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Introduction

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For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



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ISO/DIS 18976

Testing of refrigerant compressors

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ISO/TC 86/SC 4

Secretariat: **SAC**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

The basis for this document was the already withdrawn ISO 917:1989, which has been technically revised.

The main changes are as follows:

- addition of two-stage and economized compressors;
- [clause 2](#) “Normative references” was updated;
- [clause 3](#) “Terms and definitions” was updated, additional terms defined because of e.g. refrigerant blends with temperature glide;
- addition of the new [clause 4](#) “Uncertainty of measurement and test conditions”;
- deletion of the list of measuring devices;
- extraction of calibration of calorimetric methods into a separate clause;
- addition of transcritical application;
- addition of test requirements for inverter driven compressors;
- addition of cyclic capacity control;
- reference point numbering, symbols and indexes revised to allow for economised compressors and to simplify formulas;
- former [annex B](#) regarding the list of symbols was moved under [clause 3](#);
- the text content of former annex C was revised and is now [annex B](#) “Estimation of errors”;
- document was editorially revised.

ISO/DIS 18976:2024(en)

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.

Testing of refrigerant compressors

1 Scope

The provisions of this document apply to Single-Stage, Two-Stage, and economised refrigerant compressors. Selected test methods are described for the determination of the refrigerating capacity, the power input, the isentropic efficiency and where possible the volumetric efficiency. These test methods provide results of sufficient accuracy to permit consideration of the suitability of a refrigerant compressor to operate satisfactorily under any set of basic test conditions required for a given application.

NOTE Tests on complete refrigeration installations are dealt with in ISO 916.

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 817:2014, *Refrigerants — Designation and safety classification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 Terms and definitions

3.1.1

refrigerating capacity

Q

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

3.1.2

subcooling

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

3.1.4

power input

P

power demand to drive the compressor

Note 1 to entry: The determination of the power input is specified under [Clause 7](#).

3.1.5

coefficient of performance

COP_R

ratio of the refrigerating capacity to the power input

Note 1 to entry: Both the above are at the specified test condition.

Note 2 to entry: The test report should make clear, whether the power input is referring to the electrical power or the shaft power.

[SOURCE: EN 13771-2:2017, 3.1.6, modified — “power absorbed” was changed to “power input” and Note 2 to entry was added]

3.1.6

subcritical operation

operating condition with discharge pressure below the critical pressure of the refrigerant

3.1.7

transcritical operation

operating condition with discharge pressure above and the suction pressure below the critical pressure

3.1.8

part load operation

for compressors with capacity control mechanism, part load is interpreted as operation with active capacity control at reduced capacity

Note 1 to entry: On/off cycling of the compressor motor is not considered as capacity control.

3.1.9

fluid

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

3.1.10

volumetric efficiency

η_v

ratio of the actual volume rate of flow under compressor inlet conditions, at the requirements specified in [4.3](#), to the displacement of the compressor

Note 1 to entry: Ports, see [Table 2](#), index 1, index 2 and index 7.

3.1.11

isentropic efficiency

η_i

ratio of total isentropic compression power to the power input

Note 1 to entry: Total isentropic compression power is the sum of individual product of mass flow times the isentropic change in enthalpy across the corresponding compression stage.

Note 2 to entry: the value according to this definition is only used as reference value for the necessary correction calculation inside this document.

3.1.12

oil circulation ratio

x_{oil}

ratio of the measured oil mass flow to the mass flow of the circulating oil/refrigerant mixture

Note 1 to entry: Oil circulation ratio may differ at other compressor ports.

3.1.13**calorimeter**

component of the test system refrigerant circuit intended to determine the refrigerant mass flow via an energy balance

Note 1 to entry: To limit the uncertainty of the mass flow determination caused by the heat loss, calorimeters are usually heat insulated.

Note 2 to entry: The compressor or the economiser heat exchanger can be utilised as calorimeter.

3.1.14**Speed of rotation**

number or rotations per unit time

3.1.15**economiser heat exchanger**

heat exchanger in a system in which a partial massflow is evaporated at intermediate pressure and lead to the respective compressor port, to subcool the main massflow after the condenser

Note 1 to entry: With this system design the refrigeration capacity and the coefficient of performance are increased and at the same time the discharge temperate is reduced.

Note 2 to entry: There are also other economiser systems possible without heat exchanger, e.g., with flash tank.

3.1.16**zeotropic refrigerant**

blend composed of two or more refrigerants whose equilibrium vapor and liquid phase compositions are not the same at any pressure below the critical pressure

[SOURCE: ISO 817:2014, 3.1.43 – modified: The term “zoetrope” was replaced by the term “zeotropic refrigerant”.]

3.2 Symbols

For the purposes of this document, the symbols of [Table 1](#) and the indices of [Table 2](#) apply.

