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Multiple split-system air conditioners and air-to-air heat pumps — Testing and rating for performance

Climatiseurs et pompes à chaleur air/air multi-split — 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 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 second edition cancels and replaces the first edition (ISO 15042:2011), which has been technically revised.

Multiple split-system air conditioners and air-to-air heat pumps — Testing and rating for performance

1 Scope

This document specifies the 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:

— basic multi-split systems, modular multi-split systems and modular heat recovery multi-split systems. These multi-split systems include air-to-air systems with non-ducted and/or ducted indoor units with integral fans and indoor units supplied without fans.

This document is limited to:

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

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

— single- and multiple-circuit split-systems which utilize one or more compressors with no more than two steps of control of the outdoor unit;

or

— split-systems with a single refrigeration circuit which utilize one or more variable-speed compressors or alternative compressor combinations for varying the capacity of the system by three or more steps.

These split-systems are designed to operate with a combination of one or more outdoor units and two or more indoor units designed for individual operation, and such modular systems are capable of transferring recovered heat from one or more indoor units to other units in the same system.

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-cooled or water source equipment;

b) mobile (single-duct) units having a condenser exhaust duct;

c) individual assemblies not constituting a complete refrigeration system;

d) equipment using the absorption refrigeration cycle.

e) 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);

f) multiple split-system utilizing one or more refrigeration systems, one outdoor unit and one or more indoor units, controlled by a single thermostat/controller (refer to ISO 5151 or ISO 13253).

This document does not cover the determination of seasonal efficiencies or seasonal part-load performances, 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 “multi-split air conditioners” and/or “multi-split 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 5151, *Non-ducted air conditioners and heat pumps — Testing and rating for performance*

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 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
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

3.2
full capacity
capacity of the system when all indoor units and outdoor units are operated in the same mode

3.3
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.

3.4
part-load capacity
capacity of the system when the capacity ratio is less than 1

3.5
capacity ratio
ratio of the total stated cooling capacity of all operating indoor units to the stated cooling capacity of the outdoor unit at the rating conditions

3.6
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.

3.7
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
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.

3.9
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/watts.

3.10
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/watts.

3.11
heat recovery efficiency
HRE
ratio of the total capacity of the system (heating and cooling capacity) to the effective power when operating in the heat recovery mode

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

3.12
air conditioner
encased assembly or assemblies designed primarily to provide free or 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.

3.13
heat pump
encased assembly or assemblies designed primarily to provide free or ducted delivery of conditioned air to an enclosed space, room or zone (conditioned space) 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.

3.14
basic multi-split system
split-system air conditioner or heat pump incorporating a single refrigerant circuit with one or more compressors, multiple evaporators (indoor units) designed for individual operation, and one outdoor unit

Note 1 to entry: The system has no more than two steps of control and is capable of operating either as an air conditioner or as a heat pump. Alternatively, a system having a variable speed compressor and a fixed combination of indoor units specified by the manufacturer can also be considered a basic multi-split system.

3.15
multiple-circuit multi-split system
split-system air conditioner or heat pump incorporating multiple refrigerant circuits, two or more compressors, multiple evaporators (indoor units) and an integrated heat exchanger in a single outdoor unit

Note 1 to entry: The system has no more than two steps of control and is capable of operating either as an air conditioner or as a heat pump.

3.16
modular multi-split system
split-system air conditioner or heat pump incorporating a single refrigerant circuit, at least one variable speed compressor or an alternative compressor combination for varying the capacity of the system by three or more steps, multiple indoor units, each of which can be individually controlled, and one or more outdoor units

Note 1 to entry: The system is capable of operating either as an air conditioner or as a heat pump

3.17
modular heat recovery multi-split system
split-system air conditioner or heat pump incorporating a single refrigerant circuit, at least one variable-speed compressor or an alternate compressor combination for varying the capacity of the system by three or more steps, multiple evaporators (indoor units, each capable of being individually controlled), and one or more condensers (outdoor units)

Note 1 to entry: This system is capable of operating as a heat pump where recovered heat from the indoor units operating in the cooling mode can be transferred to one or more other indoor units operating in the heating mode. Heat recovery can be achieved by a gas/liquid separator or a third line in the refrigeration circuit.

3.18
effective power input
P_E
average electrical power input to the equipment obtained from

— 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, and

— 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.

3.19
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

3.20
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_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_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 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

[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 as the 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_{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
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 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 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 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_s	standard flow rate	m^3/s
q_v	air volume flow rate	m^3/s
q_{vi}	air volume flow rate, indoor-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
Re	Reynolds number	—[a]
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

[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 as the 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 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	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 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 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 as the 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

This document specifies airflow settings for ducted and non-ducted units and units supplied without a fan.

