AHRI Standard 560-2000

2000 Standard for Absorption Water Chilling and Water Heating Packages

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Note:

This standard supersedes ARI Standard 560-92.

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ABSORPTION WATER CHILLING AND WATER HEATING PACKAGES

Section 1. Purpose

1.1 *Purpose*. The purpose of this standard is to establish for Absorption Water Chilling and Water Heating Packages: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; marking and nameplate data; and conformance conditions.

1.1.1 *Intent*. This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, and users.

1.1.2 *Review and Amendment*. This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 *Scope*. This standard applies to water-cooled single-effect steam and hot water operated water chilling units, water-cooled double-effect steam and hot water operated water chilling units, and double-effect Direct-Fired (natural gas, oil, LP gas) water chilling/heating units. Water is the refrigerant and LiBr (lithium bromide) the absorbent. See definitions in Section 3.

2.2 *Exclusions*. This standard does not apply to air-cooled applications, heat pump applications, exhaust gas fired applications, and non-standard units.

Section 3. Definitions

Definitions. All terms in this document shall follow the standard industry definitions in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration* unless otherwise defined in this section.

3.1 *Absorption Water Chilling and Water Heating Package.* A factory designed and prefabricated assembly employing water as the refrigerant and consisting of an evaporator, absorber, condenser, generator(s) and solution heat exchangers, with interconnections and accessories used for chilling or heating water. The package utilizes single or multiple reconcentrations of an absorbent solution. The reconcentrations of the absorbent are known as effects. A single effect package employs one step reconcentration of the absorbent in the generator. Water vapor is released after the heat energy is introduced into the generator. The concentrated absorbent is returned to the absorber where it can absorb water vapor flashed off in the evaporator. A double effect package employs a two step reconcentration of the absorbent through the use of an additional high temperature generator. An absorption package can be further defined by the following:

3.1.1 *Direct Fired Package*. This type of package reconcentrates the absorbent from heat energy through the combustion of natural gas, LP gas or oil.

3.1.2 *Indirect Fired Package.* This type of package reconcentrates the absorbent from heat energy from steam or hot water.

3.2 *Coefficient of Performance (COP).* A ratio of Cooling/Heating Capacity in watts [W] to the power input values in watts [W] at any given set of rating conditions expressed in watts/watt [W/W]. For heating *COP*, supplementary resistance heat shall be excluded.

3.3 *Cooling Only Mode.* Operational mode of a Direct-Fired chiller/heater which supplies (only) chilled water.

3.4 *Energy Input.* The heat content of the fuel, steam or hot water excluding the electrical input.

3.4.1 *Direct Fired*. Energy Input is the gross heating content of the fuel based on the Higher Heating Value in MBH [kW].

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3.4.2 *Indirect Fired*. Energy Input is the heat content of the steam or hot water in MBH [kW].

3.5 *Fouling Factor*. The thermal resistance due to fouling accumulated on the heat transfer surface.

3.5.1 *Field Fouling Allowance*. Provision for anticipated fouling during use, h≅ft^2 EF/Btu [m^2 EC/W].

3.6 *Heating Only Mode.* Operational mode of a Direct-Fired chiller/heater which supplies only hot water.

3.7 *Higher Heating Value (HHV).* The amount of heat produced per unit of fuel when complete combustion takes place at constant pressure, the products of combustion are cooled to the initial temperature of the fuel and air, and the vapor formed during combustion is condensed, Btu/lb or Btu/ft^3 [W/m^3] for gaseous fuel, or Btu/lb [J/kg] or Btu/gal for liquid fuel.

3.8 *High Pressure Steam.* Steam pressures above 15.0 psig [103 kPa], but below 150 psig [1030 kPa].

3.9 *Hot Water Heating Option*. Hot water can be provided from an absorption chiller/heater through either of two circuits:

3.9.1 Through the evaporator circuit (2-pipe system); typically applied at temperatures up to 140EF [60.0EC] (standard temperature hot water).

3.9.2 Through a separate hot water heat exchanger (4-pipe system); typically applied at temperatures above 140EF [60.0EC] up to and including 175EF [79.4EC] and/or for simultaneous heating/cooling operation (high temperature hot water).

3.10 *Integrated Part-Load Value (IPLV).* A single number part-load efficiency figure of merit calculated per the methods described in 5.3 referenced to Standard Rating Conditions.

3.11 *Low Pressure Steam*. Steam pressures 15.0 psig [103 kPa] and below.

3.12 *Net Cooling/Heating Capacity*. The net cooling/ heating capacity is considered as the usable capacity to the user's system.

3.13 *Non-Standard Part-Load Value (NPLV).* A single number part-load efficiency figure of merit calculated per the method described in 5.3 referenced to conditions other than *IPLV* Conditions (for units that are not designed to operate at AHRI Standard Rating Conditions).

