International Standard

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Performance rating of positive displacement refrigerant compressor

Détermination des performances des compresseurs frigorifiques à déplacement positif

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Foreword

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This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 4, *Testing and rating of refrigerant compressors*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Performance rating of positive displacement refrigerant compressor

1 Scope

This document specifies normative references, terms and definitions, rating requirements, published rating, tolerance and marking provisions of positive displacement refrigerant compressors. This document applies to positive displacement refrigerant compressors and their performance in air-conditioning, heating, refrigeration and dehumidification applications. Single stage, two-stage and refrigerant-injected compressors without intermediate temperature load (only one evaporator) are included in this document. Subcritical operation and transcritical operation are also included in this document.

Compressors for other applications, compression types and operations can also refer to this document. The manufacturer is solely responsible for the determination of values to be used in the published product information.

This document is intended as guidance for the industry, including manufacturers, engineers, installers and service contractors. It defines the minimum amount of information in a standard form to enable the evaluation and comparison of different compressors for use in an application.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18976, *Testing of refrigerant compressors*

ISO 817, *Refrigerants — Designation and safety classification*

IEC 60038, *IEC standard voltages*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18976 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
positive displacement refrigerant compressor
machine that increases the pressure of a refrigerant vapour by reducing the compression chamber volume

3.2
fixed displacement compressor
compressor with only one displacement capacity

3.3
modulating compressor
compressor with more than one displacement capacity, either continuous or discrete modulating capacities

3.3.1
continuous modulating compressor
compressor with more than four displacement capacities or infinitely variable displacement capacities

Note 1 to entry: This includes but is not limited to variable speed, continuously variable mechanical unloading or cyclic modulation of discrete.

3.3.2
discrete modulating compressor
compressor with two to four discrete displacement capacities

3.4
subcooling
difference between the bubble point temperature of the refrigerant corresponding to its pressure and the temperature of the liquid refrigerant

3.5
superheat
difference between the temperature of the vapour refrigerant and its dew-point temperature corresponding to its pressure

3.6
refrigerating capacity
product of the refrigerant mass flow at the compressor inlet port and the difference between the specific refrigerant enthalpy at the compressor inlet port and the specific enthalpy of fluid entering the evaporator expansion device

3.7
heating capacity
product of the refrigerant mass flow leaving the compressor discharge port and the difference of the specific refrigerant enthalpy at the discharge port and the outlet of the condenser or gas cooler

3.8
power input
time rate of energy usage of the compressor plus any accessories required to sustain operation of the compressor at the rating condition

3.9
refrigerating coefficient of performance
ratio of the refrigerating capacity to the power input

3.10
heating coefficient of performance
ratio of *heating capacity* (3.7) to the power input

3.11
intermediate port
inlet port for vapour or liquid within a compression chamber at a pressure between suction and discharge pressure

3.12
interstage port
inlet port for vapour or liquid between two stages of compression

3.13
economizer
heat exchanger or flash tank that is used to lower the liquid specific enthalpy of the refrigerant entering the evaporator while producing vapour that is reintroduced to the compression process

3.14
economized operation
system operation mode which reduces the specific enthalpy of the refrigerant entering the evaporator and produces vapour which is injected into the compression process

Note 1 to entry: For economized operation with heat exchanger economizer, partial high-pressure liquid refrigerant is throttled to intermediate pressure to subcool the remaining refrigerant. The vapourized refrigerant can be piped to the intermediate port or interstage port of the compressor.

Note 2 to entry: For economized operation with flash tank economizer, all refrigerant at outlet condenser is throttled to intermediate pressure in the flash tank. The saturated liquid goes to evaporator loop and saturated vapour can be piped to the intermediate port or interstage port of the compressor.

3.15
variable frequency drive
VFD
power electronic device supplying an electric motor with a variable frequency and voltage

3.16
subcritical operation
operating condition with discharge pressure below the critical pressure of the refrigerant

3.17
transcritical operation
operating condition with discharge pressure above and the suction pressure below the critical pressure

3.18
liquid injection
injection of high-pressure side liquid refrigerant into the compressor

3.19
step
level of modulation achieved by changing the displacement capacity

EXAMPLE Compressor operating frequency, compressor rotation speed, frequency of variable frequency drive and mechanical unloading setting.

3.19.1
maximum step
step producing the highest displacement capacity of the modulating compressor defined by the manufacturer

3.19.2
minimum step
step producing the lowest displacement capacity of the modulating compressor defined by the manufacturer

3.19.3
reduced step
step producing less displacement capacity than the maximum step of the modulating compressor

3.20
fluid
liquid, gas or vapour including the state of appearance close to and above the critical pressure

3.21
publish
transfer information to any entity decided by the manufacturer

4 Rating requirements

4.1 General requirements

All published ratings shall be based on tests conducted in accordance with ISO 18976.

Published ratings shall be established with an ambient temperature around the compressor and its accessories of 35 °C. If rating at ambient temperatures other than 35 °C, the actual ambient temperature used to establish the rating shall be stated by the manufacturer.

Published ratings shall be established using the nameplate rated voltage and frequency. For dual nameplate voltage ratings, published ratings shall be established using both voltages, or using the higher of the two voltages, if only a single rating is to be published. For compressors with a voltage range, the rated voltage should be published.

For liquid-injected compressors, the manufacturer shall report the controlled discharge temperature.

