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Ducted air-conditioners and air-to-air heat pumps — Testing and rating for performance

Climatiseurs et pompes à chaleur air/air 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).

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For an explanation on 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 13253:2011), which has been technically revised.

Ducted air-conditioners and air-to-air 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:

— ducted air-cooled air conditioners and ducted air to air heat pumps.

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, and

— 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 (see ISO 15042 for 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) non-ducted equipment (see ISO 5151 for testing of such equipment);

g) 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, controlled by a single thermostat/controller (refer to ISO 5151).

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

ISO 817, *Refrigerants — Designation and safety classification*

ISO 5151, *Non-ducted air conditioners and heat pumps — Testing and rating for performance*

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

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.

3.2
ducted heat pump
encased assembly or assemblies designed primarily to provide ducted delivery of conditioned air to an enclosed space, room or zone (conditioned space), including 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.

3.3
standard air
dry air at 20,0 °C and at a standard barometric pressure of 101,325 kPa, having a mass density of 1 204 kg/m^3

3.4
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.

3.5
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.

3.6
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.

3.7
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.

3.8
sensible heat ratio
SHR
ratio of the *sensible cooling capacity* (3.7) to the *total cooling capacity* (3.4)

3.9
rated voltage
voltage shown on the nameplate of the equipment

3.10
rated frequency
frequency shown on the nameplate of the equipment

3.11
energy efficiency ratio
EER
ratio of the *total cooling capacity* (3.4) to the *effective power input* (3.14) 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/watts.

3.12
coefficient of performance
COP
ratio of the *heating capacity* (3.5) to the *effective power input* (3.14) 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/watts.

3.13
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.

3.14
effective power input
P_E
average electrical power input to the equipment, obtained from the following:

— the power input for operation of 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;

— the power input for operation of all fans, whether provided with the equipment or not

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

3.15
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 are functioning during full-load operations.

4 Symbols

Symbol	Description	Unit
A_l	coefficient, heat leakage	J/(s·K)
A_n	nozzle area	m^2
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)
C	airflow coefficient	$Pa/(m^3/s)^2$
C_d	nozzle discharge coefficient	—[a]
D_e	equivalent diameter	M
D_i	diameter of circular ducts, inlet	m
D_n	nozzle throat diameter	m
D_o	diameter of circular ducts, outlet	m
D_t	outside diameter of refrigerant tube	m
h_{a1}	specific enthalpy of air entering the indoor-side	J/kg[b]
h_{a2}	specific enthalpy of air leaving the indoor-side	J/kg[b]
h_{a3}	specific enthalpy of air entering the outdoor-side	J/kg[b]
h_{a4}	specific enthalpy of air leaving the 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 the indoor-side	J/kg
h_{r2}	specific enthalpy of refrigerant leaving the indoor-side	J/kg
h_{w1}	specific enthalpy of water or steam supplied to the indoor side test chamber	J/kg
h_{w2}	specific enthalpy of condensed moisture leaving the 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

[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
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
L_d	length of duct	m
L_m	length to external static pressure measuring point	m
p_a	barometric pressure	kPa
p_c	test chamber equalization pressure	Pa
p_e	external static pressure (ESP)	Pa
p_{isc}	internal static pressure drop of the indoor coil cabinet assembly measured from the cooling capacity test	Pa
p_m	external static pressure (p_e during the blowing test)	Pa
p_n	absolute pressure at nozzle throat	Pa
p_v	velocity pressure at nozzle throat or static pressure difference across the nozzle	Pa
P_{fan}	estimated fan power to circulate indoor air	W
P_i	power input, indoor-side data	W
P_K	power input to the compressor	W
P_t	total power input to the 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, outdoor-side	m^3/s
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
R_e	Reynolds number	—[a]
SHR	Sensible heat ratio	—[a]
T	thickness of tubing insulation	m
t_a	temperature, ambient of compressor calorimeter	°C
t_{a1}	temperature of air entering the indoor-side, dry bulb	°C
t_{a2}	temperature of air leaving the indoor-side, dry bulb	°C
t_{a3}	temperature of air entering the outdoor-side, dry bulb	°C
t_{a4}	temperature of air leaving the 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

