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Non-ducted air conditioners and heat pumps — Testing and rating for performance

Climatiseurs et pompes à chaleur non raccordés — Essais et détermination des caractéristiques de performance

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Foreword

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

This third edition cancels and replaces the second edition (ISO 5151:2010), which has been technically revised.

Non-ducted air conditioners and heat pumps — Testing and rating for performance

1 Scope

This document specifies performance testing, the standard conditions and the test methods for determining the capacity and efficiency ratings of air-cooled air conditioners and air-to-air heat pumps.

This document is applicable to the following equipment:

— non-ducted air-cooled air conditioners and non-ducted air-to-air heat pumps; or

— ducted air conditioners and/or ducted heat pumps rated at less than 8 kW and intended to operate at an external static pressure of less than 25 Pa.

This document is limited to:

— residential, commercial and industrial single-package and split-system air conditioners and heat pumps;

— factory-made, electrically driven and use mechanical compression;

— utilizing single, multiple and variable capacity components;

— multiple split-system utilizing one or more refrigeration systems, one outdoor unit and one or more indoor units, controlled by a single thermostat/controller.

The requirements of testing and rating contained in this document are based on the use of matched assemblies.

This document is not applicable to the rating and testing of the following:

a) water-source heat pumps or water cooled air conditioners;

b) multi-split-system air conditioners and air-to-air heat pumps (follow ISO 15042 for the testing of such equipment);

c) mobile (windowless) units having a condenser exhaust duct;

d) individual assemblies not constituting a complete refrigeration system;

e) equipment using the absorption refrigeration cycle;

f) ducted equipment except for those specified in this clause (follow ISO 13253 for the testing of such equipment).

This document does not cover the determination of seasonal efficiencies, which can be required in some countries because they provide a better indication of efficiency under actual operating conditions.

NOTE Throughout this document, the terms “equipment” and “systems” mean “air conditioners” and/or “heat pumps”.

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, *Refrigerants — Designation and safety classification*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
non-ducted air conditioner
encased assembly or assemblies, designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone

Note 1 to entry: It can be either single-package or split-system and comprises a primary source of refrigeration for cooling and dehumidification. It can also include means for heating other than a heat pump, as well as means for circulating, cleaning, humidifying, ventilating or exhausting air. Such equipment can be provided in more than one assembly, the separated assemblies (split-systems) of which are intended to be used together.

Note 2 to entry: An enclosed space, room or zone is known as a conditioned space.

3.2
non-ducted heat pump
encased assembly or assemblies designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone and includes a prime source of refrigeration for heating

Note 1 to entry: It can be constructed to remove heat from the conditioned space and discharge it to a heat sink if cooling and dehumidification are desired from the same equipment. It can also include means for circulating, cleaning, humidifying, ventilating or exhausting air. Such equipment can be provided in more than one assembly; the separated assemblies (split-systems) of which are intended to be used together.

Note 2 to entry: An enclosed space, room or zone is known as a conditioned space.

3.3
standard air
dry air at 20 °C and at a standard barometric pressure of 101,325 kPa, having a mass density of 1,204 kg/m^3

3.4
indoor discharge airflow
rate of flow of air from the outlet of the equipment into the conditioned space

Note 1 to entry: See Figure 1.

3.5
indoor intake airflow
rate of flow of air into the equipment from the conditioned space

Note 1 to entry: See Figure 1.

3.6
ventilation airflow
rate of flow of air introduced to the conditioned space through the equipment

Note 1 to entry: See Figure 1.

3.7
outdoor discharge airflow
discharge rate of flow of air from the equipment

Note 1 to entry: See Figure 1.

3.8
intake outdoor airflow
rate of flow of air into the equipment from the outdoor-side

Note 1 to entry: See Figure 1.

3.9
exhaust airflow
rate of flow of air from the indoor-side through the equipment to the outdoor-side

Note 1 to entry: See Figure 1.

3.10
leakage airflow
rate of flow of air interchanged between the indoor-side and outdoor-side through the equipment as a result of its construction features and sealing techniques

Note 1 to entry: See Figure 1.

Note 2 to entry: This is not applicable for split system products.