For economized compressors, refrigerating capacity including the increased refrigeration effect by the subcooling or gas cooling provided by economizer operation shall be reported.

For economized operation compressors with manufacturer mounted or specified heat exchanger, the liquid temperature leaving the heat exchanger shall be stated, if the refrigerant leaving at intermediate pressure is not fully evaporated.

For economized operation compressors without a manufacturer specified intermediate heat exchanger, the liquid refrigerant leaving the economizer shall be 5 K above the refrigerant temperature corresponding to the pressure at the intermediate port or interstage port of the compressor and the specific enthalpy at the outlet of the condenser.

For economized operation compressors with flash tank, liquid temperature leaving the flash tank shall be equal to the bubble point temperature corresponding to the pressure at the intermediate port or interstage port of the compressor.

4.2 Rating conditions

Rating conditions shown in Table 1 are provided for manufacturers to publish performance for the ease of comparing with other compressors. If there is no applicable application or type, the manufacturer can specify the rating conditions.

Table 1 — Rating conditions[a,b]

Compression cycle			Low side		High side	
Application	**Rating test point**	**Cycle type**	**Suction dew point temperature, °C**	**Suction gas superheat[c], K (or return gas temperature, °C)**	**Discharge dew point temperature, °C**	**Subcooling[d] at outlet of the condenser, K**
Air conditioning	Cooling	Subcritical	10	10(20)	45	0
	Heating	Subcritical	3	10(13)	49	0
	Low temperature heating	Subcritical	−15	10 (−5)	35	0
Heat pump water heater	Nominal	Subcritical	10	10 (20)	60	0
Refrigeration	High	Subcritical	5	10 (20[g])	50	0
		Subcritical (NH_3)		5 (10)	50	0
		Transcritical (CO_2)		10 (15)	100[e]	40[f]
	Medium	Subcritical	-10	10 (20[g])	45	0
		Subcritical (NH_3)		5 (−5)	45	0
		Transcritical (CO_2)		10 (0)	90[e]	35[f]
	Low	Subcritical	−35	10 (20[g])	40	0
		Subcritical (NH_3)		5 (−30)	40	0
		Transcritical (CO_2)		10 (−25)	90[e]	35[f]
		Cascade/Booster		10 (20[g])	−10	0
Household refrigerator and freezer	Nominal	Subcritical	−25	57(32)	55	0
Dehumidifier	Nominal	Subcritical	12	12(24)	45	0

Key

[a] If airflow across the compressor or other external methods of cooling are used to determine ratings, they shall be specified by the compressor manufacturer.

[b] Refer to Annex A about method to handle zeotropic mixtures.

[c] Return gas temperature entering the compressor is assumed to be useful superheat for capacity calculation. The compressor manufacturer shall specify if the superheat is not the value in the table.

[d] The compressor manufacturer shall specify if the subcooling is not the value in the table.

[e] For transcritical type, this is the discharge pressure, expressed in bar.

[f] For transcritical type, this is the temperature at the outlet of the gas cooler, expressed in °C.

[g] Return gas temperature intentionally deviates from the dew point plus superheat, representing an alternative operating condition.

5 Published rating

5.1 General requirements

A published rating is one or more individual published rating that represents the compressor's performance. The rating shall be published by single points under the rating conditions given in 4.2 or polynomial equation given in 5.4.

5.2 Individual published rating

The individual published rating of the compressor shall consist of parameters that are established through the rating conditions given in 4.2 or coefficients used in the polynomial equation given in 5.4, tested as specified in 4.1. The number of individual published ratings requirement for different modulating compressor is specified in 5.3. An individual published rating consists of data or coefficients for power input, refrigeration capacity or heating capacity, refrigerant mass flow rate, and current.

5.3 Number of individual published ratings requirement

The following requirements apply to individual published ratings used in the polynomial equation.

a) **Fixed displacement compressor**

The published rating of a fixed displacement compressor shall consist of an individual published rating at its single step.

b) **Discrete modulating compressor**

The published rating of a discrete modulating compressor shall be provided at every discrete step to comprise each set of individual published rating.

c) **Continuous modulating compressor**

The published rating of a continuous modulating compressor shall be provided at maximum and minimum step.

If the minimum step is greater than or equal to 40 % of the maximum step, at least one additional step of the compressor at an evenly spaced step (or steps) between the maximum and minimum step should be rated.

If the minimum step is less than 40 % of the maximum step, at least two additional steps of the compressor at evenly spaced steps between the maximum and minimum step should be rated.

Each step shall be evenly spaced between the maximum rated step and minimum rated step within ±5 %.

5.4 Polynomial equations

A polynomial equation shall be used to present the individual published ratings, such as Formula (1), which is a third-degree equation of ten coefficients:

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

where

X is the power input, refrigerant mass flow, refrigerating capacity (or heating capacity);

T_D is the discharge dew point temperature in subcritical cycles, expressed in °C, or the discharge pressure in transcritical cycles, expressed in bar;

T_S is the suction dew point temperature, expressed in °C;

C_1 through C_{10} are the regression coefficients provided by the manufacturer.

The coefficients used in the ten-coefficient polynomial equation shall be established using the following requirements:

— Return gas temperatures. Superheat or return gas temperature conditions specified in Table 1 shall be used. The same superheat or return gas temperature shall be used over the entire published application