BSR/ASHRAE Addendum g
to ANSI/ASHRAE Standard 30-2019

Advisory Public Review Draft

Proposed Addendum g to Standard 30-2019, Method of Testing Liquid Chillers

Advisory Public Review (June 2024)
(Draft shows Proposed Changes to Current Standard)

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ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092

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FOREWORD

ANSI/ASHRAE Standard 30 makes use of both temperature and temperature difference. The 2017 and 2019 editions of the standard make use of a non-conventional nomenclature for the unit symbol of a temperature difference or a temperature interval. The original intent was two-fold:

1) *to avoid potential misunderstanding of what a numerical value represents within a test report, whether it refers to a temperature or a temperature difference, and*
2) *to move away from historical and scientific use of an absolute temperature scale when referring to temperature differences or temperature intervals, e.g., expressing a temperature difference using kelvins or degrees Rankine such as 5 K or 9 °R, to reflect more commonly encountered engineering practice of using ordinary temperature scales, degree Celsius or degree Fahrenheit, such as 5 °C or 9 °F.*

Note that chillers and heat pumps are often used in applications where the cold side of the system is such that the numerical values for temperature using degree Celsius or degree Fahrenheit are small and approaching or less than zero. Likewise, temperature differences are often in the same ranges of numerical values.

Reviewers are invited to also see NIST Special Publication SP811, in particular Section 8.5 "Temperature interval and temperature difference", as well as noting that Appendix B Section B.8 uses the words "temperature interval" for clarity when presenting conversion factors for degree Celsius and degree Fahrenheit, but make use of the conventional unit symbols without the Greek letter delta. https://www.nist.gov/pml/special-publication-811

SSPC30 requests stakeholder feedback as the committee considers whether to continue using the non-conventional nomenclature or reverting back to more conventional notation for a temperature difference or temperature interval.

Note: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard shown are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes**.**

Addendum g to Standard 15-2022

{Note to reviewers: existing examples of the unit symbol notation for temperature differential are highlighted in yellow. Additional temperature related sections are shown for context. The options being considered by SSPC30 are as follows, please comment in regard to which of the three numbered options is preferred.}

Symbol	Description	Unit Name	Unit Symbol	Option Number
T	temperature	degree Celsius degree Fahrenheit	°C °F	(not applicable)
ΔT	temperature differential (temperature interval)	degree Celsius degree Fahrenheit	Δ°C Δ°F	1 (current)
		degree Celsius degree Fahrenheit	°C °F	2
		kelvin degree Rankine	K °R	3

Section 3 remains unchanged.

3. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

[…]

temperature: measurement of warmth or coldness with respect to an arbitrary zero or to the absolute zero. Temperatures are indicated on defined scales, such as Kelvin and Rankine for absolute temperatures and Celsius and Fahrenheit for ordinary temperatures.

[…]

Section 5 remains unchanged.

5. CALCULATIONS AND CONVERSIONS

[…]

5.4 Performance

5.4.1 Capacity. […]

[…]

5.4.1.4 Temperature Difference, Enthalpy Difference, and Pressure Difference

5.4.1.4.1 Temperature Difference

$$\Delta T = \max(T_{in}, T_{out}) - \min(T_{in}, T_{out}) = |T_{in} - T_{out}|$$

$$U_{\Delta T} = \sqrt{\left(\theta_{T_{in}} \cdot U_{T_{in}}\right)^2 + \left(\theta_{T_{out}} \cdot U_{T_{out}}\right)^2}$$

$$\theta_{T_{in}} = \text{sign}(T_{in} - T_{out})$$

$$\theta_{T_{out}} = \text{sign}(T_{out} - T_{in})$$

where sign(x) = 1 if x > 0, sign(x) = –1 if x < 0, and sign(x) = 0 otherwise.

[…]

Section 6 remains unchanged.