3.11
bypassed indoor airflow
rate of flow of conditioned air directly from the indoor-side outlet to the indoor-side inlet of the equipment

Note 1 to entry: See Figure 1.

3.12
bypassed outdoor airflow
rate of flow of air directly from the outdoor-side outlet to the outdoor-side inlet of the equipment

Note 1 to entry: See Figure 1.

3.13
equalizer opening airflow
rate of flow of air through the equalizer opening in the partition wall of a calorimeter

Note 1 to entry: See Figure 1.

3.14
total cooling capacity
amount of sensible and latent heat that the equipment can remove from the conditioned space in a defined interval of time

Note 1 to entry: Total cooling capacity is expressed in units of watts.

3.15
heating capacity
amount of heat that the equipment can add to the conditioned space (but not including supplementary heat) in a defined interval of time

Note 1 to entry: Heating capacity is expressed in units of watts.

3.16
latent cooling capacity
room dehumidifying capacity
amount of latent heat that the equipment can remove from the conditioned space in a defined interval of time

Note 1 to entry: Latent cooling capacity and room dehumidifying capacity are expressed in units of watts.

3.17
sensible cooling capacity
amount of sensible heat that the equipment can remove from the conditioned space in a defined interval of time

Note 1 to entry: Sensible cooling capacity is expressed in units of watts.

3.18
sensible heat ratio
SHR
ratio of the sensible cooling capacity to the total cooling capacity

3.19
rated voltage
voltage shown on the nameplate of the equipment

3.20
rated frequency
frequency shown on the nameplate of the equipment

3.21
energy efficiency ratio
EER
ratio of the total cooling capacity to the effective power input to the device at any given set of rating conditions

Note 1 to entry: Where the EER is stated without an indication of units, it is understood that it is derived from watts/watt.

3.22
coefficient of performance
COP
ratio of the heating capacity to the effective power input to the device at any given set of rating conditions

Note 1 to entry: Where the COP is stated without an indication of units, it is understood that it is derived from watts/watt.

3.23
total power input
P_t
average electrical power input to the equipment as measured during the test

Note 1 to entry: Total power input is expressed in units of watts.

3.24
effective power input
P_E
average electrical power input to the equipment obtained from

— the power input from the compressor(s),

— the power input to electric heating devices used only for defrosting,

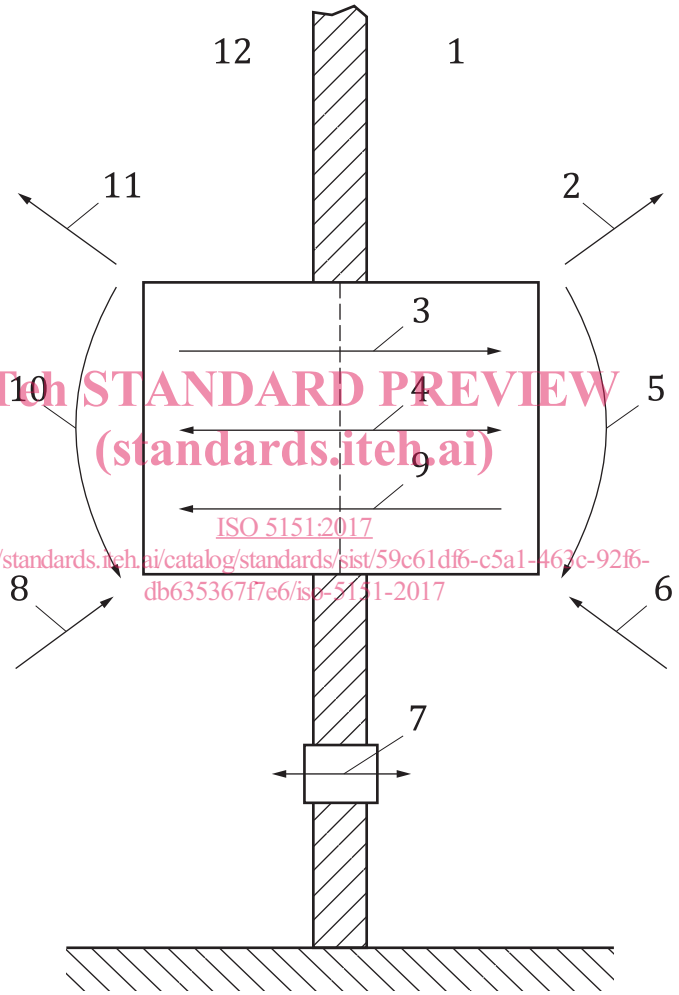
— the power input to all control and safety devices of the equipment, and

— the power input for operation of all fans

Note 1 to entry: Effective power input is expressed in units of watts.

