INTERNATIONAL STANDARD

ISO 5151

Second edition
2010-06-15

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

Reference number
ISO 5151:2010(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 5151 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 second edition cancels and replaces the first edition (ISO 5151:1994), which has been technically revised.

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

1 Scope

This International Standard specifies the standard conditions for capacity and efficiency ratings of non-ducted air-cooled air conditioners and non-ducted air to air heat pumps. This International Standard is applicable to ducted units rated at less than 8 kW and intended to operate at an external static pressure of less than 25 Pa. This International Standard also specifies the test methods for determining the capacity and efficiency ratings.

Residential, commercial and industrial single-package and split-system air conditioners and heat pumps are included. The equipment (taken to mean non-ducted air conditioners or non-ducted heat pumps, as well as ducted air conditioners and/or ducted heat pumps, rated at less than 8 kW and intended to operate at external static pressures of less than 25 Pa) shall be factory-made, electrically driven and use mechanical compression. This International Standard is applicable to equipment utilizing one or more refrigeration systems, one outdoor unit and one or more indoor units, controlled by a single thermostat/controller. It is applicable to equipment utilizing single, multiple and variable capacity components.

This International Standard 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 (see 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 (see ISO 13253 for the testing of such equipment).

This International Standard 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.

2 Normative references

The following referenced documents are indispensable for the application 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 system*

3 Terms and definitions

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

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 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 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 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 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

See Figure 1.

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

See Figure 1.

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

See Figure 1.

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

See Figure 1.

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

See Figure 1.

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

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

See Figure 1.

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

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

See Figure 1.

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

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 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 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 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 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 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 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 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,

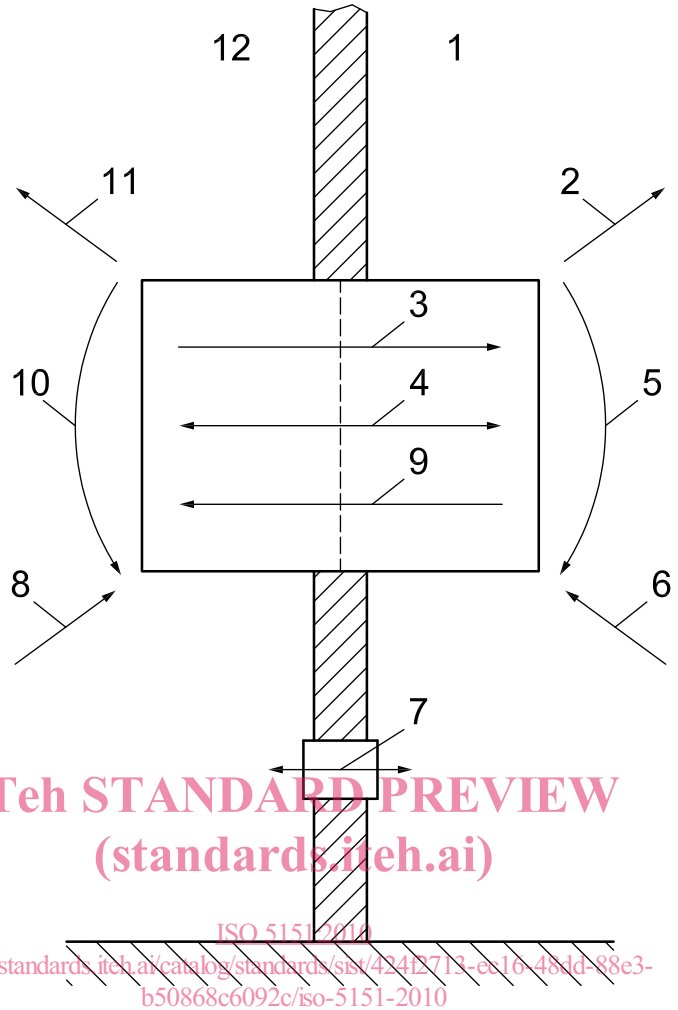
— the power input to all control and safety devices of the equipment, and

— the power input for operation of all fans

NOTE This 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 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

Figure 1 — Airflow diagram illustrating the definitions given in 3.4 to 3.13

4 Symbols

Symbol	Description	Unit
A_l	coefficient, heat leakage	J/s °C
A_n	area, nozzle	m^2
C_d	discharge coefficient nozzle	—
c_{pa}	specific heat of air, of moist air	J/kg °C
c_{pw}	specific heat of water	J/kg °C
D_n	nozzle throat diameter	mm