6. TEST REQUIREMENTS

[…]

Table 6-1 Requirements for Test Instrumentation

Measurement	Measurement System Accuracy [b,c,d,e]	Measurement Resolution [f,g]	Selected, Installed, Operated, Maintained in Accordance with
Liquid Temperature	±0.11 Δ°C (±0.20 Δ°F)	0.005°C (0.01°F)	ANSI/ASHRAE Standard 41.1 [4]
Air Temperature	±0.11 Δ°C (±0.20 Δ°F)	0.05°C (0.1°F)	ANSI/ASHRAE Standard 41.1 [4]

[…]

Table 6-3 Temperature Measurement Requirements

Measurement	Accuracy	Display Measurement
Dry-bulb and wet-bulb temperatures [a]	≤ ±0.1 Δ°C (≤ ±0.2 Δ°F)	≤ ±0.05 Δ°C (≤ ±0.1 Δ°F)
Air-sampling tree average temperature [b]	≤ ±0.5 Δ°C (≤ ±1.0 Δ°F)	≤ ±0.05 Δ°C (≤ ±0.1 Δ°F)

[…]

6.3 Instrumentation.

[…]

6.3.1 Accuracy and Calibration

[…]

6.3.1.4 Temperature

[…]

6.3.1.4.2 Air. Measurements shall be made […] These thermocouples may not indicate a temperature difference greater than 2.8 Δ°C (5.0 Δ°F) from the average inlet air. […]

[…]

Table 6-4 Criteria for Air Distribution and Control of Air Temperature

Item	Purpose	Maximum Variation	
		Δ°C	Δ°F
Dry-Bulb Temperature			
Deviation from the mean air dry-bulb temperature to the air dry-bulb temperature at any individual temperature measurement station [a]	Uniform temperature distribution	±1.00 (≤ 700 kW)	±2.00 (≤ 200 ton_R)
Difference between dry-bulb temperature measured with air sampler thermopile and with aspirating psychrometer	Uniform temperature distribution	±1.50 (> 700 kW)	±3.00 (> 200 ton_R)
Difference between mean dry-bulb air temperature and the specified target test value [b]	Test condition tolerance: for control of air temperature	±0.50	±1.00
Mean dry-bulb air temperature variation over time (from the first to the last of the data sets)	Test operating tolerance: total observed range of variation over data collection time	±0.80	±1.00
Wet-Bulb Temperature [c]			
Deviation from the mean wet-bulb temperature to the wet-bulb temperature at any individual temperature measurement station [a]	Uniform humidity distribution	±0.50	±1.00
Difference between mean wet-bulb air wet-bulb temperature and the specified target test value [b]	Test condition tolerance: for control of air temperature	±0.50	±1.00
Mean wet-bulb air temperature variation over time	Test operating tolerance: total observed range of variation over data collection time (from the first to the last of the data sets)	±0.50	±1.00

[…]

6.7.4.1 Measurement of Verification. Redundant instrument measurements shall be within the limitation in the following sections.

6.7.4.1.1 Entering liquid temperature measurements shall not differ by more than 0.1 Δ°C (0.2 Δ°F).

6.7.4.1.2 Leaving liquid temperature measurements shall not differ by more than 0.1 Δ°C (0.2 Δ°F).

[…]

{Note to reviewers: Table 6-6 from the original 2019 edition is shown below, but reviewers should note that this table has been revised more than once via addenda to the 2019 edition.}

Table 6-6 Definition of Operating Condition Tolerances and Stability Criteria

Measurement or Calculation Result		Applicable Operating Modes	Values Calculated from Data Samples		Operating Condition Tolerance Limits	Stability Criteria
			Mean	Std. Dev.		
Net capacity (cooling or heating)		Cooling, heating, heat recovery	$\bar{Q}$	—	Unit with continuous unloading: Part-load test capacity shall be within 2% of the target part-load capacity [a]. $\frac{\lvert\bar{Q} - Q_{target}\rvert}{Q_{100\%}} \le 2.000\%$	No requirement
					Units with discrete capacity steps: Part-load test points shall be taken as close as practical to the specified part-load rating points as stated in the test plan.	
Evaporator	Entering water temperature	Cooling	$\bar{T}$	s_T	No requirement	$s_T \le 0.10$ Δ°C [0.18 Δ°F]
	Leaving water temperature				$\lvert\bar{T} - T_{target}\rvert \le 0.28$ Δ°C [0.50 Δ°F]	
Condenser	Entering water temperature					
	Leaving water temperature				No requirement	
Evaporator	Entering water temperature [b]	Heating, heat recovery	$\bar{T}$	s_T	Heating portion: No requirement Defrost portion: $\lvert\bar{T} - T_{target}\rvert \le 1.11$ Δ°C [2.00 Δ°F]	Heating portion: $s_T \le 0.10$ Δ°C [0.18 Δ°F] Defrost portion: $s_T \le 0.28$ Δ°C [0.50 Δ°F]
	Leaving water temperature [b]				Heating portion: $\lvert\bar{T} - T_{target}\rvert \le 0.28$ Δ°C [0.50 Δ°F] Defrost portion: No requirement	Heating portion: $s_T \le 0.10$ Δ°C [0.18 Δ°F] Defrost portion: No requirement
Condenser	Leaving water temperature				$\lvert\bar{T} - T_{target}\rvert \le 0.28$ Δ°C [0.50 Δ°F]	$s_T \le 0.10$ Δ°C [0.18 Δ°F]
	Entering water temperature				No requirement	

