Addendum b to ANSI/ASHRAE Standard 30-2019

Public Review Draft

Method of Testing Liquid Chillers

First Public Review (October 2020)
(Draft shows Proposed Changes to Current Standard)

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FOREWORD

ASHRAE Standard 30 prescribes methods for obtaining performance data relating to liquid-chilling or liquid-heating equipment using any type of compressor. The intent of this standard is to provide uniform test methods to measure the performance of this equipment by addressing the test and instrumentation requirements, test procedures, data to be recorded, and calculations to generate and confirm valid test results.

Addendum 'b' includes the following major revisions:

1. Changed "water" to "liquid" where applicable.
2. Clarified requirements for Δp_{adj}.
3. Replaced reference to ASME and ISA standards with exclusive reference to ASHRAE 41 series standards.
4. Added an Excel workbook to facilitate calculates in accordance with Table 6-2.
5. Removed ft H2O from the standard.

[Note to Reviewers: 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 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 b to ANSI/ASHRAE Standard 30-2019

Modify Section 3 as shown below. The remainder of Section 3 is unchanged.

3. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

capacity: a measurable physical quantity, the rate that heat (*energy*) is added to or removed from the *liquid* side of a *refrigerating system*. *Capacity* is defined as the mass flow rate of the *liquid* multiplied by the difference in enthalpy of *liquid* entering and leaving the heat exchanger. For the purposes of this standard, the enthalpy change is approximated as the sensible heat transfer using specific heat and temperature difference, and in some calculations, also the energy associated with liquid-side pressure losses.

> ***gross heating capacity:*** the *capacity* of the ~~water~~*liquid-cooled condenser* as measured by the total heat transferred from the refrigerant to the liquid in the *condenser*. This value includes both the sensible heat transfer and the friction heat losses from pressure drop effects of the *liquid* flow through the *condenser*. This value is used to calculate the *energy balance* of a test.

Modify Section 5 as shown below. The remainder of Section 5 is unchanged.

5. CALCULATIONS AND CONVERSIONS

5.4.4 Liquid Pressure Drop Correction. Measured liquid pressure drop values shall be adjusted to subtract additional static pressure drop due to piping external to the chiller connection points, if any such external piping is installed for the test. The additional static pressure drop shall be the sum of all losses between the unit connections and the location of static pressure taps. Record the original measured value

Δp_{test}, the calculated adjustment value Δp_{adj}, and the final calculated result for liquid pressure drop $\Delta p_{corrected}$. The density shall be determined at the mean of the entering and leaving temperatures, corresponding to the operating test conditions of the test plan and not to non-operating or standby conditions.

$$\Delta p_{adj} = \rho_{in} g \left[\sum_i (h_f)_i + \sum_j (h_m)_j\right]_{in} + \rho_{out} g \left[\sum_i (h_f)_i + \sum_j (h_m)_j\right]_{out}$$

$$\Delta p_{adj} = \rho g \left[\sum_i (h_f)_i + \sum_j (h_m)_j\right]$$

5.4.4.1 The adjustment (Δp_{adj}) shall not exceed 10% of the measured liquid pressure drop (Δp_{test}). If Δp_{adj} is greater than 10% of Δp_{test}, either piping external to the chiller connection points shall be reconfigured to allow Δp_{adj} to be less than or equal to Δp_{test}, or Δp_{adj} shall be calculated as:

$$\Delta p_{adj} = 10\% \Delta p_{test}$$

Modify Section 6 as shown below. The remainder of Section 6 is unchanged.

6. TEST REQUIREMENTS

Table 6-1 Requirements for Test Instrumentation

Measurement	Measurement System Accuracy[2,3,4,5]	Measurement Resolution[6, 7]	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
Air Temperature	±0.11 Δ°C (±0.20 Δ°F)	0.05°C (0.1°F)	ANSI/ASHRAE Standard 41.1
Liquid Mass Flow Rate [1]	±1.0% RDG	4 significant figures	ANSI/ASHRAE Standard 41.8 ~~or ASME Power Test Code PTC 19.5~~ ~~(flow measurement)~~ ~~ASME MFC-16 (electromagnetic type)~~ ~~ASME MFC-3M (orifice & venturi type)~~ ~~ASME MFC-6M (vortex type)~~ ~~ASME MFC-11 (coriolis type)~~ ~~ISA Standard RP31.1 (turbine type)~~
Differential Pressure	±1.0% RDG	3 significant figures	ANSI/ASHRAE Standard 41.3~~ASME Power Test Code PTC 19.2~~
Electrical Power ≤ 600V > 600 V	 ±1.0% FS, ±2.0% RDG ±1.5% FS, ±2.5% RDG	4 significant figures (V, A, kW, Hz)	ANSI/ASHRAE Standard 41.11 IEEE C57.13
Atmospheric Pressure	±1.0 kPa (±0.15 psia)	0.1 kPa (0.01 psia)	ANSI/ASHRAE Standard 41.3~~ASME Power Test Code PTC 19.2~~
Steam condensate mass flow rate	±1.0% RDG	4 significant figures	
Steam pressure	±1.0% RDG	3 significant figures	
Fuel volumetric flow rate	±1.0% RDG	4 significant figures	
Fuel energy content	-	3 significant figures	Gas quality shall be acquired by contacting the local authority and requesting a gas quality report for calorific value on the day of the test

