ANSI/AHRI Standard 491 (SI)

2011 Standard for

Performance Rating of Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers

Approved by ANSI on April 16, 2012

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

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.

Note:

This standard supersedes ARI Standard 490-2003.
For the I-P version, see ANSI/AHRI Standard 490 (I-P) – 2011

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

TABLE OF CONTENTS

TABLE

APPENDICES

PERFORMANCE RATING OF REMOTE MECHANICAL-DRAFT EVAPORATIVELY-COOLED REFRIGERANT CONDENSERS

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish for Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers (Evaporative Condensers): definitions; test requirements; rating requirements; calculations; 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 Evaporative Condensers as defined in Section 3 of this standard and is limited to Halocarbon Refrigerants and ammonia (R-717), for use with or without external air resistance.

2.2 *Exclusions.*

2.2.1 This standard does not apply to Evaporative Condensers designed primarily for installation within the machinery compartment of a self-contained product or on a factory-assembled condensing unit.

2.2.2 This standard does not apply to Remote Mechanical-Draft Air-Cooled Refrigerant Condensers as covered by AHRI Standard 460.

Section 3. Definitions

Definitions. All terms in this document will 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 *Entering Air Wet-Bulb Temperature.* The average wet-bulb temperature of the air entering the condenser assembly, °C.

3.2 *Halocarbon.* A hydrocarbon derivative containing one or more of the halogens bromine, chlorine, or fluorine; hydrogen also may be present.

3.3 *Net Refrigeration Effect.* The rate of total heat absorption by the Refrigerant, at stated evaporator conditions, of the complete refrigeration system. This effect is equal to the product of the refrigerant mass flow rate through the system and the enthalpy difference between the refrigerant vapor leaving the evaporator and the refrigerant liquid entering the liquid control device of the evaporator, W.

3.4 *Published Rating.* A statement of 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, including computer software and computer-generated reports, controlled by the manufacturer, at stated Rating Conditions.

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

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

3.5 *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.

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

3.6 *Refrigerant.* Fluid used for heat transfer in a refrigerating system which absorbs heat at a low temperature and low pressure of the fluid and transfers heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the the fluid.

3.7 *Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condenser (Evaporative Condenser).* A factory-made encased unit for connection to a refrigerant piping system. The unit shall include means for mechanical air circulation, water distribution and heat transfer surface by which heat is transferred from Refrigerant to water and air. The purpose of this unit is to condense refrigerant vapor by rejecting heat to water and air which are circulated over its heat transfer surface, thereby causing evaporation of the water and an increase in the enthalpy of the air.

3.8 *Saturated Condensing Temperature (Condensing Temperature).* For single component and Azeotrope Refrigerants, the saturation temperature corresponding to the refrigerant pressure at the condenser entrance. For Zeotropic Refrigerants, the arithmetic average of the Dew Point and Bubble Point corresponding to the Refrigerant pressure at the condenser entrance, °C.

3.8.1 *Azeotropic Refrigerant.* Blend of two or more component Refrigerants whose equilibrium vapor-phase and liquid-phase compositions are the same at a given pressure.

3.8.2 *Bubble Point.* The Refrigerant temperature at which bubbles begin to appear in a saturated liquid.

3.8.3 *Dew Point.* The Refrigerant temperature at which moisture begins to form.

3.8.4 *Zeotropic Refrigerant.* Blend of two or more component Refrigerants whose equilibrium vapor-phase and liquid-phase compositions are different at a given temperature.

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

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

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

3.10 *Total Heat Rejection Effect (Capacity).* The rate of total heat removal from the Refrigerant. This effect is equal to the product of the mass flow rate and enthalpy difference between the refrigerant vapor entering the condenser and the refrigerant liquid leaving the condenser, W. (The Total Heat Rejection Effect, for all practical purposes, is equal to the Net Refrigeration Effect in the evaporator of the system plus the heat added to the Refrigerant by the refrigerant compressor.)

3.10.1 *Adjusted Total Heat Rejection Effect.* The Total Heat Rejection Effect at application rating conditions corrected to Standard Rating Conditions, W.

Section 4. Test Requirements

4.1 *Test Requirements.* Evaporative Condensers shall be tested in accordance with ANSI/ASHRAE Standard 64 except that barometric pressure shall be measured. The test-measured capacity shall be adjusted per Section 6 of this standard to determine the Adjusted Total Heat Rejection Effect at Standard Rating Conditions.

4.2 *Test Conditions.* Actual test conditions shall not deviate from Standard Rating Conditions by more than:

Barometric pressure	± 10 kPa

Entering air wet-bulb temperature	± 0.5°C
Condensing Temperature	± 0.5°C
Actual temperature of Refrigerant vapor entering condenser	± 3°C

Makeup water entering the condenser (when operational) shall be within ± 3ºC of the measured spray water temperature.

The fan and pump motor shaft output power, kW shall be within ± 10% of the Published Ratings.

Section 5. Rating Requirements

5.1 *Standard Ratings.* Standard Ratings for Evaporative Condensers shall be determined at the Standard Rating Conditions specified in Table 1.