a. The ±2.0% tolerance shall be calculated as 2.0% of the full load rated capacity (kW). For example, a nominal 50.0% part-load point shall be tested between 48.0% and 52.0% of the full-load capacity to be used directly for IPLV.SI and NPLV.SI calculations. Outside this tolerance, interpolation shall be used.
b. The heat portion shall apply when the unit is in the heating mode, except for the first ten minutes after terminating a defrost cycle. The defrost portion shall include the defrost cycle plus the first ten minutes after terminating the defrost cycle.
c. When computing average air temperatures for heating mode tests, omit data samples collected during the defrost portion of the cycle.
d. For electrically driven machines, voltage and frequency shall be maintained at the nameplate rating values within tolerance limits and stability criteria on voltage and frequency when measured at the locations specified in Section 6.3.1.7. For dual nameplate voltage ratings, tests shall be performed at the lower of the two voltages.
e. For steam turbine and gas turbine drive machines the pressure shall be maintained at the nameplate rating values within the tolerance limits.
f. For speed-controlled compressors, the speed shall be maintained at the nameplate rating value within the tolerance limits.

Table 6-6 Definition of Operating Condition Tolerances and Stability Criteria *(Continued)*

Measurement or Calculation Result		Applicable Operating Modes	Values Calculated from Data Samples: Mean	Values Calculated from Data Samples: Std. Dev.	Operating Condition Tolerance Limits	Stability Criteria
Evaporator or condenser	Entering air mean dry-bulb temperature [c]	Cooling, heating (nonfrosting)	$\bar{T}$	s_T	$\lvert\bar{T} - T_{target}\rvert \le 0.56$ Δ°C [1.00 Δ°F]	$s_T \le 0.42$ Δ°C [0.75 Δ°F]
		Heating (frosting) [c]			Heating portion: $\lvert\bar{T} - T_{target}\rvert \le 1.1$ Δ°C [2.00 Δ°F]	Heating portion: $s_T \le 5.6$ Δ°C [1.00 Δ°F]
					Defrost portion: No requirement for $\bar{T}$	Defrost portion: $s_T \le 1.39$ Δ°C [2.50 Δ°F]
	Entering air mean wet-bulb temperature [c]	Cooling, heating (nonfrosting)			$\lvert\bar{T} - T_{target}\rvert \le 0.56$ Δ°C [1.00 Δ°F]	$s_T \le 0.28$ Δ°C [0.50 Δ°F]
		Heating (frosting) [c]			Heating portion: $\lvert\bar{T} - T_{target}\rvert \le 0.83$ Δ°C [1.50 Δ°F]	
					Defrost portion: No requirement for $\bar{T}$	
Water flow (volumetric, entering)		Cooling, heating, heat recovery	$\bar{V}_w$	s_{V_w}	$\frac{\lvert\bar{V} - V_{w,target}\rvert}{V_{w,target}} \le 5.000\%$	$\frac{s_{V_w}}{\bar{V}_w} \le 0.750\%$
Voltage [d] (If multiphase, this is the average of all phases.)			$\bar{V}$	s_V	$\frac{\lvert\bar{V} - V_{target}\rvert}{V_{target}} \le 10.00\%$	$\frac{s_V}{\bar{V}} \le 0.500\%$
Frequency [d]			$\bar{\omega}$	s_ω	$\frac{\lvert\bar{\omega} - \omega_{target}\rvert}{\omega_{target}} \le 1.000\%$	$\frac{s_\omega}{\bar{\omega}} \le 0.500\%$
Condenserless refrigerant saturated discharge temperature		Cooling	$\bar{T}$	s_T	$\lvert\bar{T} - T_{target}\rvert \le 0.28$ Δ°C [0.50 Δ°F]	$s_T \le 0.14$ Δ°C [0.25 Δ°F]
Condenserless liquid temperature					$\lvert\bar{T} - T_{target}\rvert \le 0.56$ Δ°C [1.00 Δ°F]	$s_T \le 0.28$ Δ°C [0.50 Δ°F]
Steam turbine pressure/vacuum [e]		Cooling, heating, heat recovery	$\bar{p}$	s_p	$\lvert\bar{p} - p_{rating}\rvert \le 3.45$ kPa [0.500 psid]	$s_p \le 1.72$ kPa [0.250 psid]
Gas turbine inlet gas pressure [e]						
Governor control compressor speed [f]			$\bar{n}$	s_n	$\frac{\lvert\bar{n} - n_{target}\rvert}{n_{target}} \le 0.500\%$	$\frac{s_n}{\bar{n}} \le 0.250\%$