Notes:

1. Accuracy requirement also applies to volumetric type meters.
2. Measurement system accuracy shall apply over the range of use during testing, as indicated by the Turn Down Ratio determined during calibration, i.e., from full scale down to a value of full scale divided by the Turn Down Ratio. For many types of instruments and/or systems, this may require exceeding the accuracy requirement at full scale.
3. %RDG = percent of Reading, %FS = percent of Full Scale for the useable range of the measurement instrument or measurement system.
4. If dual requirements are shown in the table, FS and RDG, then both requirements shall be met.
5. Current Transformers (CT's) and Potential Transformers (PT's) shall have a metering accuracy class of 0.3 or better, rated in accordance with IEEE C57.13.
6. Measurement resolution shown is the minimum requirement (most coarse resolution allowable). Better (finer) resolution is acceptable for instrument or panel displays, or computer screen displays. Resolution includes all parts of the measurement system, such as analog to digital conversion.
7. Significant figures (also known as significant digits) determined in accordance with Section 5.6.

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

Measurement or Calculation Result		Applicable Operating Mode(s)	Values Calculated from Data Samples: Mean	Values Calculated from Data Samples: Std Dev.	Operating Condition Tolerance Limits	Stability Criteria
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 [1] $\frac{\lvert\bar{Q} - Q_{target}\rvert}{Q_{100\%}} \leq 2.000\%$	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~~ Liquid Temperature	Cooling	$\bar{T}$	s_T	No Requirement	$s_T \leq 0.10\ °C\ [0.18\ °F]$
	Leaving ~~Water~~ Liquid Temperature				$\lvert\bar{T} - T_{target}\rvert \leq 0.28\ \Delta°C\ [0.50\ \Delta°F]$	
Condenser	Entering ~~Water~~ Liquid Temperature					
	Leaving ~~Water~~ Liquid Temperature				No Requirement	
Evaporator	Entering ~~Water~~ Liquid Temperature [2]	Heating, Heat Recovery	$\bar{T}$	s_T	Heating portion: No requirement Defrost portion: $\lvert\bar{T} - T_{target}\rvert \leq 1.11\ \Delta°C\ [2.00\ \Delta°F]$	Heating portion: $s_T \leq 0.10\ °C\ [0.18\ °F]$ Defrost portion: $s_T \leq 0.28\ °C\ [0.50\ °F]$
	Leaving ~~Water~~ Liquid Temperature [2]				Heating portion: $\lvert\bar{T} - T_{target}\rvert \leq 0.28\ \Delta°C\ [0.50\ \Delta°F]$ Defrost portion: no requirement	Heating portion: $s_T \leq 0.10\ °C\ [0.18\ °F]$ Defrost portion: no requirement
Condenser	Leaving ~~Water~~ Liquid Temperature				$\lvert\bar{T} - T_{target}\rvert \leq 0.28\ \Delta°C\ [0.50\ \Delta°F]$	$s_T \leq 0.10\ °C\ [0.18\ °F]$
	Entering ~~Water~~ Liquid Temperature				No Requirement	

