NOTE: This standard has been consolidated into AHRI Standard 540-2020 (SI/I-P)

AHRI Standard 571 (SI)

2012 Standard for

Performance Rating of Positive Displacement Carbon Dioxide Refrigerant Compressors and Compressor Units

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IMPORTANT

SAFETY RECOMMENDATIONS

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This standard is a new standard.
For I-P ratings, see AHRI Standard 570 (I-P)-2012.
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PERFORMANCE RATING OF POSITIVE DISPLACEMENT CARBON DIOXIDE REFRIGERANT COMPRESSORS AND COMPRESSOR UNITS

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish for positive displacement carbon dioxide refrigerant compressors and compressor units: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; 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 electric motor driven, single and variable capacity, single and two stage Positive Displacement Refrigerant Compressors and Compressor Units operating with carbon dioxide in both Subcritical and Transcritical applications for refrigeration. This standard also applies to the presentation of performance data for Positive Displacement Compressors and Compressor Units operating with carbon dioxide.

2.1.1 *Refrigerant.* The rating points in this standard are based on R-744 (carbon dioxide).

2.2 *Exclusions*.

2.2.1 This standard does not apply to compressors and compressor units intended for use in:

2.2.1.1 Household refrigerators and freezers
2.2.1.2 Automotive air-conditioners
2.2.1.3 Dehumidifiers
2.2.1.4 Industrial products other than heating and cooling

2.2.2 This standard does not apply to compressors that are coupled with condensers or gas cooler heat exchangers.

2.2.3 This standard does not apply to carbon dioxide compressors used in heat pump and air-conditioning applications.

Section 3. 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 *Coefficient of Performance (COP)*. A ratio of the cooling capacity in watts (W) to the power input value in watts (W) at any given set of Rating Conditions expressed in watts/watt, W/W.

3.2 *Compressor Efficiency or Compressor Unit Efficiency*. A ratio of theoretical to actual power as defined in Appendix C.

3.3 *Positive Displacement Refrigerant Compressor*. A machine in which an increase in refrigerant vapor pressure is attained by changing the internal volume of the compression chamber through work applied to the compressor's mechanism. This shall include desuperheaters, head fans or other accessories required to sustain operation of the compressor at the Rating Conditions.

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3.3.1 *Hermetic Refrigerant Compressor.* A compressor and motor assembly, both of which are enclosed in the same housing, with the motor operating in the refrigerant.

3.3.2 *Semi-Hermetic Refrigerant Compressor.* A compressor and motor assembly contained within a gas-tight housing that contains sealed joints to provide access for servicing internal parts.

3.3.3 *Open Drive Compressor.* A refrigerant compressor with a shaft or other moving part extending through its casing to be driven by an external source of power.

3.4 *Positive Displacement Refrigerant Compressor.* A Positive Displacement Refrigerant Compressor(s) with accessories, such as condensers, gas coolers, interstage coolers, desuperheaters, head fans, strainers, service valves, check valves, suction filters, oil separators, external power source (for Open Drive Refrigerant Compressor), as provided by the manufacturer. This will also include variable capacity controls, electronic or electro-mechanical, as supplied or specified by the manufacturer.

3.5 *Power Input.* The time rate of energy usage of the compressor (compressor power) or compressor unit (compressor unit power).

3.6 *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.

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

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

3.7 *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.

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

3.8 *Refrigerating Capacity*. The capacity associated with the increase in total enthalpy between the refrigerant entering the evaporator and the superheated return gas entering the compressor. Parasitic heat transfer effects shall not be included in the calculation of Refrigerating Capacity (W).

3.9 *"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 *Single Stage Compressor.* A compressor that has one or more compression chambers and it has only two ports for refrigerant communication with the refrigeration system: a low pressure suction port and a high pressure discharge port. A Single Stage Compressor may or may not have refrigerant injection.

3.11 *Subcritical Cycle.* A refrigeration cycle where the transfer of heat from the low-temperature reservoir and transfer of heat to the high-temperature reservoir both occur at pressures lower than the critical pressure of the refrigerant.

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3.12 *Transcritical Cycle.* A refrigeration cycle where the transfer of heat from the low-temperature reservoir occurs at a pressure lower than the critical pressure of the refrigerant and transfer of heat to the high-temperature reservoir occurs at a pressure higher than the critical pressure of the refrigerant.