[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
v_n	specific volume of dry air portion of mixture at nozzle[b]	m^3/kg[b]
v'_n	specific volume of dry air portion of 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 the indoor-side[b]	kg/kg[b]
W_{i2}	specific humidity of air leaving the 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	pressure ratio	—[a]
α_a	Interconnecting tubing heat transfer coefficient	$W/(m^2 \cdot K)$
λ	thermal conductivity	$W/(m \cdot K)$
ν	kinematic viscosity of air	m^2/s
$\eta_{fan,i}$	estimated indoor fan static efficiency	—[a]
$\eta_{mot,i}$	estimated indoor motor efficiency	—[a]
$\sum P_{ic}$	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 the 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
ϕ_{ho}	heating capacity, outdoor-side test chamber	W
ϕ_{li}	heat leakage into the indoor side test chamber through walls, floor and ceiling	W
ϕ_{lo}	heat leakage out of the outdoor side test chamber through walls, floor and ceiling	W
ϕ_{lp}	heat leakage into the indoor-side test chamber through the partition separating the indoor-side from the 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 Airflow setting

5.1 General

The airflow rate shall be specified by the manufacturer. This flow rate shall be for full-load cooling and be expressed in cubic metres per second (m^3/s) of standard air conditions, as defined in 3.3, and correspond with the compressor or compressors not operating.

P_{fan} is the estimated fan power required to circulate indoor air, in watts.

5.2 Indoor airflow setting

The airflow rate setting shall be made when only the fan is operating, at an ambient temperature between 20 °C to 30 °C and relative humidity between 30 % and 70 %. The airflow settings of the units shall be in accordance with Annex A for units supplied with a fan, and in accordance with Annex L for units supplied without a fan.

The rated airflow rate given by the manufacturer shall be set and the resulting external static pressure (ESP), p_e, measured. The measured ESP shall be not less than the ESP for rating, defined in Table 1. If the unit has an adjustable speed, it shall be adjusted to the lowest speed that provides the ESP for rating or greater.

5.3 ESP for rating

5.3.1 If the rated ESP specified by the manufacturer is greater than or equal to the minimum value given in Table 1, the specified rated ESP is used as the ESP for rating.

5.3.2 If the rated ESP specified by the manufacturer is less than the minimum value given in Table 1, and greater than or equal to 80 % of the maximum ESP, the specified rated ESP is used as the ESP for rating. The maximum ESP may either be specified by the manufacturer or be identified from fan curves provided by the manufacturer.

5.3.3 If the rated ESP specified by the manufacturer is less than the minimum value given in Table 1, and less than 80 % of the maximum ESP, the value of Table 1 or 80 % of the maximum ESP, whichever is less, is used as the ESP for rating.

5.3.4 If the rated ESP is not specified by the manufacturer, the value of Table 1 or 80 % of the maximum ESP, whichever is less, is used as the ESP for rating.

5.3.5 The process of selecting the ESP for rating is shown in Figure 1.

5.3.6 In the case that the determined ESP for rating is less than 25 Pa, the unit can be considered as a non-ducted unit and be tested in accordance with ISO 5151.

