AHRI Standard 550/590
(formerly ARI Standard 550/590)

2003 Standard for Performance Rating Of Water -Chilling Packages Using The Vapor Compression Cycle

AHRI Air-Conditioning, Heating, and Refrigeration Institute

2111 Wilson Boulevard, Suite 500
Arlington, VA 22201, USA
www.ahrinet.org

PH 703.524.8800
FX 703.562.1942

AVA Documents
Document Sharing Hub

Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

IMPORTANT

SAFETY DISCLAIMER

AHRI does not set safety standards and does not certify or guarantee the safety of any products, components or systems designed, tested, rated, installed or operated in accordance with this standard/guideline. It is strongly recommended that products be designed, constructed, assembled, installed and operated in accordance with nationally recognized safety standards and code requirements appropriate for products covered by this standard/guideline.

AHRI uses its best efforts to develop standards/guidelines employing state-of-the-art and accepted industry practices. AHRI does not certify or guarantee that any tests conducted under its standards/guidelines will be non-hazardous or free from risk.

AHRI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

60 Hz Power	
Included in Certification Program	
Water-Cooled	**Air-Cooled**
All compressor types	All compressor types
Rated up to 2000 tons [7034 kW] at ARI Standard Rating Conditions	Rated up to 200 tons [703 kW] at ARI Standard Rating Conditions
Hermetic & open type, electric motor driven	Hermetic & open type, electric motor driven
Voltages up to 5000 volts	Voltages up to 600 volts
Excluded from Certification Program	
Water-Cooled	**Air-Cooled**
Condenserless chillers	Condenserless chillers
Evaporatively cooled chillers	Evaporatively cooled chillers
Chillers above 2000 tons [7034 kW]	Chillers above 200 tons [703 kW]
Chillers with voltages above 5000 volts	Chillers with voltages above 600 volts
Chillers powered by other than electric motor drives	Chillers powered by other than electric motor drives
Chillers with motors not supplied with the unit by The manufacturer	Secondary coolant ratings (other than water)
	Free cooling
Secondary coolant ratings (other than water)	Heat recovery & heat pump ratings
Free cooling	
Heat recovery & heat pump ratings	

Price $10.00 (M) $20.00 (NM)
Printed in U.S.A.

©Copyright 2003, by Air-Conditioning, Heating, and Refrigeration Institute
Registered United States Patent and Trademark Office

Documents Document Sharing Hub

Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Scope of the Certification Program (Continued)

50 Hz Power	
Included in Certification Program	
Water-Cooled	**Air-Cooled**
Centrifugal & screw chillers with continuous unloading	Not applicable
Rated 200 - 1000 tons [703-3517 kW] at ARI Standard Rating Conditions	
Hermetic & open type, electric motor driven	
Voltages up to 5000 volts	
Excluded from Certification Program	
Water-Cooled	**Air-Cooled**
Scroll & reciprocating compressor chillers with step unloading	Not applicable
Condenserless chillers	
Evaporatively cooled chillers	
Chillers below 200 tons [703 kW]	
Chillers above 1000 tons [3517 kW]	
Chillers with voltages above 5000 volts	
Chillers powered by other than electric motor drives	
Chillers with motors not supplied with the unit by The manufacturer	
Secondary coolant ratings (other than water)	
Free cooling	
Heat recovery & heat pump ratings	

Certified Ratings

The Certification Program ratings verified by test are:

1. Capacity, tons [kW]
2. Energy Efficiency, as applicable:
   - Power Input per Capacity, kW/ton [kW/kW]
   - Energy Efficiency Ratio (EER), Btu/(W·h)
   - Coefficient of Performance (COP), watts/watt [W/W]
3. Water pressure drop, psi or ft H_2O [kPa]
4. Integrated Part-Load Value (IPLV) (Section 5.4.1)
5. Non-Standard Part-Load Value (NPLV) (Section 5.4.1)

Items 1- 5 are at Standard Rating Conditions (Section 5.2) and at non-standard Rating Conditions (Section 5.3) for both full and part load (Section 5.4 for part-load performance requirements).