Table 1. Standard Rating Conditions

	Halocarbon Refrigerants	Ammonia (R-717)
Barometric Pressure, kPa	101.0	101.0
Entering Air Wet-Bulb Temperature, ºC	24	24
Condensing Temperature, ºC	40	36
Actual Temperature of Refrigerant Vapor Entering Condenser, ºC	60	60º
External Static Pressure, kPa	0	0

5.1.2 *Standard Unit Configuration.* Standard Ratings shall be based on the standard unit configuration as supplied by the manufacturer with all guards, safety screens and other appurtenances in place.

5.2 *Application Ratings.* Application Ratings are used to select an Evaporative Condenser for a specific operating condition within the operating range for which it is intended and shall include the Total Heat Rejection Effect in the same terms as the Standard Rating in Section 5.1.

5.3 *Tolerances.* To comply with this standard, any representative production unit selected at random shall have an Adjusted Total Heat Rejection Effect at Standard Rating Conditions, q_{src}, not less than 95% of the published Standard Rating.

5.4 *Optional Accessories.* The effect on performance of optional accessories available from the manufacturer should clearly be stated in the manufacturer's Published Ratings.

Section 6. Calculations

6.1 *Adjustments.* The Total Heat Rejection Effect at test conditions, q_c, shall be adjusted to determine the Adjusted Total Heat Rejection Effect at Standard Rating Conditions, q_{src}.

6.1.1 *Adjusted Total Heat Rejection Effect at Standard Rating Conditions.* For each test, a Total Heat Rejection Effect at Standard Rating Conditions, q_{src}, shall be calculated as follows:

$$q_{SRC} = q_c \cdot CF_{bp} \cdot CF_{tc} \cdot CF_{tfp} \quad (1)$$

Where:

CF_{bp} = Barometric pressure correction factor
CF_{tc} = Temperature condition correction factor
CF_{tfp} = Total fan power correction factor
q_c = Total Heat Rejection Effect at test conditions, W
q_{src} = Adjusted Total Heat Rejection Effect at Standard Rating Conditions, W

6.1.2 *Barometric Pressure Correction Factor.* The barometric pressure correction factor shall be calculated as follows:

$$CF_{bp} = \frac{1}{[1 + K_1 \cdot (BP_{std} - BP_c)]} \quad (2)$$

Where:

BP_c = Barometric pressure at test conditions, kPa
BP_{std} = 101.0, kPa
K_1 = 0.0023, 1/kPa

6.1.3 *Temperature Condition Correction Factor.* The temperature correction factor shall be based on the manufacturer's published Application

6.1.4 Ratings shall be calculated as follows:

$$CF_{tc} = \frac{q_{psrc}}{q_{papp}} \quad (3)$$

Where:

q_{psrc} = Published Total Heat Rejection Effect at Standard Rating Conditions, W
q_{papp} = Published Total Heat Rejection Effect at Application Rating Conditions, W

6.1.5 *Fan Power Correction Factor.* The fan power correction factor shall be based on the manufacturer's published fan power exponent for capacity adjustment and shall be calculated as follows:

$$CF_{tfp} = \left(\frac{TFP_{src}}{TFP_c} \right)^x \quad (4)$$

Where:

TFP_{src} = Total fan motor shaft output power at Standard Rating Conditions, W
TFP_c = Total fan motor shaft output power at test conditions, W
x = Manufacturer's fan power exponent for Adjusted Total Heat Rejection Effect

Section 7. Minimum Data Requirements for Published Ratings

7.1 *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 include the statement "Rated in accordance with ANSI/AHRI Standard 491 (SI)." All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of ANSI/AHRI Standard 491 (SI)." Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

7.2 Each Published Rating of Evaporative Condensers shall include the following information:

7.2.1 Refrigerant designation(s) in accordance with ANSI/ASHRAE Standard 34 with Addenda
7.2.2 Total Heat Rejection Effect, W
7.2.3 Fan motor shaft output power, W at 0 kPa external pressure
7.2.4 Condenser air flow rate, m^3/s
7.2.5 Pump motor shaft output power, kW
7.2.6 Condenser recirculating water flow rate, L/s
7.2.7 Equipment dimensions, mm/m
7.2.8 Connection quantity and size, mm

Section 8. Marking and Nameplate Data

As a minimum, the nameplate shall display the manufacturer's name, model designation and serial number.

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of AHRI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard 60038.

Section 9. Conformance Conditions

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 the standard.

A1.1 AHRI Standard 110-2002 , *Air-Conditioning and Refrigeration Equipment Nameplate Voltages*, 2002, Air Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, USA.

A1.2 ANSI/AHRI 460-2005, *Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers*, 2005, Air Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, USA.

A1.3 ANSI/ASHRAE Standard 34-2010 with Addenda, *Designation and Safety Classification of Refrigerants*, 2010, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-5478, USA.

A1.4 ANSI/ASHRAE Standard 64-2011, *Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers*, 2011, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-5478, USA.

A1.5 *ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-5478, USA.

A1.6 IEC 60038, *IEC Standard Voltages*, 2009, International Electrotechnical Commission, 3 rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

None.