

AHRI Standard 450-2007
(Formerly ARI Standard 450-2007)

2007 Standard for
**Performance Rating of
Water-Cooled Refrigerant
Condensers, Remote Type**



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IMPORTANT

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Note:

This standard supersedes ARI Standard 450-99.

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PERFORMANCE RATING OF WATER-COOLED REFRIGERANT CONDENSERS, REMOTE TYPE

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish for remote type, Water-Cooled Refrigerant Condensers: 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 refrigerant condensers.

2.2 Exclusions. This standard does not apply to condensers supplied as components of factory-assembled refrigeration and air-conditioning units.

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 Clean Tube Capacity. The Total Heat Rejection Effect of the condenser with clean tubes at Standard Rating Conditions expressed in Btu/h [W].

3.3 Dew Point. Refrigerant vapor saturation temperature at a specified pressure.

3.4 Field Fouling Allowance. Provision for the anticipated Fouling Factor during use.

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

3.5 Liquid Refrigerant Storage Capacity. The maximum liquid refrigerant storage capacity of a condenser shall be computed as being 80 percent of the available volume for the refrigerant and shall be expressed in ft³ [L] or in lb [kg] of a specified refrigerant, assuming saturated liquid refrigerant density at 90.0°F [32.2°C].

3.6 Nominal Refrigerating System Capacity. The cooling effect determined by the product of the mass flow rate of refrigerant and the difference in enthalpy between the refrigerant entering the evaporator and the refrigerant leaving the evaporator.

3.7 Published Rating. 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 Water-Cooled Refrigerant Condensers of like nominal size and type 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.

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

3.7.2 Standard Rating. A rating based on tests performed at Standard Rating Conditions.

3.8 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.

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

3.9 Saturated Condensing Temperature. For single component and azeotrope refrigerants, it is the saturated temperature corresponding to the refrigerant pressure at the condenser entrance. For zeotropic refrigerants, it is the arithmetic average of the dew point and bubble point temperatures corresponding to the refrigerant pressure at the condenser entrance.

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

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

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

3.11 Total Heat Rejection Effect. The total amount of heat removed from the refrigerant. This value is the product of the mass flow rate of refrigerant and the difference in enthalpy between the entering refrigerant vapor and the leaving refrigerant liquid, expressed in Btu/h [W]. (The total heat rejection, for all practical purposes, is the total heat transfer in the evaporator of the system plus the heat added to the refrigerant by the refrigeration compressor.)

3.12 Water-Cooled Refrigerant Condenser. A factory-made assembly in which heat is transferred from the refrigerant vapor to the water such that the refrigerant vapor is condensed into a liquid.

Section 4. Test Requirements

4.1 Test Requirements. All Standard Ratings shall be verified by tests conducted in accordance with ASHRAE Standard 22.

Section 5. Rating Requirements

5.1 Standard Rating. Published Ratings shall include the Standard Rating, as specified, for at least one of the rating conditions shown in Table 1 and properly identified as the Standard Rating. Standard Ratings shall be based on tests with initially clean tubes. The water-side and refrigerant-side Fouling Factors shall be assumed to be zero.

5.2 Application Ratings. Application Ratings provide performance data at operating conditions other than those shown in Table 1. Whenever Application Ratings are published or printed, they shall include, or be accompanied by, the Standard Rating, clearly designated as such, including a statement of the conditions at which the ratings apply. Application Ratings shall contain all information shown in 6.2. When Application Ratings include a water-side Field Fouling Allowance, they shall be calculated by the method specified in 5.3. Published Ratings shall be subject to the tolerances of this standard.

5.2.1 Either Application Ratings or a method of adjusting the clean tube ratings may be presented to show the effect of various water-side Field Fouling Allowances. These calculation methods or methods of adjusting these ratings shall be calculated in accordance with 5.3.

Table 1. Standard Rating Conditions								
Rating Condition	Saturated Condensing Temperature of the Entering Refrigerant		Minimum Actual Temperature of the Entering Refrigerant Vapor		Temperature of Entering Water		Temperature of Leaving Water	
	°F	°C	°F	°C	°F	°C	°F	°C
1	105	40.6	125	51.7	75.0	23.9	95.0	35.0
2	105	40.6	125	51.7	85.0	29.4	95.0	35.0
3	85.0	29.4	105	40.6	50.0	10.0	70.0	21.1
4	100	37.8	120	48.9	70.0	21.1	85.0	29.4

5.2.2 The manufacturer shall publish the maximum and minimum recommended flow rates for clean water.

5.3 *Determination of Ratings.* Ratings shall be determined in accordance with the following:

5.3.1 *Clean Tube Ratings.* Clean tube ratings shall be based on tests with initially clean tubes and conducted in accordance with 4.1. The results of these tests shall be accepted as reflecting a Fouling Factor of zero.

5.3.2 *Fouled Ratings.* From the results of the clean tube tests, calculate the clean tube overall heat transfer coefficient, U_c . Then, mathematically add the specified Fouling Factor to the reciprocal of the clean tube U_c and calculate the fouled ratings for publication using the following method (refer to ARI Guideline E for discussion of Fouling Factors).

$$U_c = \frac{q}{A \times (LMTD)_c} \tag{1}$$

where:

$$LMTD = \frac{(t_s - t_{we}) - (t_s - t_{wl})}{\ln \left[\frac{t_s - t_{we}}{t_s - t_{wl}} \right]}$$

$$= \frac{(t_{wl} - t_{we})}{\ln \left[\frac{(t_s - t_{wl}) + (t_{wl} - t_{we})}{t_s - t_{wl}} \right]}$$

$$LMTD = \frac{R}{\ln (1 + R/S)} \tag{2}$$

The following equations shall be used to calculate fouled ratings:

5.3.2.1 For fouling inside tubes (condensing outside):

a. Based on outside surface:

$$U_{fo} = \frac{1}{\frac{1}{U_{co}} + \left[\frac{A_o}{A_i} \right] r_{fi}} \tag{3a}$$

- b. Based on inside surface:

$$U_{fi} = \frac{1}{\frac{1}{U_{ci}} + r_{fi}} \quad (3b)$$

5.3.2.2 For fouling outside tubes (condensing inside):

- a. Based on outside surface:

$$U_{fo} = \frac{1}{\frac{1}{U_{co}} + r_{fo}} \quad (3c)$$

- b. Based on inside surface:

$$U_{fi} = \frac{1}{\frac{1}{U_{ci}} + \left[\frac{A_i}{A_o} \right] r_{fo}} \quad (3d)$$

5.3.2.3 The following equations shall be used for all configurations to obtain the small temperature difference, S_f , at the fouled conditions:

- a. Based on outside surface:

$$S_f = \frac{R}{e^x - 1} \quad (4a)$$

Where:

$$x = \frac{R \cdot U_{fo} \cdot A_o}{q}$$

- b. Based on inside surface:

$$S_f = \frac{R}{e^y - 1} \quad (4b)$$

Where:

$$y = \frac{R \cdot U_{fi} \cdot A_i}{q}$$

5.3.2.4 The new condensing temperature with fouled tubes, t_{sf} , can then be found using the small temperature difference, S_f :

$$t_{sf} = t_{w1} + S_f \quad (5)$$

5.3.2.5 Symbols and Subscripts. The symbols and subscripts used in Equations 1 through 5 are as follows:

Symbols:

- A = Total heat transfer surface, ft² [m²]
- A_i/A_o = Ratio of inside to outside surface area
- A_o/A_i = Ratio of outside to inside surface area
- e = Base of natural logarithm
- $LMTD$ = Logarithmic mean temperature difference, °F [°C]
- q = Total heat rejection rate, Btu/h [W]
- r = Heat transfer resistance, h · ft² · °F/Btu [m² · °C/W]
- R = Water temperature range = $t_{wl} - t_{we}$, °F [°C]
- S = Small temperature difference = $t_s - t_{wl}$, °F [°C]
- t = Temperature, °F [°C]
- U = Overall heat transfer coefficient, Btu/h · ft² · °F [W/m² · °C]

Subscripts:

- c = clean
- e = entering
- f = fouled or fouling
- i = inside
- l = leaving
- o = outside
- s = saturated condensing
- w = water

5.4 Tolerances. To comply with this standard, measured test results shall not be less than 95% of the Published Rating for Total Heat Rejection Effect and shall not exceed 110 percent of the Published Ratings for pressure drop.

Section 6. Minimum Data Requirements for Published Ratings

6.1 Minimum Data Requirements for Published Ratings. As a minimum, Published Ratings shall include all Standard Ratings. All claims to ratings within the scope of this standard shall be accompanied by the statement “Rated in accordance with AHRI Standard 450.” All claims to ratings outside the scope of this standard shall be accompanied by the statement “Outside the scope of ARI Standard 450.” Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

Application Ratings shall contain all information shown in 6.2. When Application Ratings include a liquid-side Fouling Factor, they shall be calculated by the method specified in 5.3.

6.2 Published Ratings

6.2.1 Published Ratings shall include the following:

- a. Refrigerant designation(s) in accordance with ANSI/ASHRAE Standard 34 with Addenda
- b. Saturated Condensing Temperature, °F [°C]
- c. Leaving liquid refrigerant temperature, °F [°C]
- d. Total Heat Rejection Effect, Btu/h [W]
- e. Water flow rate, gpm [L/s]
- f. Water pressure drop, psi [kPa]
- g. Fouling Factor (waterside) ft² · h · °F/Btu [m² · °C/W]

plus at least one of the following:

- h. Temperature of entering water, °F [°C]
- i. Temperature of leaving water, °F [°C]

6.2.2 Published Ratings shall be accompanied by the following information:

- a. Design pressures for water-side and refrigerant-side, psig [kPa]
- b. Overall dimensions
- c. All connection sizes and types
- d. Maximum refrigerant storage capacity, ft³ [L] or lb [kg]
- e. Shipping weight, lb [kg]
- f. Operating weight (including refrigerant and water), lb [kg]
- g. If only clean tube ratings are published, a statement shall be included to contact the manufacturer if fouled tube ratings are required

Section 7. Marking and Nameplate Data

7.1 *Marking and Nameplate Data.* As a minimum, each condenser shall have the following information shown in a conspicuous place:

- a. Name of manufacturer
- b. Manufacturer's model or serial number
- c. Design pressure for the water-side, psig [kPa]
- d. Design pressure for the refrigerant-side, psig [kPa]
- e. Refrigerant designation in accordance with ANSI/ASHRAE 34 with Addenda

Section 8. Conformance Conditions

8.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's *Purpose* (Section 1) and *Scope* (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES – NORMATIVE

A1 Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of this standard.

A1.1 ANSI/ASHRAE Standard 34-2004 with Addenda, *Designation and Safety Classification of Refrigerants*, 2004, American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 11 West 42nd Street, New York, NY 10036 U.S.A./1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.2 ASHRAE Standard 22-2003, *Methods of Testing for Rating Water Cooled Refrigerant Condensers*, 2003, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.3 *ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration*, 1991, Second Edition, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

APPENDIX B. REFERENCES – INFORMATIVE

B1 Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

B1.1 AHRI Guideline E-1997 (formerly ARI Guileline E-1997), *Fouling Factors: A Survey of Their Application in Today's Air-Conditioning and Refrigeration Industry*, 1997, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, U.S.A.