AHRI Standard 421 (SI)

2016 Standard for

Performance Rating of Forced-circulation Free-delivery Unit Coolers for Refrigeration

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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 ANSI/AHRI Standard 420-2009.
For I-P ratings, see AHRI Standard 420 (I-P)-2016.

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PERFORMANCE RATING OF FORCED-CIRCULATION FREE-DELIVERY UNIT COOLERS FOR REFRIGERATION

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish for Forced-circulation Free-delivery Unit Coolers for Refrigeration: 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, Forced-circulation, Free-delivery Unit Coolers, as defined in Section 3, operating with a Volatile Refrigerant fed by either direct expansion or liquid overfeed at wet and/or dry conditions.

2.1.1 *Exclusions.* This standard does not apply to:

2.1.1.1 Air-conditioning units used primarily for comfort cooling for which testing methods are given in other standards.

2.1.1.2 Unit Coolers operating at latent load conditions with Refrigerant Saturation Temperature < 0.0 ºC to prevent frost.

2.1.1.3 Unit Coolers installed in or connected to ductwork.

2.1.1.4 Unit Coolers using zeotropic refrigerants with Glides greater than 1.0 ºC.

2.1.1.5 Field testing of Unit Coolers.

Section 3. Definitions

All terms in this document follow the standard industry definitions in the current edition of *ASHRAE Terminology (https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology)* unless otherwise defined in this section.

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

3.2 *Enthalpy Difference (HD).* The difference between the enthalpy of the air entering the Unit Cooler and the calculated enthalpy of saturated air at the Refrigerant Saturation Temperature at the Unit Cooler outlet, J/kg.

3.3 *Forced-circulation Free-delivery Unit Coolers (Unit Coolers).* A factory-made assembly, including means for forced air circulation and elements by which heat is transferred from air to refrigerant without any element external to the cooler imposing air resistance. These may also be referred to as Air Coolers, Cooling Units, Air Units or Evaporators.

3.3.1 *Direct Expansion Unit Cooler*. A Unit Cooler in which the leaving refrigerant vapor is superheated.

3.3.2 *Liquid Overfeed Unit Cooler*. A Unit Cooler in which the refrigerant liquid is supplied at a Recirculation Rate greater than 1.

3.4 *Glide.* The absolute value of the difference between the starting and ending temperatures of a phase-change process (condensation or evaporation) for a zeotropic refrigerant exclusive of any liquid subcooling or vapor superheating.

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3.5 *Gross Total Cooling Effect (Cooling Capacity).* The heat absorbed by the refrigerant, W. This is the sum of the Net Total Cooling Effect and the heat equivalent of the energy required to operate the Unit Cooler. This includes both sensible and latent cooling.

3.6 *Net Total Cooling Effect.* The refrigeration capacity available for space and product cooling, W. It is equal to the Gross Total Cooling Effect less the heat equivalent of energy required to operate the Unit Cooler. This includes both sensible and latent cooling.

3.7 *Overfeed Ratio*. The mass ratio of liquid to vapor at the outlet of the Liquid Overfeed Unit Cooler. This may also be referred to as overfeed rate.

3.8 *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 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.

3.8.1 *Application Rating.* A rating at conditions other than Standard Rating Conditions.

3.8.2 *Standard Rating.* A rating at one of the Standard Rating Conditions shown in Table 1 that is an accurate representation of test data.

3.9 *Rated Power.*

3.9.1 For single phase motors, total fan motor input power, W or kW.

3.9.2 For polyphase motors, individual fan motor output power, kW.

3.10 *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.

3.10.1 *Standard Rating Conditions.* Rating Conditions listed in Table 1 that can be used as a basis of comparison for performance characteristics.

3.10.1.1 *Dry Rating Condition*. Rating Condition where latent cooling is not present.

3.10.1.2 *Wet Rating Condition*. Rating Condition where both sensible and latent cooling are present and the coil surface temperature is above freezing.

3.11 *Recirculation Ratio. (Recirculation Rate)* The mass ratio of liquid circulated to the amount of liquid vaporized.

3.12 *Refrigerant Saturation Temperature.* Refrigerant temperature at the Unit Cooler inlet or outlet determined either by measuring the temperature at the outlet of the two-phase refrigerant flow, for a Liquid Overfeed Unit Cooler, or by measuring refrigerant pressure and determining the corresponding temperature from reference thermodynamic tables or equations for the refrigerant, ºC. For zeotropic refrigerants, the corresponding temperature to a measured pressure is the refrigerant Dew Point.

