International Standard

ISO 18976

Testing of refrigerant compressors

Essais des compresseurs pour fluides frigorigènes

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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*.

This first edition of ISO 18976 is a technical revision of ISO 917:1989, which was withdrawn in 2015.

The main changes are as follows:

— addition of two stage and economized compressors;

— Clause 2 was updated;

— Clause 3 was updated, additional terms defined because of, for example, 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 formulae;

— 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.

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Testing of refrigerant compressors

1 Scope

This document applies 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

There are no normative references in this document.

3 Terms, definitions and symbols

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

3.1.3
power input
P
power demand to drive the compressor

Note 1 to entry: The determination of the power input is specified in Clause 7.

3.1.4
coefficient of performance
COP_R
ratio of the refrigerating capacity to the power input

Note 1 to entry: Both, refrigerating capacity and power input are at the specified test condition.

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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]

3.1.5
subcritical operation
operating condition with discharge pressure below the critical pressure of the refrigerant

3.1.6
transcritical operation
operating condition with discharge pressure above and the suction pressure below the critical pressure

3.1.7
part load operation
operation with active capacity control at reduced capacity for compressors with capacity control mechanism

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

[SOURCE: EN 13771-2:2017, 3.1.9]

3.1.8
fluid
liquid, gas or vapour including the state of appearance close to and above the critical pressure

3.1.9
volumetric efficiency
η_v
ratio of the actual volume rate of flow under compressor inlet conditions, at the requirements specified in 4.4, to the displacement of the compressor

3.1.10
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 multiplied by 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 specified in this document.

3.1.11
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 can differ at the different compressor ports.

3.1.12
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.

3.1.13
speed of rotation
number or rotations per unit time

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3.1.14
economiser heat exchanger
heat exchanger in a system in which a partial mass flow is evaporated at intermediate pressure and lead to the respective compressor port, to subcool the main mass flow after the condenser

Note 1 to entry: With this system design, the refrigeration capacity and the coefficient of performance increase. At the same time, the discharge temperature falls.

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

3.1.15
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 817:2024, 3.1.47, modified — The term "zeotrope" was replaced by the term "zeotropic refrigerant" and the references to 3.1.7 and 3.1.37 were removed.]

3.2 Symbols

For the purposes of this document, the symbols of Table 1 and the indexes 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
$h_{i1\text{-}2}$	specific enthalpy of refrigerant gas at the compressor outlet pressure (2) having the same entropy as the refrigerant gas at the compressor inlet pressure (1) for calculation of the isentropic efficiency (specified test conditions)	J/kg
$h_{i7\text{-}2}$	specific enthalpy of refrigerant gas at the compressor outlet pressure (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}
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

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Table 1 *(continued)*

Symbol	Designation	SI unit
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
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 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)
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 heat exchanger (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

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Table 2 *(continued)*

Index	Designation
i	isentropic
cal	calorimeter surface
crit	critical point of refrigerant
f	fluid
oil	oil
s	secondary fluid
x	refrigerant/oil mixture

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: ±2,5 %;

— electrical power input: ±1 %;

— mechanical power input: ±2,5 %.

4.2 Uncertainty of measurement

Uncertainty values are considered to cover a 95 % confidence interval, i.e. ±2 times the standard deviation. This is also known as 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 directly measured value.

— absolute pressure: ±1 %;

— electrical:

  — current: ±1 %;

  — frequency: ±0,2 %;

  — power: ±1 %;

  — voltage: ±1 %;

— refrigerant mass flow: ±1 %;

— refrigerant volume flow: ±1 %;

— speed of rotation: ±0,07 %;

— temperatures:

  — temperature for differences: ±0,05 K;

  — temperature differences measured directly: ±1 %;

  — other temperatures: ±0,3 K;

— time: ±0,1 %;

— torque: ±1 %;

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