Table 1 — Symbols

Symbol	Designation	SI unit
A	Area	m ²
a	Speed of sound	m/s
c	Specific heat capacity of heating and cooling liquid	J/(kg K)
d	Diameter	m
f	Electrical frequency	Hz
F	Heat leakage factor	W/K
F_F	flow factor for centrifugal compressor	m ²
F_H	head factor for centrifugal compressor	—
F_m	Mass flow ratio	—
h	Specific enthalpy	J/kg
h_{i1-2}	Specific enthalpy of refrigerant gas at the compressor outlet (2) having the same entropy as the refrigerant gas at the compressor inlet (1) for calculation of the isentropic efficiency (specified test conditions)	J/kg
h_{i7-2}	Specific enthalpy of refrigerant gas at the compressor outlet (2) having the same entropy as the refrigerant gas at the compressor intermediate pressure port (7) for calculation of the isentropic efficiency (specified test conditions)	J/kg
n	Compressor speed of rotation	S ⁻¹

Table 1 (continued)

Symbol	Designation	SI unit
P	Power input	W
p	Absolute pressure	Pa
m_a	Refrigerant mass flow as determined by the test	kg/s
m	Refrigerant mass flow at the specified test conditions	kg/s
m_f	Mass flow of heating or cooling liquid	kg/s
m_{oil}	Oil mass flow	kg/s
m_x	Mass flow of liquid refrigerant oil mixture	kg/s
V	Refrigerant volume flow	m ³ /s
V_x	Volume flow of refrigerant oil mixture	m ³ /s
T	Absolute temperature	K
ΔT_{eco}	Difference between fluid outlet of economiser heat exchanger and bubble temperature corresponding to intermediate pressure	K
t	Temperature	°C
t_{cal}	Mean surface temperature of the calorimeter	°C
t_b	Bubble point temperature of the refrigerant	°C
t_{bs}	Bubble point temperature of the secondary fluid	°C
t_x	Reference temperature	°C
t_{s1}	Inlet temperature of heating or cooling liquid	°C
t_{s2}	Outlet temperature of heating or cooling liquid	°C
U	Electrical voltage	V
V_{sw}	Theoretical compressor displacement at declared speed	m ³ /s
x_{oil}	Oil circulation ratio in the refrigerating system, expressed in mass of oil per mass of mixture	kg/kg
COP_R	Coefficient of performance	—
η_i	Isentropic efficiency	—
η_v	Volumetric efficiency	—
v	Specific volume	m ³ /kg
ρ_a	Density of refrigerant corresponding to pressure and temperature at which the flow rate is measured	kg/m ³
Q_i	Heat input to the calorimeter	W
Q_n	Electrical input to the heater	W
Q	Refrigerating capacity of the compressor at the specified test conditions	W

Table 2 — Indexes

Index	Designation
a	Actual
amb	Ambient
1	Refrigerant at the compressor inlet
2	Refrigerant at the compressor outlet
3	Refrigerant at the inlet of the condenser/gas cooler
4	Refrigerant at the outlet of the condenser/gas cooler
5	Refrigerant at the inlet of the expansion device
6	Refrigerant at the outlet of the evaporator
7	Refrigerant at the intermediate pressure port (connection to the compressor)

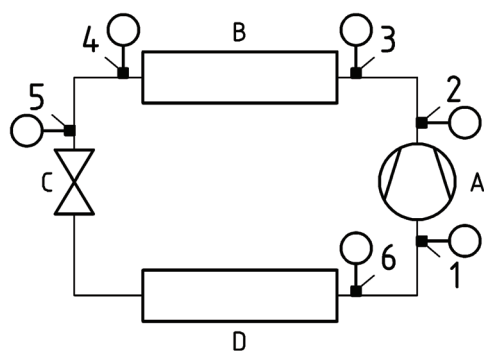
Table 2 (continued)

Index	Designation
8	Refrigerant at the inlet to flow meter
9	Refrigerant at the inlet of expansion device C7
10	Liquid outlet of refrigerant at the economiser HX
f2	Liquid refrigerant at bubble point corresponding to the pressure at the compressor outlet according to the specified test conditions, for subcritical operation or fluid refrigerant at the compressor outlet pressure and the temperature of the gas cooler outlet at the specified test condition
f7	Liquid refrigerant at bubble point corresponding to the pressure at the compressor intermediate pressure port according to the specified test conditions, for subcritical operation
f10	Liquid refrigerant at bubble point corresponding to the pressure at the compressor intermediate pressure port plus the temperature difference of the economiser HX
b	Bubble
d	Dew
i	Isentropic
cal	Calorimeter surface
crit	Critical point of refrigerant
f	Fluid
oil	Oil
s	Secondary fluid
x	Refrigerant/oil mixture

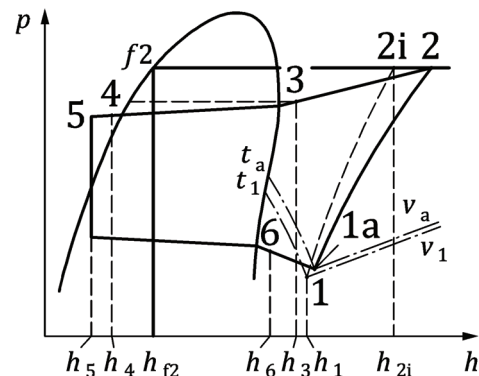
3.3 Refrigerant circuit state points

Figure 1 illustrates the state of the refrigerant as it passes through the system.