3.14 *Published Ratings.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. As used herein, the term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

3.14.1 *Application Rating*. A rating based on tests performed at Application Rating conditions (other than Standard Rating Conditions).

3.14.2 *Standard Rating*. A rating based on tests performed at Standard Rating Conditions.

3.15 *"Shall" or "Should"*. "Shall" or "should" shall be interpreted as follows:

3.15.1 *Shall.* Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.15.2 *Should.* "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.16 *Simultaneous Heating/Cooling Mode.* Operational mode of a Direct-Fired absorption chiller/heater whereby chilled water and hot (heating) water are produced at the same time.

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Section 4. Test Requirements

4.1 *Test Requirements.* All tests for chiller or chiller/heater ratings shall be conducted in accordance with the test method specified in Appendix C.

Section 5. Rating Requirements

5.1 *Standard Rating Conditions*. Published Ratings for all Absorption Water Chilling Packages shall include the Standard Rating, corresponding to the applicable Standard Rating Conditions shown in Table 1, and identified as the Standard Rating. Standard Ratings shall include a water-side fouling factor allowance for the absorber/condenser of 0.00025 h≅ft^2≅EF/Btu [0.000044 m^2≅EC/W] and for the evaporator of 0.0001 h≅ft^2≅EF/Btu [0.000018 m^{2}AEC/W].

5.2 *Application Rating Conditions.* Application Ratings (at other than Standard Rating Conditions) include ratings at the following range of conditions or within the operating limits of the equipment:

Leaving chilled water temperature	40 to 48EF [4.4 to 8.9EC] in increments of 2EF [1EC] or less.
Entering absorber/condenser water temperature	70.0 to 90EF [26.7 to 32.2EC] in increments of 5EF [3EC] or less.
Absorber/condenser water flow rate limit	2.8 to 6.0 gpm/ton [0.05 to 0.11 L/s per kW].
Evaporator chilled water flow rate limit	1.6 to 3.0 gpm/ton [0.03 to 0.05 L/s per kW].
Heating water flow rate (double effect heating cycle)	manufacturer's standard gpm/ton [L/s per kW].
Steam pressure (at steam valve or inlet header of a single stage unit)	0 to 15.0 psig [0 to 103 kPa gauge] in increments of 2.0 psi [14 kPa] or less – manufacturer to specify.
Steam pressure (at steam valve or inlet header of a two-stage unit	0 to 125 psig [0 to 861 kPa] in increments of 15.0 psi [103 kPa] or less – manufacturer to specify.
Hot water (to generator) temperature	180EF to 400EF [82EC to 204EC].

5.3 *Part-Load Ratings*. The intent of part-load ratings is to permit the development of part-load performance over a range of operating conditions.

5.3.1 Part-Load rating points shall be presented in one or more of the following three ways:

5.3.1.1 *Integrated Part-Load Value (IPLV).* Based on the conditions defined in Table 2.

5.3.1.2 *Non-Standard Part-Load Value (NPLV)*. Based on the conditions defined in Table 2.

5.3.1.3 *Separate Part-Load Data Point(s) Suitable for Calculating IPLV or NPLV*. In addition, other part-load points may also be presented.

5.3.2 *Determination of Part-Load Performance*. For water chilling packages covered by this standard, Part-Load Values (*IPLV* or *NPLV*) shall be calculated as follows:

5.3.2.1 Determine the part-load energy efficiency at 100%, 75%, 50%, and 25% load points at the conditions specified in Table 2.

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5.3.2.2 Use the following equation to calculate the *IPLV* or *NPLV*:

For *COP*:

$$IPLV\,or\ NPLV = 0.01A+0.42B+0.45C+0.12D \quad (1a)$$

Where: A = *COP* at 100%
B = *COP* at 75%
C = *COP* at 50%
D = *COP* at 25%

For MBH/ton:

$$IPLV\ or\ NPLV = \frac{1}{\frac{0.01}{A}+\frac{0.42}{B}+\frac{0.45}{C}+\frac{0.12}{D}} \quad (1b)$$

Where: A = MBH/ton at 100%
B = MBH/ton at 75%
C = MBH/ton at 50%
D = MBH/ton at 25%

5.3.2.3 For a derivation of equations (1a), (1b) and example of an *IPLV* or *NPLV* calculation, see Appendix D. The weighting factors have been based on the weighted average of the most common building types and operations using average weather in 29 U.S. cities, with and without airside economizers.

