AHRI Standard 421-2023 (SI)

2023 Standard for

Performance Rating of Forced-circulation Free-delivery Unit Coolers

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Note:

This standard supersedes AHRI Standard 421 (SI)-2016.

For I-P ratings, see AHRI Standard 420-2023 (I-P).

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Intent

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

Review and Amendment

This standard is subject to review and amendment as technology advances.

2023 Edition

This edition of AHRI 421, *Performance Rating of Forced-circulation Free-delivery Unit Coolers*, was prepared by the Industrial Refrigeration Standards Technical Committee. It was published by the Refrigeration Standards Subcommittee on 22 June 2023.

Origin and Development of AHRI Standard 421

The initial publication was ARI Standard 421-2016, *Unit Coolers for Refrigeration*. Subsequent revisions were:

Summary of Changes

AHRI Standard 421-2023 (SI) contains the following updates to the previous edition:

- Updated Equations for the inclusion of heat exchanger heat loss/gain in Appendix C.
- Updated Figure 3 to better represent the liquid overfeed method
- Added R-744 to Table 4
- Updated Definitions to include heat exchanger heat loss/gain

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Industrial Refrigeration Standards Technical Committee Scope:

The Industrial Refrigeration Standards Technical Committee (STC) is responsible for the development and maintenance of AHRI standards and guidelines pertaining to the performance ratings of Industrial Refrigeration equipment which includes Industrial Unit Coolers, and Industrial Heat Rejection Equipment.

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Refrigeration Standards Subcommittee Scope:

The scope of the Refrigeration Standards Subcommittee is standards and guidelines related to the end products that are part of the AHRI Refrigeration Industry Sector. (The definition of and list of products associated with each sector are found on the AHRI website.

These lists represent the membership at the time the Standards Technical Committee and Standards Subcommittee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership on these committees shall not in and of itself constitute an endorsement by the committee members or their employers of any document developed by the committee on which the member serves.

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PERFORMANCE RATING OF FORCED-CIRCULATION FREE-DELIVERY UNIT COOLERS

Section 1. Purpose

This standard establishes definitions, test requirements, rating requirements; minimum data requirements for *published ratings*, marking and nameplate data, and conformance conditions for *forced-circulation free-delivery unit coolers* for refrigeration.

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 or dry conditions, or both.

2.2 Exclusions

This standard does not apply to:

1) Air-conditioning units used primarily for comfort cooling where testing methods are given in other standards
2) *Unit coolers* operating at latent load conditions with *refrigerant saturation temperature* < 0,0ºC to prevent frost
3) *Unit coolers* installed in or connected to ductwork
4) *Unit coolers* using zeotropic refrigerants with *glides* greater than 1,0ºC
5) Field testing of *unit coolers*

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section.

3.1 Expressions of Provision

Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 “Can” or “cannot”

Express an option or capability.

3.1.2 “May”

Signifies a permission expressed by the document.

3.1.3 “Must”

Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 “Shall” or “shall not”

Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 “Should” or “should not”

Indication of recommendations rather than requirements. In the negative form, a recommendation is the expression of potential choices or courses of action that is not preferred but not prohibited.

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3.2 Standard Specific Definitions

3.2.1 Dew Point

Refrigerant vapor saturation temperature at a specified pressure.

3.2.2 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.

3.2.3 Forced-circulation Free-delivery Unit Coolers (Unit Coolers)

A factory-made assembly, including means for forced air circulation and elements where heat is transferred from air to refrigerant without any element external to the cooler imposing air resistance. These can be referred to as air coolers, cooling units, air units or evaporators.

3.2.3.1 Direct Expansion Unit Cooler

A *unit cooler* where the leaving refrigerant vapor is superheated.

3.2.3.2 Liquid Overfeed Unit Cooler

A *unit cooler* where the refrigerant liquid is supplied at a *recirculation rate* greater than 1.

3.2.4 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.

3.2.5 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 equal to the energy required to operate the *unit cooler*. This includes both sensible and latent cooling.