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

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

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

3.14 *Standard Air Conditions.* Dry air at 21 ºC and absolute pressure 101.3 kPa. Under these conditions, dry air has a mass density of 1.2 kg/m^3.

3.15 *Steady-State Conditions*. An operating state of a system, including its surroundings, in which the extent of change with time is within the limits specified in Tables C3 and C4.

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3.16 *Temperature Difference (TD).* The difference between the dry-bulb temperature of the air entering the Unit Cooler and the Refrigerant Saturation Temperature at the unit cooler outlet, K.

3.17 *Test Measurement.* The reading of a specific test instrument at a specific point in time. The Test Measurement may be averaged with other measurements of the same parameter at the same time to determine a Test Reading or averaged over the duration of the test to determine the value for the Test Run.

3.18 *Test Reading.* The recording of one full set of the Test Measurements required to assess the performance of the test unit.

3.19 *Test Run.* Test Readings compiled during Unit Cooler operation during which steady-state conditions have been maintained. It shall last for a minimum of 30 minutes with at least 15 consecutive Test Readings, all of which shall comply with the requirements of Tables C1, C2, C3 and C4. It includes all the information required to determine Unit Cooler performance at a specific rating condition.

3.20 *Test Series.* A group of Test Runs, performed on the same test unit, to determine performance at all required rating conditions.

3.21 *Volatile Refrigerant.* A refrigerant which changes from liquid to vapor in the process of absorbing heat.

Section 4. Test Requirements

4.1 *Test Requirements*. All Standard Ratings of Unit Coolers shall be verified by tests conducted at Standard Rating Conditions, Table 1, in accordance with one of the methods set forth in Appendix C.

Table 1. Standard Rating Conditions

Condition Number	Coil rating condition	Entering Air				Refrigerant Saturation Temperature[2], °C	Temperature Difference, K
		Dry-bulb Temperature, °C	Wet-bulb Temperature, °C	Relative Humidity[1], %	Dew Point Temperature[1], °C		
1	Wet	10	7.8	75	-	1.5	8.5
2	Dry	10	-	< 45	< -1.0	1.5	8.5
3	Dry	1.5	-	< 50	< -7	-4.0	5.5
4	Dry	-12	-	< 46	< -21	-18	5.5
5	Dry	-23	-	< 43	< -32	-29	5.5

Notes:

1. The coil Dry Rating Condition can be confirmed by measuring either the entering air dew point or relative humidity according to the instrumentation requirements of Table 2. At coil Wet Rating Condition, relative humidity is for reference only.

2. Measured at coil outlet.

4.1.1 All regularly furnished equipment that will affect performance shall be in place during the test.

4.1.2 The refrigerant used during the test shall be one that is published for use with the Unit Cooler.

4.1.3 Each Standard Rating test shall be performed at either 50 Hz or 60 Hz and at the highest rated voltage as specified by the manufacturer on the unit or motor nameplate.

4.1.4 *Instrumentation Requirements*. Precision instruments and automated electronic data acquisition equipment shall be used to measure and record temperature, pressure and refrigerant flow rate test parameters. The use of advanced technologies or methods of measurement not described in this appendix are acceptable, provided the accuracy requirements of this appendix are achieved by the alternative method.

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4.1.4.1 *Calibration* All measuring instruments and instrument systems (e.g. data acquisition coupled to temperature, pressure, or flow sensors) shall be calibrated by comparison to primary or secondary standards with calibrations traceable to National Institute of Standards and Technology (NIST) measurements, other recognized national laboratories, or derived from accepted values of natural physical constants. All test instruments shall be calibrated annually, whenever damaged, or when the accuracy is called into question.

4.1.4.2 *Selection and Accuracy*. All measuring instruments shall be selected to meet or exceed the accuracy criteria listed in Table 2 for each type of measurement.

Table 2. Instrumentation Accuracy

Measurement	Medium	Minimum Accuracy	Instrument Examples
Temperature	Air dry-bulb	± 0.06 K	Resistance temperature device (RTD) thermistor
	Air wet-bulb		
	Refrigerant liquid		
	Refrigerant vapor	± 0.3 K	Special calibrated thermocouple
	Air Dew Point	± 0.3 K	Chilled mirror hygrometer
	Others	± 0.6 K	Liquid-in-glass thermometer
Relative Humidity[1]	Air	± 3 percentage points Rh	Capacitive or resistive rh sensor
Pressure	Refrigerant	Pressure corresponding to ± 0.1 K of saturation temperature	Transducer
	Air	170 Pa	Barometer
Flow	Refrigerant	1% of reading	Mass flow meter
	Liquids	1% of reading	Venturi
Electrical	Motor kilowatts/amperes/voltage	1% of reading	Power meter
	Auxiliary kilowatt input (e.g. heater)		Amp probe
			Multimeter
Speed	Motor/fan shaft	1% of reading	Tachometer
Weight	Oil/refrigerant solution	0.5% of reading	Gravimeter (scale or analytical balance)
Specific Gravity	Brine	1% of reading	Hydrometer
Time	Hours/minutes/seconds	0.5% of time interval	Electronic clock

Note:

1. Relative humidity and air dew point measurements are intended to confirm the dry coil condition for test condition numbers 2 through 5 from Table 1.