5.3.2.4 The *IPLV* or *NPLV* rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% at the conditions as specified in Table 2. If the unit, due to its capacity control logic, cannot be operated at 25% capacity, then the unit can be operated at its minimum capacity and the 25% chiller capacity point shall then be determined by using the following equation:

$$COP = \frac{Net\ Output}{C_D \times Net\ Input} \quad (2)$$

Where C_D is a degradation factor to account for cycling of the chiller for capacities less than the minimum capacity. C_D shall be calculated using the following equation:

$$C_D = (-0.13 \times LF) + 1.13$$

The factor *LF* shall be calculated using the following equation:

$$LF = \frac{\frac{\%\ Load}{100} \cdot (Full\ Load\ Unit\ Capacity)}{(Minimum\ Unit\ Capacity)}$$

Where:

% Load is the standard rating point i.e. 75%, 50% and 25%

Minimum Unit Capacity is the measured or calculated unit capacity from which standard rating points are determined using the method above.

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5.3.2.5 *Sample Calculation.* The following is an example of an *IPLV* calculation:

Part-Load Values Provided				
Point	Load %	Capacity (tons)	MBH	*COP*
A	100	100	1200	1.00
B	75	75	849	1.06
C	50	50	536	1.12
MIN	35	35	368	1.14

Using the above data, the part-load *COP* value can be calculated.

Because the unit cannot unload to 25% capacity, the following additional calculations are required to determine point AD.@ Using the minimum capacity data point listed above that was determined at the minimum step of capacity at the conditions of a 25% capacity:

$$LF = \frac{(0.25)\,x\,(1.00)}{35.0} = 0.71$$

$$C_D = (-0.13\ x\ 0.71) + 1.13 = 1.04$$

$$COP = \frac{35.0\ \ tons\ x\ 12000\ \ Btu/ton \cdot h}{1.04\ x\ 368\ x\ 1000} = 1.10$$

Using the A, B, C and D efficiencies, the *IPLV* can then be calculated as follows:

$$IPLV\ (COP)\ =\ (0.01\ x\ 1.00) + (0.42\ x\ 1.06) + (\ 0.45\ x\ 1.12) + (0.12\ x\ 1.10) = 1.09$$

5.4 *Fouling Factor Allowances*. When ratings are published, they shall include those with Fouling Factors as specified in Table 1. Additional ratings, or means of determining those ratings, at other fouling factor allowances may also be published.

5.4.1 *Method of Establishing Cleaned and Fouled Ratings from Laboratory Test Data.*

5.4.1.1 A series of tests shall be run in accordance with the method outlined in Appendix C to establish the unit's performance.

5.4.1.2 Evaporator water-side and absorber/condenser water-side heat transfer surfaces shall be considered clean during testing. Tests will be assumed to reflect Fouling Factors of 0.000 h≅ft^2 EF/Btu [0.000 m^2≅EC/W].

5.4.1.3 To determine the capacity of the chiller package at the rated fouling conditions, the procedure defined in C7.3 shall be used to determine an adjustment for the evaporator and or absorber/condenser water temperatures.

5.4.1.4 To simulate fouling factor allowance at full and part-load conditions, the method defined in C7.3 shall be used.

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5.5 *Tolerances.*

5.5.1 *Allowable Tolerances.* The allowable test tolerance on capacity tons [kW]; *COP*; MBH/ton and heat balance shall be determined from the following equation:

U.S. Standard Units: DT_{FL} in °F

Tolerance, %

$$= 10.5 - (0.07 \times \%FL) + \left(\frac{1500}{DT_{FL} \times \%FL}\right)$$

or

SI Units: DT_{FL} in EC

Tolerance, %

$$= 10.5 - 0.07 \times \%FL + \left(\frac{833.3}{DT_{FL} \times \%FL}\right)$$

Where:

FL = Full Load
DT_{FL} = Difference between entering and leaving chilled water temperature at full load, EF [EC]

See Figure 1 for graphical representation only.

5.5.2 *Full Load.* To comply with this standard, published or reported net refrigeration capacity shall be based on data obtained in accordance with the provisions of this section, and shall have a net refrigeration capacity and full load efficiency of not less than 100% of its ratings within the allowable tolerance. The allowable tolerance shall be determined by the equation specified in 5.5.1.

Water pressure drop in the evaporator and absorber/condenser shall not exceed 115% of the rated pressure drop at the specified water flow rate.

Full Load Example in *COP* (for Direct Fired Chillers):

Rated Full Load Performance:

Rated Capacity = 100 tons
Rated Input = 1200 MBH
Evaporator DT_{FL} = 10EF

$$COP = \frac{100 \text{ tons} \times 12000 \text{ Btu/ton} \cdot h}{1200 \text{ MBH} \times 1000} = 1.0$$

Allowable Test Tolerance:

Tolerance =

$$10.5 - (0.07 \times 100) + \frac{(1500)}{(10 \times 100)}$$

$$= 10.5 - 7 + 1.5 = 5\ \%$$

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