Note:

This standard supersedes ARI Standard 550/590-98 with addenda

Documents
Document Sharing Hub
Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

TABLE OF CONTENTS

SECTION		PAGE
Section 1.	Purpose	1
Section 2.	Scope	1
Section 3.	Definitions	1
Section 4.	Test Requirements	2
Section 5.	Rating Requirements	3
Section 6.	Minimum Data Requirements for Published Ratings	12
Section 7.	Marking and Nameplate Data	13
Section 8.	Conformance Conditions	13

TABLES

Table 1.	Standard Rating Conditions	4
Table 2.	Heat Reclaim Standard Rating Conditions	5
Table 3.	Part-Load Conditions for Rating	6

FIGURES

Figure 1.	Part-Load Efficiency Curve	7
Figure 2.	Air-Cooled Condenser Entering Air Temperature vs. % Load	9
Figure 3.	Allowable Tolerance Curves for Full and Part Load	9
Figure 4.	IPLV and NPLV Tolerance Curve	11

APPENDICES

Appendix A.	References - Normative	14
Appendix B.	References - Informative	14
Appendix C.	Method of Testing Water Chilling Packages Using the Vapor Compression Cycle - Normative	15

Documents
Document Sharing Hub

Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Appendix D. Derivation of Integrated Part-Load Value (IPLV) - Normative 24

TABLES FOR APPENDICES

Table D1. Group 1 Air-Cooled IPLV Data and Calculation 28

Table D2. Group 1 Water-Cooled IPLV Data and Calculation.....29

Table D3. Group 1 - 4 IPLV Summary 30

FIGURES FOR APPENDICES

Figure D1. Ton-Hour Distribution Categories.....25

Figure D2. Bin Groupings – Ton-Hours 26

Figure D3. Group 1 Ton-Hour Distribution Categories 26

Figure D4. Group 2 Ton-Hour Distribution Categories 26

Documents
Document Sharing Hub

Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Documents
Document Sharing Hub

Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

PERFORMANCE RATING OF WATER-CHILLING PACKAGES USING THE VAPOR COMPRESSION CYCLE

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish for Water-Chilling Packages using the vapor compression cycle: 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 factory-made vapor compression refrigeration Water-Chilling Packages including one or more hermetic or open drive compressors. These Water-Chilling Packages include:

- Water-Cooled, Air-Cooled, or Evaporatively-Cooled Condensers,
- Air-Cooled or Water-Cooled Heat Reclaim Condensers,
- Packages supplied without a Condenser.

Section 3. Definitions

All terms in this document 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 *Bubble Point.* Refrigerant liquid saturation temperature at a specified pressure.

3.2 *Compressor Saturated Discharge Temperature.* For single component and azeotrope refrigerants, it is the saturated temperature corresponding to the refrigerant pressure at the compressor discharge. For zeotropic refrigerants, it is the arithmetic average of the Dew Point and Bubble Point temperatures corresponding to refrigerant pressure at the compressor discharge. It is usually taken at or immediately downstream of the compressor discharge service valve (in either case on the downstream side of the valve seat), where discharge valves are used.

3.3 *Condenser.* A refrigeration system component which condenses refrigerant vapor. Desuperheating and sub-cooling of the refrigerant may occur as well.

3.3.1 *Air-Cooled Condenser.* A component which condenses refrigerant vapor by rejecting heat to air mechanically circulated over its heat transfer surface causing a rise in the air temperature.

3.3.2 *Air-Cooled Heat Reclaim Condenser.* A component which condenses refrigerant vapor in the process of rejecting the heat of condensation to air causing a rise in the air temperature. This Condenser may be a separate Condenser the same as or a portion of the Air-Cooled Condenser.

3.3.3 *Evaporatively-Cooled Condenser.* A component which condenses refrigerant vapor by rejecting heat to a water and air mixture mechanically circulated over its heat transfer surface, causing evaporation of the water and an increase in the enthalpy of the air.

3.3.4 *Water-Cooled Condenser.* A component which utilizes refrigerant-to-water heat transfer means, causing the refrigerant to condense and the water to be heated.

3.3.5 *Water-Cooled Heat Reclaim Condenser.* A component which utilizes refrigerant-to-water heat transfer means, causing the refrigerant to condense and the water to be heated. This Condenser may be a separate condenser, the same as, or a portion of the Water-Cooled Condenser.

3.4 *Dew Point.* Refrigerant vapor saturation temperature at a specified pressure.

3.5 *Energy Efficiency.*

3.5.1 *Coefficient of Performance (COP).* A ratio of the cooling capacity in watts [W] to the Total Power Input, in watts [W] at any given set of Rating Conditions, expressed in watts/watt [W/W].

3.5.2 *Energy Efficiency Ratio (EER).* A ratio of the cooling capacity in Btu/h [W] to the Total Power Input in watts [W] at any given set of Rating Conditions, expressed in Btu/(W·h).