3.13 *Two Stage Compressor.* A compressor that has one or more compression chambers and has at least three refrigerant communication ports: a low pressure suction port, a high pressure discharge port, and at least a third, intermediate pressure inlet, port. When the term intermediate port is used for refrigerant injection, for the sole purpose of controlling discharge gas temperature, the compressor shall be considered a Single Stage Compressor.

Section 4. Test Requirements

4.1 *Test Requirements*. All Published Ratings shall be verified by tests conducted in accordance with Appendix C for transcritical applications and ASHRAE Standard 23.1 for subcritical applications.

4.2 *Ambient Temperature*. The ambient temperature specified in AHRI Standard 571 (SI) may be different than the value in ASHRAE Standard 23.1. For the purpose of rating to AHRI Standard 571 (SI), the ambient temperature specified herein shall supersede any requirement in ASHRAE Standard 23.1.

Section 5. Rating Requirements

5.1 *Standard Ratings.* The Standard Ratings of a compressor or compressor unit shall consist of a refrigerating capacity rating, W, mass flow rate rating, kg/s, power input rating, W, and COP, identified at the Standard Rating Conditions, when tested as specified in Section 4.

5.1.1 *Standard Rating of a Refrigeration Compressor or Compressor Unit*. The rating when operated at one of the Standard Rating Conditions presented in Table 1.

5.2 *Application Ratings of Compressor and Compressor Units*. Application Ratings shall consist of a refrigerating capacity rating, W, mass flow rate rating, kg/s, power input rating, W, and COP when tested at stated conditions other than those presented in Table 1, as specified by the manufacturer.

5.3 *Nameplate Voltages for Rating.* Rating tests shall be performed at the nameplate rated voltage and frequency.

For dual nameplate voltage ratings, rating tests shall be performed at both voltages, or at the higher of the two voltages, if only a single rating is to be published.

5.4 *Tolerances*. To comply with this standard, measured test results shall not be less than 90% of Published Ratings for Refrigerating Capacity (or mass flow), shall not be more than 105% of Published Ratings for Power Input and shall not be less than 90% of Published Ratings for COP.

5.5 *Rating Methods*. Compressors or compressor units shall be rated in one of four ways described below. Manufacturers shall declare which rating method is used when providing Published Ratings.

5.5.1 *Method 1: Standard Applications*. This test method should be referenced as "AHRI Standard 571 (SI) Method 1"

Subcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity at condenser exit subcooling specified in Table 1. [Refer to Figure C5]

Transcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity at the gas cooler exit temperature specified in Table 1. [Refer to Figure C6]

5.5.2 *Method 2: Compressor Units with Manufacturer Specified or Supplied Subcoolers Only*. This test method should be referenced as "AHRI Standard 571 (SI) Method 2"

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Subcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity including the increased refrigeration effect provided by the manufacturer specified or supplied subcooler. Note: Liquid entering the subcooler shall be at the condenser exit subcooling specified in Table 1. [Refer to Figure C7]

Transcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity including the increased refrigeration effect provided by the manufacturer specified or supplied subcooler. Note: Fluid entering the subcooler shall be at the gas cooler exit temperature specified in Table 1. [Refer to Figure C8]

5.5.3 *Method 3: Compressors Applied with Non-Specified Subcoolers.* This test method should be referenced as "AHRI Standard 571 Method 3"

Subcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity including increased refrigeration effect provided by the subcooler. Note: Liquid entering the subcooler shall be at the condenser exit subcooling specified in Table 1. Liquid temperature leaving the subcooler shall be 5 K above the saturated intermediate temperature. [Refer to Figure C9]

Transcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity including increased refrigeration effect provided by the subcooler. Note: Fluid entering the subcooler shall be at the gas cooler exit temperature specified in Table 1. Liquid temperature leaving the subcooler shall be 5 K above the saturated intermediate temperature. [Refer to Figure C10]

5.5.4. *Method 4: Compressors or Compressor Units Applied with Open Flash Style Liquid Subcoolers.* This test method should be referenced as "AHRI Standard 571 Method 4."

Subcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity including increased refrigeration effect provided by the subcooler. Note: Liquid entering the subcooler shall be at the condenser exit subcooling specified in Table 1. Liquid temperature leaving the subcooler shall be equal to the saturated intermediate temperature. [Refer to Figure C11]

Transcritical Cycles: Under this rating method, manufacturers shall report Refrigerating Capacity including increased refrigeration effect provided by the subcooler. Note: Fluid entering the subcooler shall be at the gas cooler exit temperature specified in Table 1. Liquid temperature leaving the subcooler shall be equal to the saturated intermediate temperature. [Refer to Figure C12]

5.6 *Interstage Heat Rejection.* For compressors requiring interstage heat rejection, manufacturers shall specify the inlet and outlet refrigerant temperatures and maximum allowable refrigerant pressure drop for the interstage heat exchanger.