This is a general illustration showing conditions occurring in typical single stage systems, which are not all relevant for compressors performances (e.g. the shown pressure drops), but still important for inherent calculation. p-h diagrams relating to specific test methods will not show the various pressure drops in order to keep diagrams as clear as possible.



a) Circuit diagram



b) Pressure vs enthalpy diagram

Key

1	Refrigerant gas at the compressor inlet	6	Refrigerant gas at the outlet of the evaporator
2	Refrigerant gas at the compressor outlet	A	Compressor
3	Refrigerant gas at the inlet of the condenser/gas cooler	B	Condenser
4	Refrigerant at the outlet of the condenser or gas cooler	C	Expansion device
5	Refrigerant fluid at the inlet of the expansion device	D	Evaporator

Figure 1 — Refrigerant circuit

4 Uncertainty of measurement and test conditions

4.1 Uncertainty of performance data

All measuring instruments in the test setup shall be selected and calibrated so that the final result is within the maximum uncertainties of the measured value as indicated:

- refrigerating capacity: $\pm 2,5$ %;
- electrical power input: ± 1 % and
- mechanical power input: $\pm 2,5$ %.

4.2 Uncertainty of measurement

Uncertainty values are considered to cover a 95 % confidence interval, i.e. ± 2 times the standard deviation, also called extended uncertainty. Except where otherwise stated in the particular clauses, measurements shall be carried out within the maximum uncertainty of the measured value as indicated. Where a percent value is stated, it is the relative uncertainty of the direct measured value.

- Absolute pressure: ± 1 %;
- Electrical:
 - Current ± 1 %;
 - Frequency: $\pm 0,2$ %;
 - Power ± 1 %;
 - Voltage ± 1 %;
- Refrigerant mass flow: ± 1 %;
- Refrigerant volume flow: ± 1 %;
- Speed of rotation: $\pm 0,07$ %;
- Temperatures:
 - Temperature for differences: $\pm 0,05$ K;
 - Temperature differences measured directly: ± 1 %;
 - other temperatures: $\pm 0,3$ K;
- Time: $\pm 0,1$ %;
- Torque: ± 1 %;
- Water flow: ± 1 %.

Adherence to the limits listed above does not ensure the requirements of [4.1](#) are obtained automatically.
For the combined uncertainty of the performance data see also [Annex B](#).

4.3 Test conditions

The specified test conditions under which the test is to be performed and their allowable deviations are given in [Table 3](#).

Table 3 — Specified test conditions and the allowable deviations

Specified test conditions	Allowable deviation during the entire test period
Absolute pressure ^a , compressor inlet, p_1	$\pm 1,0 \%$
Absolute pressure ^a , compressor outlet, p_2	$\pm 1,0 \%$
Absolute pressure ^a , compressor intermediate pressure port, p_7	$\pm 1,0 \%$
Refrigerant temperature at the compressor inlet, t_1	$\pm 3,0 \text{ K}$
Refrigerant temperature at the compressor intermediate pressure port, t_7	$\pm 3,0 \text{ K}$
Nominal compressor speed of rotation, n	$\pm 1,0 \%$
Nominal electrical voltage, U	$\pm 1,5 \%$
Nominal electrical frequency, f	$\pm 1,0 \%$
Ambient temperature, t_{amb}	$\pm 3,0 \text{ K}$
^a Dynamic deviations due to pulsations are not considered	

The values for the relevant specified test conditions shall be recorded.

For the calculation of refrigeration capacity – additional values can be necessary:

- Gas cooler outlet temperature in case of transcritical operation;
- Temperature difference at the liquid subcooler or aftercooler in case of two-stage operation (flash tank without temperature difference). The value of the pressure p_7 shall be adjusted according to [Annex A](#) to reach the requested temperature difference.

For cyclic capacity control the deviations of [Table 3](#) refer to the average values per control cycle.

For operation with constant capacity, the deviations can be applied either

- to every single recorded value or;
- to the average values per minute or;
- to the average of the values for the test period, ± 2 times standard deviation of the measured values.

For wet operation at point 7, intermediate pressure port (see also [Figure 3 a](#)), the correction of [Annex A](#) can still be used. In this case the heat balance at the economiser heat exchanger can be used to determine the specific enthalpy of the refrigerant at point 7.

For compressors with factory assembled economiser heat exchanger, where the temperature at point 7 cannot be measured, and thus the state of appearance, cannot be determined exactly, same assumptions apply.