other optional regional standard conditions may be added as points #50, etc.

Table 3b. Cooling Towers (CT) Heat Rejection Capacity Conditions, SI Units (l/s)

Range °C		5	5	5	5.56	6	6	6	8	8
Approach °C		4	5	6	3.89	4	6	7	4	7
Wet Bulb Temperature °C	10					#1	#2	#3	#4	#5
	13					#6	#7	#8	#9	#10
	16					#11	#12	#13	#14	#15
	18					#16	#17	#18	#19	#20
	21			* #46		#21	#22	#23	#24	#25
	24					#26	#27	#28	#29	#30
	25.56				* #47					
	27		* #48			#31	#32	#33	#34	#35
	28	* #49								
	29					#36	#37	#38	#39	#40
	32.2					#41	#42	#43	#44	#45

* Widely recognized international "standard" design conditions to be included in selection table.

Capacity condition reference number for values required in selection table.

Other optional regional standard conditions may be added as points #50, etc.