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

Evaporator or Condenser	Entering Air Mean Dry Bulb Temperature [3]	Cooling, Heating (non-frosting)	$\overline{T}$	s_T	$\lvert\overline{T} - T_{target}\rvert \le 0.56\ \Delta°C\ [1.00\ \Delta°F]$	$s_T \le 0.42\ °C\ [0.75\ °F]$
		Heating (frosting) [3]			Heating portion: $\lvert\overline{T} - T_{target}\rvert \le 1.11\ \Delta°C\ [2.00\ \Delta°F]$	Heating portion: $s_T \le 0.56\ °C\ [1.00\ °F]$
					Defrost portion: no requirement for $\overline{T}$	Defrost portion: $s_T \le 1.39\ °C\ [2.50°F]$
	Entering Air Mean Wet Bulb Temperature [3]	Cooling, Heating (non-frosting)			$\lvert\overline{T} - T_{target}\rvert \le 0.56\ \Delta°C\ [1.00\ \Delta°F]$	$s_T \le 0.28\ °C\ [0.50\ °F]$
		Heating (frosting) [3]			Heating portion: $\lvert\overline{T} - T_{target}\rvert \le 0.83\ \Delta°C\ [1.50\ \Delta°F]$	
					Defrost portion: no requirement for $\overline{T}$	
~~Water~~ Liquid Flow (Volumetric, Entering)		Cooling, Heating, Heat Recovery	$\overline{V}_w$	s_{Vw}	$\frac{\lvert\overline{V}_w - V_{w,target}\rvert}{V_{w,target}} \le 5.000\%$	$\frac{s_{V_w}}{\overline{V}_w} \le 0.750\%$
Voltage [4] (if multiphase, this is the average of all phases)		Cooling, Heating, Heat Recovery	$\overline{V}$	s_V	$\frac{\lvert\overline{V} - V_{target}\rvert}{V_{target}} \le 10.00\%$	$\frac{s_V}{\overline{V}} \le 0.500\%$
Frequency [4]		Cooling, Heating, Heat Recovery	$\overline{\omega}$	s_ω	$\frac{\lvert\overline{\omega} - \omega_{target}\rvert}{\omega_{target}} \le 1.000\%$	$\frac{s_\omega}{\overline{\omega}} \le 0.500\%$
Condenserless Refrigerant Saturated Discharge Temperature		Cooling	$\overline{T}$	s_T	$\lvert\overline{T} - T_{target}\rvert \le 0.28\ \Delta°C\ [0.50\ \Delta°F]$	$s_T \le 0.14\ °C\ [0.25\ °F]$
Condenserless Liquid Temperature		Cooling	$\overline{T}$	s_T	$\lvert\overline{T} - T_{target}\rvert \le 0.56\ \Delta°C\ [1.00\ \Delta°F]$	$s_T \le 0.28\ °C\ [0.50\ °F]$
Steam Turbine Pressure/Vacuum [5]		Cooling, Heating, Heat Recovery	$\overline{p}$	s_p	$\lvert\overline{p} - p_{rating}\rvert \le 3.45\ kPa\ [0.500\ psid]$	$s_p \le 1.72\ kPa\ [0.250\ psid]$
Gas Turbine Inlet Gas Pressure [5]						Gas Turbine Inlet Gas Pressure [5]
Governor Control Compressor Speed [6]		Cooling, Heating, Heat Recovery	$\overline{n}$	s_n	$\frac{\lvert\overline{n} - n_{target}\rvert}{n_{target}} \le 0.500\%$	$\frac{s_n}{\overline{n}} \le 0.250\%$

Notes:

1. 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.
2. 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.
3. When computing average air temperatures for heating mode tests, omit data samples collected during the defrost portion of the cycle.
4. 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 6.3.1.7. For dual nameplate voltage ratings, tests shall be performed at the lower of the two voltages.
5. For steam turbine and gas turbine drive machines the pressure shall be maintained at the nameplate rating values within the tolerance limits.
6. For speed controlled compressors the speed shall be maintained at the nameplate rating value within the tolerance limits.

Modify Section 8 as shown below. The remainder of Section 8 is unchanged.

8. TEST PROCEDURES

8.4 Liquid Pressure Drop Measurement Procedure

8.4.1 Purpose. The purpose of this section is to prescribe a measurement method for Liquid Pressure Drop and, when required, a correction method to compensate for friction losses associated with external piping measurement sections when installed per Section 6.3.1.6. The measurement method only applies to pipe of circular cross section.

8.4.2 Background. As a certified test point for the liquid to refrigerant heat exchangers, the liquid-side pressure drop needs to be determined by test with acceptable measurement uncertainty. In some cases, the measured Liquid Pressure Drop per this standard will be determined by using static pressure taps in piping external to the unit. When using external piping, adjustment factors are allowed to compensate the reported pressure drop measurement. Numerous studies conclude that the determination of a calculated correction term for these external components may contain significant sources of error, and therefore, the use of external correction factors will be restricted to limit the magnitude of these potential errors. For units with small connection sizes, it is feasible that straight pipe sections be directly connected to the units with adequate length to obtain static pressure measurements with acceptable systematic errors due to instrument installation location. This is the preferred connection methodology. Units with larger size connections may have spatial limits in the connection arrangement such that elbows or pipe diameter changes may be necessary to accommodate the available space at the test facility, or to provide mechanical support for piping weight loads. While this may increase the measurement uncertainty, it is a practical compromise considering capital costs of test facilities.