3.25
full-load operation
operation with the equipment and controls configured for the maximum continuous duty refrigeration capacity specified by the manufacturer and allowed by the unit controls

Note 1 to entry: Unless otherwise regulated by the automatic controls of the equipment, all indoor units and compressors operate during full-load operations.



Key

1	outdoor-side	7	equalizer opening
2	outdoor discharge	8	indoor intake
3	exhaust	9	ventilation
4	leakage	10	bypassed indoor
5	bypassed outdoor	11	indoor discharge
6	outdoor intake	12	indoor-side

NOTE Airflow diagram illustrating the definitions given in 3.4 to 3.13

Figure 1 — Airflow diagram

4 Symbols

Symbol	Description	Unit
A_l	coefficient, heat leakage	J/(s·K)
A_n	area, nozzle	m^2
C_d	nozzle discharge coefficient	[a]
c_{pa1}	specific heat of moist air entering indoor-side[b]	J/(kg[b]·K)
c_{pa2}	specific heat of moist air leaving indoor-side[b]	J/(kg[b]·K)
c_{pa3}	specific heat of moist air entering outdoor-side[b]	J/(kg[b]·K)
c_{pa4}	specific heat of moist air leaving outdoor-side[b]	J/(kg[b]·K)
c_{pw}	specific heat of water	J/(kg[b]·K)
D_n	nozzle throat diameter	m
D_t	outside diameter of refrigerant tube	m
h_{a1}	specific enthalpy of air entering indoor-side	J/kg[b]
h_{a2}	specific enthalpy of air leaving indoor-side	J/kg[b]
h_{a3}	specific enthalpy of air entering outdoor-side	J/kg[b]
h_{a4}	specific enthalpy of air leaving outdoor-side	J/kg[b]
h_{f1}	specific enthalpy of refrigerant liquid entering expansion device	J/kg
h_{f2}	specific enthalpy of refrigerant liquid leaving condenser	J/kg
h_{g1}	specific enthalpy of refrigerant vapour entering compressor	J/kg
h_{g2}	specific enthalpy of refrigerant vapour leaving compressor	J/kg
h_{r1}	specific enthalpy of refrigerant entering indoor-side	J/kg
h_{r2}	specific enthalpy of refrigerant leaving indoor-side	J/kg
h_{w1}	specific enthalpy of water or steam supplied to indoor side test chamber	J/kg
h_{w2}	specific enthalpy of condensed moisture leaving indoor side test chamber	J/kg
h_{w3}	specific enthalpy of condensed moisture leaving outdoor-side test chamber	J/kg
h_{w4}	specific enthalpy of the water supplied to the outdoor side test chamber	J/kg
h_{w5}	specific enthalpy of the condensed water (in the case of H1 test condition) and the frost, respectively (in the case of H2 or H3 test conditions) in the test unit	J/kg
K_1	latent heat of vaporization of water (2 460 × 10^3 J/kg at 15 °C)	J/kg
L	length of refrigerant line	m
p_a	barometric pressure	kPa
p_c	test chamber equalization pressure	Pa
p_n	absolute pressure at nozzle throat	Pa
p_v	velocity pressure at nozzle throat or static pressure difference across nozzle	Pa
P_i	power input, indoor-side data	W
P_K	power input to compressor	W
P_t	total power input to equipment	W
q_m	air mass flow rate	kg/s
q_r	refrigerant flow rate	kg/s
q_{ro}	refrigerant and oil mixture flow rate	kg/s
q_v	air volume flow rate	m^3/s
q_{vi}	air volume flow rate, indoor-side	m^3/s

[a] Dimensionless value.