Documents
Document Sharing Hub
Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

3.5.3 *Heat Reclaim Coefficient of Performance (COP_{HR}).* A ratio of the Net Heat Reclaim Capacity (Btu/h) to the Total Power Input to the unit, W converted to Btu/h

3.5.4 *Power Input per Capacity.* A ratio of the Total Power Input to the unit, in kW to the Net Refrigerating Capacity at any given set of Rating Conditions, expressed in kW/ton [kW/kW].

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

3.6.1 *Fouling Factor Allowance*. Provision for anticipated fouling during use specified in $h \cdot ft^2 \cdot {}^oF/Btu$ [$m^2 \cdot {}^oC/W$].

3.7 *Net Heat Reclaim Capacity*. A quantity defined as the mass flow rate of the condenser water multiplied by the difference in enthalpy of water entering and leaving the heat reclaim Condenser, Btu/h [kW].

3.8 *Net Refrigeration Capacity*. A quantity defined as the mass flow rate of the evaporator water multiplied by the difference in enthalpy of water entering and leaving the evaporator, Btu/h or tons [kW].

3.9 *Part-Load Value (PLV).* A single number figure of merit expressing part-load efficiency for equipment on the basis of weighted operation at various partial load capacities for the equipment.

3.9.1 *Integrated Part-Load Value (IPLV).* A single number part-load efficiency figure of merit calculated per the method described in this standard at Standard Rating Conditions.

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

3.10 *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. 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.

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

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

3.11 *Rating Conditions*. Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.1.1 *Standard Rating Conditions*. Rating Conditions used as the basis of comparison for performance characteristics.

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

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

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

3.13 *Total Power Input*. Power input of all components of the unit.

3.14 *Water-Chilling Package.* A factory-made and prefabricated assembly (not necessarily shipped as one package) of one or more compressors, Condensers and evaporators, with interconnections and accessories, designed for the purpose of cooling water. It is a machine specifically designed to make use of a vapor compression refrigeration cycle to remove heat from water and reject the heat to a cooling medium, usually air or water. The refrigerant Condenser may or may not be an integral part of the package.

3.14.1 *Heat Reclaim Water-Chilling Package*. A factory-made package, designed for the purpose of chilling water and containing a Condenser for reclaiming heat. Where such equipment is provided in more than one assembly, the separate assemblies are to be designed to be used together, and the requirements of rating outlined in this standard are based upon the use of matched assemblies. It is a package specifically designed to make use of the refrigerant cycle to remove heat from the refrigerant and to reject the heat to another fluid (air or water) for heating use. Any excess heat may be rejected to another medium, usually air or water.

Section 4. Test Requirements

4.1 *Test Requirements*. Ratings shall be established at the Rating Conditions specified in Section 5. Ratings shall be verified by tests conducted in accordance with the test method and procedures described in Appendix C.

AVA Documents
Document Sharing Hub
Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Section 5. Rating Requirements

5.1 *Standard Ratings.* Standard Ratings for all Water-Chilling Packages shall be established at the Standard Rating Conditions specified in 5.2.

5.2 *Standard Rating Conditions*. Water-Chilling Packages shall be rated at conditions specified in Table 1. Heat Reclaim Water-Chilling Packages shall be rated at conditions specified in Table 2 and properly identified as the Heat Reclaim Standard Rating. Standard Ratings shall include a water-side Fouling Factor Allowance of 0.00025 $h \cdot ft^2 \cdot ^oF/Btu$ [0.000044 $m^2 \cdot ^oC/W$] for the Condenser and 0.0001 $h \cdot ft^2 \cdot ^oF/Btu$ [0.000018$m^2 \cdot ^oC/W$] for the evaporator.

5.3 *Application Rating Conditions.* Application Ratings should include the following range of Rating Conditions or be within the operating limits of the equipment:

All Condenser Types:

Leaving chilled water temperature .....40.0 to 48.0ºF [4.4 to 8.9ºC] in increments of 2ºF or less [1ºC or less].

Water-Cooled Condensers:

Entering condenser water temperature .....65.0 to 105.0ºF [18.3 to 40.6ºC] in increments of 5ºF or less [3°C or less].

Air-Cooled Condensers:

Entering Condenser air dry-bulb temperature .....55.0 to 125.0°F [12.8 to 51.7°C] dry-bulb in increments of 10°F or less [6°C or less].

Evaporatively-Cooled Condensers:

Entering Condenser air wet-bulb temperature .....50.0 to 80.0°F [10.0 to 26.7°C] wet-bulb in increments of 2.5°F or less [1.4°C or less].