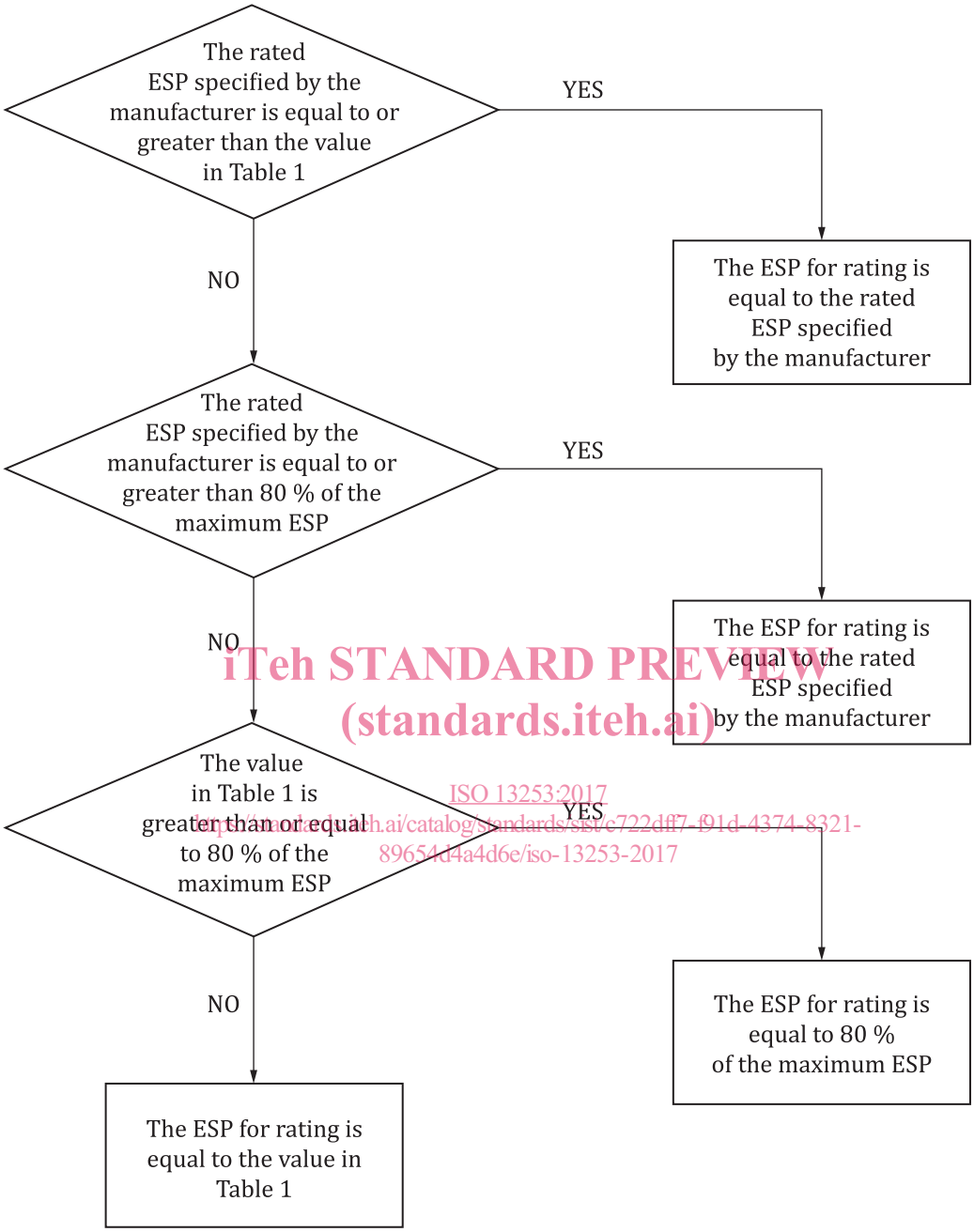

Figure 1 — Flowchart of selecting the ESP for rating

Table 1 — Pressure requirement for comfort air-conditioners

Standard capacity ratings kW	**Minimum external static pressure**[a] Pa
$0 < Q < 8$	25
$8 \leq Q < 12$	37
$12 \leq Q < 20$	50

[a] For equipment tested without an air filter installed, the minimum ESP, p_e, shall be increased by 10 Pa.

Table 1 *(continued)*

Standard capacity ratings kW	Minimum external static pressure[a] Pa
$20 \leq Q < 30$	62
$30 \leq Q < 45$	75
$45 \leq Q < 82$	100
$82 \leq Q < 117$	125
$117 \leq Q < 147$	150
$Q > 147$	175

[a] For equipment tested without an air filter installed, the minimum ESP, p_e, shall be increased by 10 Pa.

5.4 Outdoor airflow

If the outdoor airflow is adjustable, all tests shall be conducted at the outdoor-side air quantity or fan control setting that is specified by the manufacturer. Where the fan is non-adjustable, all tests shall be conducted at the outdoor-side air volume flow rate inherent in the equipment when operated with the following in place: all of the resistance elements associated with inlets, louvers, and any ductwork and attachments considered by the manufacturer as normal installation practice. Once established, the outdoor-side air circuit of the equipment shall remain unchanged throughout all tests prescribed in document, except to adjust for any change caused by the attachment of the airflow measuring device when using the outdoor air enthalpy test method (see G.2.1).

5.5 Unit supplied without indoor fan

If no fan is supplied with the unit (i.e. coil only units), supplemental requirements given in Annex L also apply.

6 Cooling tests

6.1 Cooling capacity tests

6.1.1 General conditions

6.1.1.1 All equipment within the scope of this document shall have the cooling capacities and energy efficiency ratios (EERs) determined in accordance with the provisions of this document and rated at the cooling test conditions specified in Table 2. All tests shall be carried out in accordance with the requirements of Annex B and the test methods specified in Clause 8. All tests shall be conducted with the equipment functioning at full-load operation, as defined in 3.15. The electrical input values used for rating purposes shall be measured during the cooling capacity test.

6.1.1.2 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.