a. The ±2.0% tolerance shall be calculated as 2.0% of the full load rated capacity (kW). For example, a nominal 50.0% part-load point shall be tested between 48.0% and 52.0% of the full-load capacity to be used directly for IPLV.SI and NPLV.SI calculations. Outside this tolerance, interpolation shall be used.
b. The heat portion shall apply when the unit is in the heating mode, except for the first ten minutes after terminating a defrost cycle. The defrost portion shall include the defrost cycle plus the first ten minutes after terminating the defrost cycle.
c. When computing average air temperatures for heating mode tests, omit data samples collected during the defrost portion of the cycle.
d. For electrically driven machines, voltage and frequency shall be maintained at the nameplate rating values within tolerance limits and stability criteria on voltage and frequency when measured at the locations specified in Section 6.3.1.7. For dual nameplate voltage ratings, tests shall be performed at the lower of the two voltages.
e. For steam turbine and gas turbine drive machines the pressure shall be maintained at the nameplate rating values within the tolerance limits.
f. For speed-controlled compressors, the speed shall be maintained at the nameplate rating value within the tolerance limits.

Section 9 remains unchanged.

9. REPORTING OF RESULTS

[…]

9.1 General

[…]

*{Note to reviewers: Section 9.1.5 is shown as published in the 2019 edition, but **Addendum a** moves Section 9.1 content into an expanded Table 9-1 for data to be reported, and relies upon reference to Section 7 and a revised Section 7.1 to require that temperatures, or leaving temperature and temperature difference, are recorded and reported. As a result the units of measure will not be explicitly stated in the next edition as shown in Section 9.1.5.}*

9.1.5 Chilled-liquid entering and leaving temperatures (°C [°F]) or leaving liquid temperature and temperature difference (Δ°C [Δ°F]).

[…]

Section 10 remains unchanged.

10. NOMENCLATURE

Table 10-1 Nomenclature

			SI		IP	
Group	**Symbol**	**Description**	**Unit Name**	**Unit Symbol**	**Unit Name**	**Unit Symbol**
	Q'	gross capacity, heat flow rate	watt	W	British thermal unit (IT)	Btu/h
	$Q\%$	percent load				
	c_p	specific heat at constant pressure	kilojoule per kilogram kelvin	kJ/(kg·K)	British thermal unit (IT) per pound degree Fahrenheit	Btu/(lb·°F)
	h	enthalpy	kilojoule per kilogram	kJ/kg	British thermal unit (IT) per pound	Btu/lb
	Δh	enthalpy differential	kilojoule per kilogram	kJ/kg	British thermal unit (IT) per pound	Btu/lb
	T	temperature	degree Celsius	°C	degree Fahrenheit	°F
	ΔT	temperature differential (temperature interval)	degree Celsius	Δ°C	degree Fahrenheit	Δ°F