AHRI Standard 420-2023 (I-P)

2023 Standard for

# Performance Rating of Forced-circulation Free-delivery Unit Coolers

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ICS Code: 27.200

Note:

This standard supersedes AHRI Standard 420-2016 (I-P).

For SI ratings, see AHRI Standard 421-2023 (SI).

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

## Origin and Development of AHRI Standard 420

The initial publication was ARI Standard 420-1989, *Unit Coolers for Refrigeration*. Subsequent revisions were:

- ARI Standard 420-1994, *Unit Coolers for Refrigeration*
- ARI Standard 420-2000, *Unit Coolers for Refrigeration*
- AHRI Standard 420-2008, *Performance Rating of Forced-Circulation Free-delivery Unit Coolers for Refrigeration*
- AHRI Standard 420 (I-P)-2016, *Performance Rating of Forced-Circulation Free-delivery Unit Coolers for Refrigeration*

## Summary of Changes

AHRI Standard 420-2023 (I-P) 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**

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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**

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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* < 32ºF to prevent frost
3) *Unit coolers* installed in or connected to ductwork
4) *Unit coolers* using zeotropic refrigerants with *glides* greater than 2.0°F
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, Btu/lb.

### 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 one.

### 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, Btu/h. 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 Btu/h, 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, hp

### 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, ºF. For zeotropic refrigerants, the corresponding temperature to a measured pressure is the refrigerant *dew point*.

**3.2.14 Standard Air Conditions**

Dry air at 70ºF and absolute pressure 29.92 in Hg. Under these conditions, dry air has a mass density of 0.075 lb/ft$^3$.

**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 *refrigerant saturation temperature* at the *unit cooler* outlet, ºF.

**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 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.

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], °F | *TD*, °F |
|---|---|---|---|---|---|---|---|
| | | Dry-bulb Temperature, °F | Wet-bulb Temperature, °F | Relative Humidity[1], % | *Dew Point* Temperature[1], °F | | |
| 1 | Wet | 50.0 | 46.1 | 75 | - | 35.0 | 15 |
| 2 | Dry | 50.0 | - | < 45 | < 30.0 | 35.0 | 15 |
| 3 | Dry | 35.0 | - | < 50 | < 20.0 | 25.0 | 10 |
| 4 | Dry | 10.0 | - | < 46 | < -5.0 | 0.00 | 10 |
| 5 | Dry | -10.0 | - | < 43 | < -25.0 | -20.0 | 10 |

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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