8.4.3 Correction Method. The average measured Liquid Pressure Drop value~~s~~ Δp_{test} during test shall be adjusted to subtract additional static pressure drop Δp_{adj} due to external piping. The additional static pressure drop shall be the sum of all losses between the unit connections and the location of static pressure taps. Record the original measured value Δp_{test}, the calculated adjustment value Δp_{adj}, and the final calculated corrected test result for Liquid Pressure Drop $\Delta p_{corrected}$.

~~**8.4.3.1** The adjustment shall not exceed 10% of the measured Liquid Pressure Drop.~~

~~**8.4.3.2**~~**8.4.3.1** Refer to Section 5.4.4 for the equations to be used.

Modify Section 9 as shown below. The remainder of Section 9 is unchanged.

9. REPORTING OF RESULTS

Table 9-1 Data to be Reported[1]

Type	Report Item
General	Name and address of the chiller test facility
	Report identification number
Chiller Operation	Operating mode (Cooling, Heating, Simultaneous Heating and Cooling, or Heat Recovery)
	All inputs necessary to ensure that the equipment under test runs in the operating mode tested[2]
Capacity	Net capacity
	Gross capacity values as used for energy balance
	Heat reclaim capacity[3]
Input Power	*Total input power*
	List of components that utilize auxiliary power
Energy Efficiency[4]	One or more of the *energy efficiency* metrics per Section 5.4.3
Liquid Pressure Drop[5]	Liquid corrected pressure drop ($\Delta p_{corrected}$) at operating conditions ~~water temperatures~~ per the test plan, measured per Section 8.4 and corrected per Section 5.4.4
	Report if $\Delta p_{corrected}$ was calculated using $\Delta p_{adj} = 10\% \Delta p_{test}$ in accordance with Section 5.4.4.1.
Test Validation	Energy Balance when required per Sections 5.5.1 and 5.5.1.4
	Voltage Balance per Section 5.5.2
Correction Values	Δp_{adj} per Section 5.4.4 (even if exceeding 10% of Δp_{test})
	Any other correction values required by the test plan
Test Plan	Attach a copy of the test plan in accordance with Section 6.4 or provide target operating condition values such as capacity, temperature, and flow.
Test Data	All data recorded in accordance with Section 7
Uncertainty Analysis	Results of the uncertainty analysis in accordance with Section 6.7.3.

Notes:

1. Test Results shall be rounded to the number of significant figures identified in Section 5.7, using the definitions in Section 3, and rounding rules and formats in Section 5.7.
2. Example: In the case that a unit operates in "Heating" mode only when the ambient temperature is below 12.8°C (55.0°F) the report shall state the temperature and how the ambient temperature signal is provided to the equipment under test.
3. Required for *liquid-cooled heat reclaim condenser* only.
4. Pump energy associated with pressure drop through the chiller heat exchangers is not included in the *total input power*. This is done because any adjustment to the chiller performance would confuse the overall system analysis for capacity and efficiency. It is therefore important for any system analysis to account for the cooling loads associated with the system pump energy and to include the pump power into the overall equations for system efficiency.
5. Liquid pressure drop shall be reported in units of pressure differential, not in head or liquid column height.

   Note: Due to industry typical practice, Liquid Pressure Drop is often reported in head (ft H_2O) and corrected to a reference temperature (e.g. 60 °F); however, test data is acquired in pressure, psid, for use in calculations and test result reporting.

Modify Section 10 as shown below. The remainder of Section 10 is unchanged.

10. NOMENCLATURE

			SI		IP	
Group	**Symbol**	**Description**	**Unit Name**	**Unit Symbol**	**Unit Name**	**Unit Symbol**
Pressure Drop						
	d	pipe inside diameter dimension	millimeter	mm	inch	in
	ε	absolute roughness	meter	m	foot	ft
	f	Darcy friction factor				
	g	standard gravitational term	meter per second squared	m/s²	foot per second squared	ft/s²
	h_f	frictional head loss in pipe (pressure drop, pressure differential)	meter	m	foot	ft
	h_m	minor head loss in fittings (pressure drop, pressure differential)	meter	m	foot	ft
	K	resistance coefficient				
	p	pressure	kilopascal	kPa	pound-force per square inch	psia
	Δp	pressure differential	kilopascal	kPa	pound-force per square inch	psid~~or ft H_2O (at 60°F)~~
	r	radius of the centerline of the elbow	millimeter	mm	inch	in
	Re	Reynolds number				
	v	velocity, average across at the inlet cross section	meter per second	m/s	foot per second	ft/s

Modify Section 11 as shown below.

11. NORMATIVE REFERENCES

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