Symbol	Description	Unit
D_t	outside diameter of refrigerant tube	mm
f	factor, dependent on temperature, for Re	—
h_{a1}	specific enthalpy of air entering indoor side	J/kg of dry air
h_{a2}	specific enthalpy of air leaving indoor side	J/kg of dry air
h_{a3}	specific enthalpy of air entering outdoor side	J/kg of dry air
h_{a4}	specific enthalpy of air leaving outdoor side	J/kg of dry air
h_{f1}	specific enthalpy of refrigerant liquid entering the 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 condenser	J/kg
h_{k1}	specific enthalpy of steam entering calorimeter evaporator	J/kg
h_{k2}	specific enthalpy of fluid leaving calorimeter evaporator	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 compartment	J/kg
h_{w2}	specific enthalpy of condensed moisture leaving indoor-side compartment	J/kg
h_{w3}	specific enthalpy of condensate removed by air-treating coil in the outdoor-side compartment reconditioning equipment	J/kg
h_{w4}	specific enthalpy of the water supplied to the outdoor-side compartment	J/kg
h_{w5}	specific enthalpy of the condensed water (in the case of test condition, high) and the frost, respectively (in the case of test conditions low or extra-low) in the test unit	J/kg
K_1	latent heat of vaporization of water (2 500,4 J/g at 0 °C)	J/kg
L	length of refrigerant line	m
Re	Reynolds number	—
p_a	pressure, barometric	kPa
p_c	compartment equalization pressure	kPa
p_n	pressure, at nozzle throat	kPa abs
p_v	velocity pressure at nozzle throat or static pressure difference across nozzle	Pa
ϕ_{ci}	heat removed from indoor-side compartment	W
ϕ_c	heat removed by cooling coil in the outdoor-side compartment	W
ϕ_{lp}	heat leakage into indoor-side compartment through partition separating indoor side from outdoor side	W
ϕ_{li}	heat leakage into indoor-side compartment through walls, floor and ceiling	W
ϕ_{lo}	heat leakage out of outdoor-side compartment through walls, floor and ceiling, W	W
ϕ_L	line heat loss in interconnecting tubing	W
ϕ_e	heat input to calorimeter evaporator	W
ϕ_{lci}	latent cooling capacity, (indoor-side data)	W

Symbol	Description	Unit
ϕ_{sc}	sensible cooling capacity	W
ϕ_{sci}	sensible cooling capacity, (indoor-side data)	W
ϕ_{d}	latent cooling capacity (dehumidifying)	W
ϕ_{hi}	heating capacity, indoor-side compartment	W
ϕ_{ho}	heating capacity, outdoor-side compartment	W
ϕ_{tci}	total cooling capacity, (indoor-side data)	W
ϕ_{tco}	total cooling capacity, (outdoor-side data)	W
ϕ_{thi}	total heating capacity, (indoor-side data)	W
ϕ_{tho}	total heating capacity, (outdoor-side data)	W
P_{i}	power input, indoor-side data	W
$\sum P_{ic}$	other power input to the indoor-side compartment (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 compartment, not including power to the equipment under test	W
$\sum P_{E}$	power input to the equipment	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_{mo}	airflow, outdoor, measured	m^3/s
q_{r}	refrigerant flow rate	kg/s
q_{ro}	refrigerant and oil mixture flow rate	m^3/s
q_{v}	air-volume flow rate	m^3/s
q_{w}	condenser water flow rate	kg/s
q_{wo}	water mass flow supplied to the outside compartment for maintaining the test conditions	kg/s
q_{wc}	rate at which water vapour is condensed by the equipment	g/s
t_{a}	temperature, ambient	°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 calorimeter condenser	°C
t_{w1}	temperature of water entering calorimeter	°C
t_{w2}	temperature of water leaving calorimeter	°C
t_{w3}	temperature of water entering outdoor side	°C
t_{w4}	temperature of water leaving outdoor side	°C
v_{a}	velocity of air, at nozzle	m/s

Symbol	Description	Unit
v_n	specific volume of dry air portion of mixture at nozzle	m^3/kg
v'_n	specific volume of air-water vapour mixture at nozzle	m^3/kg
μ	kinematic viscosity of air	kg/m·s
W_{i1}	specific humidity of air entering indoor side	kg/kg of dry air
W_{i2}	specific humidity of air leaving indoor side	kg/kg of dry air
W_n	specific humidity at nozzle inlet	kg/kg of dry air
W_{a1}	flow rate, indoor air	kg/s
W_r	water vapour (rate) condensed by the equipment	g/s
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
X_o	concentration of oil	—
x_r	mass ratio, refrigerant to refrigerant-oil mixture	—

5 Cooling tests

5.1 Cooling capacity test

5.1.1 General conditions

5.1.1.1 All equipment within the scope of this International Standard shall have the cooling capacities and energy efficiency ratios determined in accordance with the provisions of this International Standard 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.

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 International Standard.

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
Condenser water temperature:			
— inlet	30 °C	22 °C	30 °C
— outlet	35 °C	27 °C	35 °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.