3.2.6 Net Total Cooling Effect

The refrigeration capacity for space and product cooling, expressed in W, and is equal to the *gross total cooling effect* less the heat equal to energy required to operate the *unit cooler*. This includes both sensible and latent cooling.

3.2.7 Overfeed Ratio

The mass ratio of liquid to vapor at the outlet of the *liquid overfeed unit cooler*. This can be referred to as overfeed rate.

3.2.8 Published Rating

A statement of the assigned values of those performance characteristics, under stated rating conditions, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This 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*.

3.2.8.1 Application Rating

A rating based on tests performed at *rating conditions* other than *standard rating conditions*.

3.2.8.2 Standard Rating

A rating based on tests performed at *standard rating conditions*.

3.2.9 Rated Power

1) For single phase motors, total fan motor input power, W, or kW
2) For polyphase motors, individual fan motor output power, kW

3.2.10 Rating Conditions

Any set of operating conditions where a single level of performance results and causes only that level of performance to occur.

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3.2.11 Standard Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics.

3.2.11.1 Dry Rating Condition

Rating condition where latent cooling is not present.

3.2.11.2 Wet Rating Condition

Rating condition where both sensible and latent cooling are present, and the coil surface temperature is above freezing.

3.2.12 Recirculation Ratio (Recirculation Rate)

The mass ratio of liquid circulated to the amount of liquid vaporized.

3.2.13 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*.

3.2.14 Standard Air Conditions

Dry air at 21ºC and absolute pressure 101,3 kPa. Under these conditions, dry air has a mass density of 1,2 kg/m^3.

3.2.15 Steady-State Conditions

An operating state of a system, including the system surroundings, where the extent of change with time is within the limits specified in Table 5 and Table 6.

3.2.16 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.

3.2.17 Test Measurement

The reading of a specific test instrument at a specific point in time. Can 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.

3.2.18 Test Reading

The recording of one full set of the *test measurements* required to assess the performance of the test unit.

3.2.19 Test Series

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

3.2.20 Volatile Refrigerant

A refrigerant that changes from liquid to vapor in the process of absorbing heat.

Section 4. Test Requirements

4.1 Test Requirements

All *standard ratings* of *unit cooler* shall be verified by tests conducted at *standard rating conditions*, Table 1, in accordance with one of the methods set forth in Appendix C.

1) All regularly furnished equipment that affects performance shall be in place during the test
2) The refrigerant used during the test shall be one that is published for use with the *unit cooler*
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

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Table 1 Standard Rating Conditions

Condition Number	Coil rating condition	Entering Air				*Refrigerant Saturation Temperature*[2], °C	*TD*, °K
		Dry-bulb Temperature, °C	Wet-bulb Temperature, °C	Relative Humidity[1], %	*Dew Point* Temperature[1], °C		
1	Wet	10,0	7,8	75,0	-	1,5	8,5
2	Dry	10,0	-	< 45,0	< -1,0	1,5	8,5
3	Dry	1,5	-	< 50,0	< -7,0	-4,0	5,5
4	Dry	-12,0	-	< 46,0	< -21,0	-18,0	5,5
5	Dry	-23,0	-	< 43,0	< -32,0	-29,0	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.

4.2 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. Advanced technologies or methods of measurement not described in this standard can be used, provided the accuracy requirements of this standard are achieved by the alternative method.

4.2.1 Calibration

All measuring instruments and instrument systems (for example 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.

4.2.2 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.

4.3 Test Run

Test readings compiled during *unit cooler* operation when *steady-state conditions* have been maintained. The test run shall last for a minimum of thirty minutes with at least fifteen consecutive *test readings*, and all shall comply with the requirements of Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6. The test run includes all the information required to determine *unit cooler* performance at a specific *rating condition*.

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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 (for example. 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 the published *standard rating* and not exceed 105% of the *rated power*.

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 include 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”. *Application ratings* within the scope of the standard shall include a statement of the conditions under which the ratings apply.

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