[b] It means the mass of dry air; the mass, kg, of denominator in this unit is based on dry air (or DA). For units practically used in the air conditioning field, "kg (DA)" is very often used for denominator. Example: J/kg(DA), m^3/kg (DA), kg/kg (DA)

NOTE All parameters are in relation to the unit being tested unless specified otherwise.

Symbol	Description	Unit
q_{vo}	air volume flow rate, outdoor-side	m^3/s
q_w	condenser water flow rate	kg/s
q_{wc}	rate at which water vapour is condensed by the equipment	kg/s
q_{wo}	water mass flow supplied to the outside test chamber for maintaining the test conditions	kg/s
Re	Reynolds number	a
T	thickness of tubing insulation	m
t_a	temperature, ambient of compressor calorimeter	°C
t_{a1}	temperature of air entering indoor-side, dry bulb	°C
t_{a2}	temperature of air leaving indoor-side, dry bulb	°C
t_{a3}	temperature of air entering outdoor-side, dry bulb	°C
t_{a4}	temperature of air leaving outdoor-side, dry bulb	°C
t_c	temperature of surface of condenser of the compressor calorimeter	°C
t_e	temperature of surface of evaporator of the compressor calorimeter	°C
t_{w1}	temperature of water entering condenser of the compressor calorimeter	°C
t_{w2}	temperature of water leaving condenser of the compressor calorimeter	°C
v_a	velocity of air, at nozzle	m/s
v_n	specific volume of dry air portion of mixture at nozzle[b]	m^3/kg[b]
v'_n	specific volume of air-water vapour mixture at nozzle	m^3/kg
W_1	mass of cylinder and bleeder assembly, empty	g
W_3	mass of cylinder and bleeder assembly, with sample	g
W_5	mass of cylinder and bleeder assembly, with oil from sample	g
W_{i1}	specific humidity of air entering indoor-side[b]	kg/kg[b]
W_{i2}	specific humidity of air leaving indoor-side[b]	kg/kg[b]
W_n	specific humidity at nozzle inlet[b]	kg/kg[b]
W_r	water vapour (rate) condensed	kg/s
X_o	concentration of oil to refrigerant-oil mixture	a
X_r	mass ratio, refrigerant to refrigerant-oil mixture	a
Y	expansion factor	a
α_a	Interconnecting tubing heat transfer coefficient	$W/(m^2 \cdot K)$
λ	thermal conductivity	W/(m·K)
ν	kinematic viscosity of air	m^2/s
$\sum P_{ic}$	other power input to the indoor-side test chamber (e.g. illumination, electrical and thermal power input to the compensating device, heat balance of the humidification device)	W
$\sum P_{oc}$	sum of all total power input to the outdoor-side test chamber, not including power to the equipment under test	W
ϕ_c	heat removed by cooling coil in the outdoor-side test chamber	W
ϕ_{ci}	heat removed by cooling coil in the indoor side test chamber	W
ϕ_d	latent cooling capacity (dehumidifying)	W
ϕ_e	heat input to evaporator of compressor calorimeter	W
ϕ_{hi}	heating capacity, indoor-side test chamber	W

a Dimensionless value.

b It means the mass of dry air; the mass, kg, of denominator in this unit is based on dry air (or DA). For units practically used in the air conditioning field, "kg (DA)" is very often used for denominator. Example: J/kg(DA), m^3/kg (DA), kg/kg (DA)

NOTE All parameters are in relation to the unit being tested unless specified otherwise.

Symbol	Description	Unit
ϕ_{ho}	heating capacity, outdoor-side test chamber	W
ϕ_{li}	heat leakage into indoor side test chamber through walls, floor and ceiling	W
ϕ_{lo}	heat leakage out of outdoor side test chamber through walls, floor and ceiling	W
ϕ_{lp}	heat leakage into indoor-side test chamber through partition separating indoor-side from outdoor-side	W
ϕ_{L}	line heat loss in interconnecting tubing	W
ϕ_{sci}	sensible cooling capacity, indoor side	W
ϕ_{tc}	refrigerating capacity of a refrigerant compressor	W
ϕ_{tci}	total cooling capacity, indoor-side	W
ϕ_{tco}	total cooling capacity, outdoor-side	W
ϕ_{thi}	total heating capacity, indoor-side	W
ϕ_{tho}	total heating capacity, outdoor-side	W

[a] Dimensionless value.