5.6.1 *Compressor Units with Manufacturer Specified or Supplied Air-Cooled Interstage Heat Rejection*. The manufacturer shall include the power consumed for heat rejection at ambient air conditions specified in Table 1.

5.6.2 *Compressor Units with Manufacturer Specified or Supplied Water-Cooled Interstage Heat Rejection*. The manufacturer shall specify the required heat rejection in W at entering water temperature of 29ºC and water flow rate of 0.011 m^3 per minute of heat rejection.

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 571 (SI)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 571 (SI)". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

6.2 *Tabular Data.* General performance data, covering the operational spectrum of the equipment, shall be presented in tabular form within defined accuracies and ranges of operation. The tables shall include:

6.2.1 Suction dew point temperature range, °C

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6.2.2 Discharge dew point temperature range for subcritical compression cycles, °C, or Discharge pressure range for transcritical compression cycles, bar
6.2.3 Applicable superheat, K
6.2.4 Subcooling for subcritical compression cycles, K, or gas cooler exit temperature for transcritical compression cycles, °C
6.2.5 Liquid temperature leaving the subcooler (for Methods 2, 3 and 4 in Section 5.1), °C.
6.2.6 Refrigerating Capacity, W
6.2.7 Suction mass flow rate, kg/s
6.2.8 Intermediate mass flow rate, kg/s (for Two Stage Compressors and compressor units)
6.2.9 Power Input, W
6.2.10 Coefficient of Performance, W/W
6.2.11 Current, A
6.2.12 Refrigerant designation per ASHRAE Standard 34 with Addenda
6.2.13 Shaft or compressor speed for open drive and variable speed compressors, rpm

The manufacturer's tabular data shall be based on data obtained from tests performed or calculated at conditions within the range of application usage specified in Sections 6.3.1 and 6.3.2.

6.3 *Data to be Reported.* The tabular data shall be reported at the following conditions for the compressor or compressor unit application usage intended. The extreme ends of the tabular data may be omitted and not reported due to limits of acceptable operation of the compressor or compressor unit as determined by the manufacturer.

6.3.1 *Medium Temperature (fresh food display cases, for example)*

6.3.1.1 Suction dew point temperature, -20 °C to 0 °C
6.3.1.2 Discharge dew point temperature for subcritical compression cycle, 0 °C to 25 °C, or discharge pressure for transcritical compression cycle, 80 bar to 110 bar
6.3.1.3 Useful superheat of 10 K for all operating points
6.3.1.4 For subcritical applications, condenser exit subcooling of 0 K
6.3.1.5 For transcritical applications, gas cooler exit temperature of 35 ºC
6.3.1.6 Refrigerating Capacity may include increased refrigeration effect provided by the subcooler per rating methods of Section 5.5

6.3.2 *Low Temperature (freezer cases, for example)*:

6.3.2.1 Suction dew point temperature, -50 °C to -10 °C
6.3.2.2 Discharge dew point temperature for subcritical compression cycle, 0 °C to 25 °C or discharge pressure for transcritical compression cycle, 80 bar to 110 bar
6.3.2.3 Useful superheat of 10 K for all operating points
6.3.2.4 For subcritical applications, condenser exit subcooling of 0 K
6.3.2.5 For transcritical applications, gas cooler exit temperature of 35 ºC
6.3.2.6 Refrigerating Capacity may include increased refrigeration effect provided by the subcooler per rating methods of Section 5.5

6.4 *Polynomial Equation.* The polynomial equation that shall be used to represent the tabular data is a third degree equation of ten coefficients in the form of:

$$X = C_1 + C_2 \cdot (t_S) + C_3 \cdot t_D + C_4 \cdot (t_S^2) + C_5 \cdot (t_S \cdot t_D) + C_6 \cdot (t_D^2) + C_7 \cdot (t_S^3) + C_8 \cdot (t_D \cdot t_S^2) + C_9 \cdot (t_S \cdot t_D^2) + C_{10} \cdot (t_D^3) \quad 1$$

Where:

C_1 through C_{10} = Regression coefficients.
t_D = Discharge dew point temperature for subcritical compression cycles, °C, or discharge pressure for transcritical compression cycles, bar
t_S = Suction dew point temperature for subcritical compression cycles, °C, or suction pressure for transcritical compression cycles, bar

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