Section 5. Rating Requirements

5.1 *Standard Ratings.* Standard Ratings shall include Rated Power and Gross Total Cooling Effect established at all applicable Standard Rating Conditions specified in Table 1.

5.2 *Application Ratings*. Application Ratings shall include Rated Power and Gross Total Cooling Effect at conditions other than Standard Rating Conditions. Application Ratings with Refrigerant Saturation Temperatures below 0.0 ˚C shall be rated at dry conditions. Application Ratings published by the manufacturer shall be clearly identified as Application Ratings.

5.3 *Tolerances.* To comply with this standard, any representative production unit selected at random, when tested at the Standard Rating Conditions, shall have a Gross Total Cooling Effect not less than 95 % of its published Standard Rating and not exceed 105 % of its Rated Power.

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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 at which the unit will be produced, marketed or sold. All claims to ratings for products within the scope of this standard shall be accompanied by the statement "Rated in accordance with AHRI Standard 421." All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 421." Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

6.2 *Required Published Ratings.* All published Standard Ratings and Application Ratings shall include:

6.2.1 Model number
6.2.2 Gross Total Cooling Effect, W
6.2.3 Temperature Difference, K
6.2.4 Refrigerant designation(s) in accordance with ANSI/ASHRAE Standard 34 with Addenda
6.2.5 Refrigerant saturation temperature, °C
6.2.6 Rated power W or kW
6.2.7 Number of motors
6.2.8 Coil fin density, fins per inch or coil fin spacing [mm]; Actual fin density or fin spacing shall be within 10 % of published values.
6.2.9 Airflow rate, m^3/s of Standard Air

6.3 *Recommended Published Ratings*. It is recommended that the following data be published in addition to the required Published Ratings per Section 6.2:

6.3.1 Type of defrost
6.3.2 Unit cooler motor current, A; voltage, V; and frequency, Hz
6.3.3 Defrost heater power, W; and voltage, V (if used)

Section 7. Marking and Nameplate Data

7.1 *Marking and Nameplate Data.* As a minimum, the manufacturer name or trade-name; model number; refrigerant(s); current, A; voltage, V; frequency, Hz; and phase shall be shown in a conspicuous place on the unit.

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 Publication 60038.

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.

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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 except where deviations are noted.

A1.1 AHRI Standard 110-2016, *Air-Conditioning, Heating, and Refrigerating Equipment Nameplate Voltages*, 2016, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.2 ANSI/ASHRAE Standard 34-2013 with Addenda, *Designation and Safety Classification of Refrigerants*, 2013, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.3 ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*, 2013, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.4 ANSI/ASHRAE Standard 41.3-2014, *Standard Method for Pressure Measurement*, 2014, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.5 ANSI/ASHRAE Standard 41.4-2015, *Standard Method for Measurement of Proportion of Lubricant in Liquid Refrigerant*, 2015, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.6 ANSI/ASHRAE Standard 41.10-2013, *Standard Methods for Refrigerant Mass Flow Measurement Using Flowmeters*, 2013, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.7 *ASHRAE Handbook Fundamentals*, 2013, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.8 ASHRAE *Psychrometric Analysis* software, Version 7, 2016, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.9 ASHRAE Terminology, https://www.ashrae.org/resources--publications/free-resources/ashraeterminology, 2016, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.10 IEC Standard Publication 60038-2009, *IEC Standard Voltages*, 2009, International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH - 1211 GENEVA 20, Switzerland.

A1.11 NIST Reference Fluid Thermodynamic and Transport Properties, *REFPROP*, Version 9.1, 2016, National Institute of Standards and Technology, Boulder, CO 80303, USA.

APPENDIX B. REFERENCES – INFORMATIVE

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

B1.1 *Ammonia Refrigeration Piping Handbook*, 2014, International Institute of Ammonia Refrigeration, 1001 North Fairfax Street, Suite 503, Alexandria, VA 22314, U.S.A.

B1.2 ANSI/ASHRAE Standard 41.9-2011, *Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Calorimeters*, 2011, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

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