[b] It means the mass of dry air; the mass, kg, of denominator in this unit is based on dry air (or DA). For units practically used in the air conditioning field, “kg (DA)” is very often used for denominator. Example: J/kg(DA), m^3/kg (DA), kg/kg (DA)

NOTE All parameters are in relation to the unit being tested unless specified otherwise.

5 Cooling tests

5.1 Cooling capacity test

5.1.1 General conditions

5.1.1.1 All equipment within the scope of this document shall have the cooling capacities and energy efficiency ratios determined in accordance with the provisions of this document and rated at the cooling test conditions specified in Table 1. All tests shall be carried out in accordance with the requirements of Annex A and the test methods specified in Clause 7. All tests shall be conducted with the equipment functioning at full-load operation, as defined in 3.25. The electrical input values used for rating purposes shall be measured during the cooling capacity test.

5.1.1.2 If the manufacturer of equipment having a variable-speed compressor does not provide information on the full-load frequency and how to achieve it during a cooling capacity test, the equipment shall be operated with its thermostat or controller set to its minimum allowable temperature setting.

5.1.2 Temperature conditions

5.1.2.1 The temperature conditions stated in Table 1 (columns T1, T2 and T3) shall be considered standard rating conditions for the determination of cooling capacity. For equipment intended for space cooling, testing shall be conducted at one or more of the standard rating conditions specified in Table 1.

5.1.2.2 Equipment manufactured only for use in a moderate climate similar to that specified in Table 1, column T1, shall have ratings determined by tests conducted at T1 conditions and shall be designated as type T1 equipment.

5.1.2.3 Equipment manufactured only for use in a cool climate similar to that specified in Table 1, column T2, shall have ratings determined by tests conducted at T2 conditions and shall be designated as type T2 equipment.

5.1.2.4 Equipment manufactured only for use in a hot climate similar to that specified in Table 1, column T3, shall have ratings determined by tests conducted at T3 conditions and shall be designated as type T3 equipment.

5.1.2.5 Equipment manufactured for use in more than one of the climates defined in Table 1 shall have marked on the nameplate the designated type (T1, T2 and/or T3). The corresponding ratings shall be determined by the standard rating conditions specified in Table 1.

5.1.3 Airflow conditions

5.1.3.1 Indoor-side air quantity — Air enthalpy test method

5.1.3.1.1 Tests shall be conducted at standard rating conditions (see Table 1) with 0 Pa static pressure maintained at the air discharge of the equipment and with the refrigeration means in operation. All air quantities shall be expressed as cubic metre per second (m^3/s) of standard air, as defined in 3.3.

When the fan speed is adjustable, the difference of the mass airflow rate from the standard air due to low barometric pressure should be adjusted by the fan speed.

5.1.3.1.2 Airflow measurements should be made in accordance with the provisions specified in Annex B, as appropriate, as well as the provisions established in other appropriate annexes of this document.

NOTE Additional guidance for making airflow measurements can be found in ISO 3966 and ISO 5167-1.

Table 1 — Cooling capacity rating conditions

Parameter	Standard rating conditions		
	T1	T2	T3
Temperature of air entering indoor-side:			
— dry-bulb	27 °C	21 °C	29 °C
— wet-bulb	19 °C	15 °C	19 °C
Temperature of air entering outdoor-side:			
— dry-bulb	35 °C	27 °C	46 °C
— wet-bulb[a]	24 °C	19 °C	24 °C
Test frequency[b]	Rated frequency		
Test voltage	See Table 2		

NOTE

T1 Standard cooling capacity rating conditions for moderate climates.

T2 Standard cooling capacity rating conditions for cool climates.

T3 Standard cooling capacity rating conditions for hot climates.

[a] The wet-bulb temperature condition shall only be required when testing air-cooled condensers which evaporate the condensate.

[b] Equipment with dual-rated frequencies shall be tested at each frequency.