5.4 *Part-Load Rating*. Water-Chilling Packages which are capable of capacity reduction shall be rated at 100% and at each step of capacity reduction provided by the refrigeration system(s) as published by the manufacturer. Part-load ratings points shall be presented in one or more of the following three ways:

a. *IPLV*- Based on the conditions defined in Table 3.
b. *NPLV*- Based on the conditions defined in Table 3.
c. *Separate Part-Load Data Point(s) Suitable for Calculating IPLV or NPLV*. In addition, other part-load points may also be presented.

5.4.1 *Determination of Part- Load Performance*. For Water-Chilling Packages covered by this standard, the IPLV or NPLV shall be calculated as follows:

a. Determine the part-load energy efficiency at 100%, 75%, 50%, and 25% load points at the conditions specified in Table 3.

b. Use the following equation to calculate the IPLV or NPLV.

$$\text{IPLV or NPLV} = 0.01A + 0.42B + 0.45C + 0.12D \quad \text{1a}$$

For COP and EER:

where: A = COP or EER at 100%
B = COP or EER at 75%
C = COP or EER at 50%
D = COP or EER at 25%

For kW/ton:

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

where: A = kW/Ton at 100%
B = kW/Ton at 75%
C = kW/Ton at 50%
D = kW/Ton at 25%

5.4.1.1 For a derivation of equations 1a and 1b, and an 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.

Documents
Document Sharing Hub
Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Table 1. Standard Rating Conditions

	Water-Cooled	Evaporatively-Cooled	Air-Cooled
Condenser Water			
Entering	85.0 °F 29.4 °C		
Flow Rate	3.0 gpm/ton 0.054 L/s per kW		
Condenser Fouling Factor Allowance			
Water-Side	0.00025 h · ft^2 · °F/Btu 0.000044 m^2 · °C/ W		
Air-Side		0.0 ft^2 · °F/Btu 0.0 m^2 · °C/W	0.0 h · ft^2 · °F/Btu 0.0 m^2 · °C/W
Entering Air			
Dry-Bulb			95.0 °F 35.0 °C
Wet-Bulb		75.0 °F 23.9 °C	
Evaporator Water			
Leaving	44.0 °F 6.7 °C	44.0 °F 6.7 °C	44.0 °F 6.7 °C
Flow Rate	2.4 gpm/ton 0.043 L/s per kW	2.4 gpm/ton 0.043 L/s per kW	2.4 gpm/ton 0.043 L/s per kW
Evaporator Fouling Factor Allowance			
Water-Side	0.0001 h · ft^2 °F/Btu 0.000018 m^2 · °C/W	0.0001 h · ft^2 °F/Btu 0.000018 m^2 · °C/W	0.0001 h · ft^2 °F/Btu 0.000018 m^2 · °C/W
Without Condenser			
Saturated Discharge	105.0 °F 40.6 °C	105.0 °F 40.6 °C	125.0 °F 51.7 °C
Liquid Refrigerant	98.0 °F 36.7 °C	98.0 °F 36.7 °C	105.0 °F 40.6 °C
Barometric Pressure	29.92 in Hg 101.3 kPa	29.92 in Hg 101.3 kPa	29.92 in Hg 101.3 kPa

Documents
Document Sharing Hub
Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Full document details: AHRI Standard 550-590-2003 - Performance Rating Of Water-Chilling Packages Using The Vapor Compression Cycle

Table 2. Heat Reclaim Standard Rating Conditions			
Temperature	Water-Cooled	Evaporatively-Cooled	Air-Cooled
Condenser Water			
Entering	75.0 °F 23.9 °C		
Flow Rate	Flow rate same as in standard cooling ratings	Flow rate same as in standard cooling ratings	Flow rate same as in standard cooling ratings
Entering Air			
Dry-Bulb			40.0 °F 4.4 °C
Wet-Bulb		38.0 °F 3.3 °C	
Evaporator Water Leaving	44.0 °F 6.7°C	44.0 °F 6.7°C	44.0 °F 6.7°C
Field Fouling Allowance	0.00025 h · ft^2 · °F/Btu	0.0 h · ft^2 · °F/Btu	0.0 h · ft^2 · °F/Btu
Heat Reclaim Condenser			
Entering	105.0 °F 40.6 °C or or 95.0 °F 35.0 °C		70.0 °F 21.1°C
Leaving	120.0 °F 48.9 °C or or 105.0 °F 40.6 °C		95.0 °F 35.0 °C
Barometric Pressure	29.92 in Hg 101.3 kPa	29.92 in Hg 101.3 kPa	29.92 in Hg 101.3 kPa

Document Sharing Hub