Ducted indoor units rated less than 8 kW and intended to operate at an external static pressure of less than 25 Pa shall be tested as non-ducted units.

5.2 Airflow setting for ducted indoor units

5.2.1 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 3.1, and correspond to a non-operating compressor.

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

5.2.2 Airflow setting procedure for ducted indoor units

The airflow rate setting shall be made when only the fan is operating, at an ambient temperature between 20 °C and 30 °C and a 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 O for units supplied without a fan.

The rated airflow rate given by the manufacturer shall be set and the resulting external static pressure, p_e, (ESP) measured. The measured ESP shall be larger 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 at least the ESP for rating.

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 larger than or equal to the 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 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 smaller, 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 smaller, is used as the ESP for rating.

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

If the determined ESP for rating is less than 25 Pa, the unit can be considered a non-ducted indoor unit.

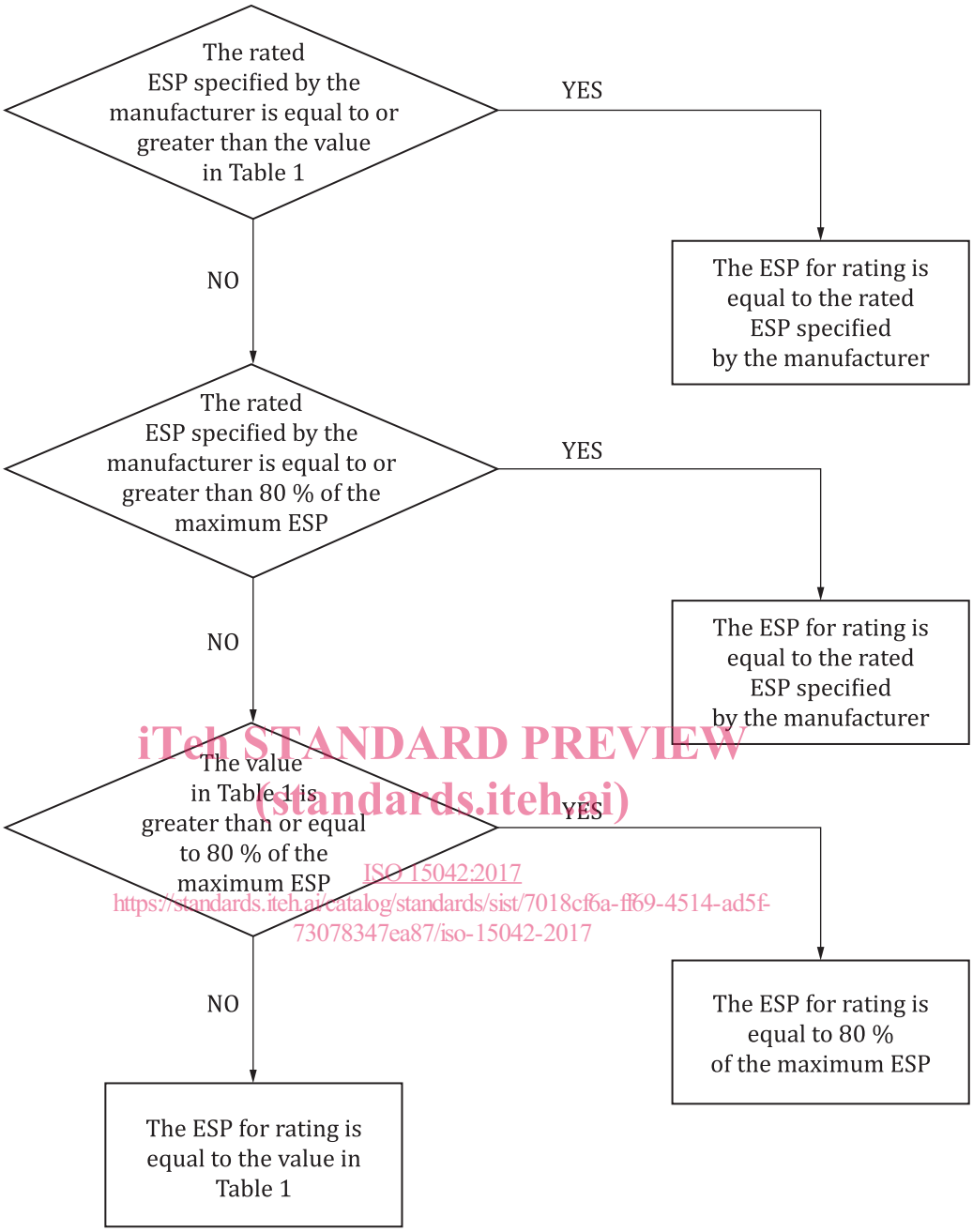

Figure 1 — Flowchart for selecting ESP for rating

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
$20 \leq Q < 30$	62

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