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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 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.

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ISO 15042 was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

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

1 Scope

This International Standard establishes performance testing and rating criteria for factory-made residential, commercial and industrial, electrically driven, mechanical-compression, air-cooled air-conditioners and air-to-air heat pumps, described as 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 International Standard is limited to single- and multiple-circuit split-systems which utilize one or more compressors with no more than two steps of control of the outdoor unit. It is also limited to 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 that 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 International Standard are based on the use of matched assemblies.

This International Standard is not applicable to the testing and rating of:

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.

This International Standard does not cover the determination of either 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 International Standard, the terms “equipment” and “systems” mean “multi-split air-conditioners” and/or “multi-split heat pumps”.

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 and safety classification*[1)]

1) To be published. (Revision of ISO 817:2005.)

3 Terms and definitions

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

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 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 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 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 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 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 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 Where HRE is stated without an indication of units, it is understood that it is derived from watts/watts.

3.12
air-conditioner
an 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 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
an 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 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
a 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 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
a 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 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
a 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 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 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 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 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 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 °C
A_n	nozzle area	m^2
α	pressure ratio	—
C_d	nozzle discharge coefficient	—
c_o	concentration of oil	—
c_{pa}	specific heat of moist air	J/kg °C
c_{pa1}	specific heat of moist air entering indoor side	J/kg °C
c_{pa2}	specific heat of moist air leaving indoor side	J/kg °C

Symbol	Description	Unit
c_{pw}	specific heat of water	J/kg °C
D_e	equivalent diameter	mm
D_n	nozzle throat diameter	mm
D_i	diameter of circular ducts, inlet	mm
D_o	diameter of circular ducts, outlet	mm
D_t	outside diameter of refrigerant tube	mm
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_{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 of the reconditioning equipment	J/kg
h_{w4}	specific enthalpy of the water supplied to the outdoor-side compartment	J/kg
h_{w5}	specific enthalpy of, respectively, the condensed water (in the case of test condition, high) and the frost (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_d	length of duct	m
L_m	length to external static pressure measuring point	m
ln	natural logarithm	—
m_1	mass of cylinder and bleeder assembly, empty	g
m_3	mass of cylinder and bleeder assembly with sample	g
m_5	mass of cylinder and bleeder assembly with oil from sample	g
$\eta_{fan,i}$	estimated indoor fan static efficiency	—
$\eta_{mot,i}$	estimated indoor motor efficiency	—
p_a	barometric pressure	kPa
p_c	compartment equalization pressure	kPa
p_e	external static pressure (ESP)	kPa
p_{isc}	internal static pressure drop of the indoor coil cabinet assembly measured from cooling capacity test	Pa

Symbol	Description	Unit
p_{m}	measured external static pressure	kPa
p_{n}	pressure at the nozzle throat	kPa abs
p_v	velocity pressure at nozzle throat or static pressure difference across nozzle	Pa
Re	Reynolds number	—
μ	kinematic viscosity of air	m^2/s
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
ϕ_{L}	line heat loss in interconnecting tubing	W
ϕ_{e}	heat input to calorimeter evaporator	W
ϕ_{d}	latent cooling capacity (dehumidifying)	W
ϕ_{lci}	latent cooling capacity (indoor-side data)	W
ϕ_{sc}	sensible cooling capacity	W
ϕ_{sci}	sensible cooling capacity (indoor-side data)	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_{fan}	estimated fan power to circulate indoor air	W
P_{i}	power input (indoor-side data)	W
$\sum P_{\mathrm{ic}}$	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
$\sum P_{\mathrm{oc}}$	sum of all total power input to the outdoor-side compartment, not including power to the equipment under test	W
P_{E}	effective 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
$q_{V,\mathrm{o}}$	measured outdoor air volume flow	m^3/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

Symbol	Description	Unit
$q_{V,\mathrm{i}}$	indoor air-volume flow rate	m^3/s
q_w	condenser water flow rate	kg/s
q_wc	rate at which water vapour is condensed by the equipment	g/s
$q_{m,\mathrm{w}}$	water mass flow supplied to the outside compartment for maintaining the test conditions	kg/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 indoor 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
v_n	velocity of air at nozzle	m/s
V_n	specific volume of dry air portion of mixture at nozzle	m^3/kg
V'_n	specific volume of air at nozzle	m^3/kg of air-water vapour mixture
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_r	water vapour (rate) condensed by the equipment	g/s
X_r	mass ratio, refrigerant to refrigerant-oil mixture	—
Y	expansion factor	—

5 Airflow setting

5.1 General

This International Standard 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.

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.

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.

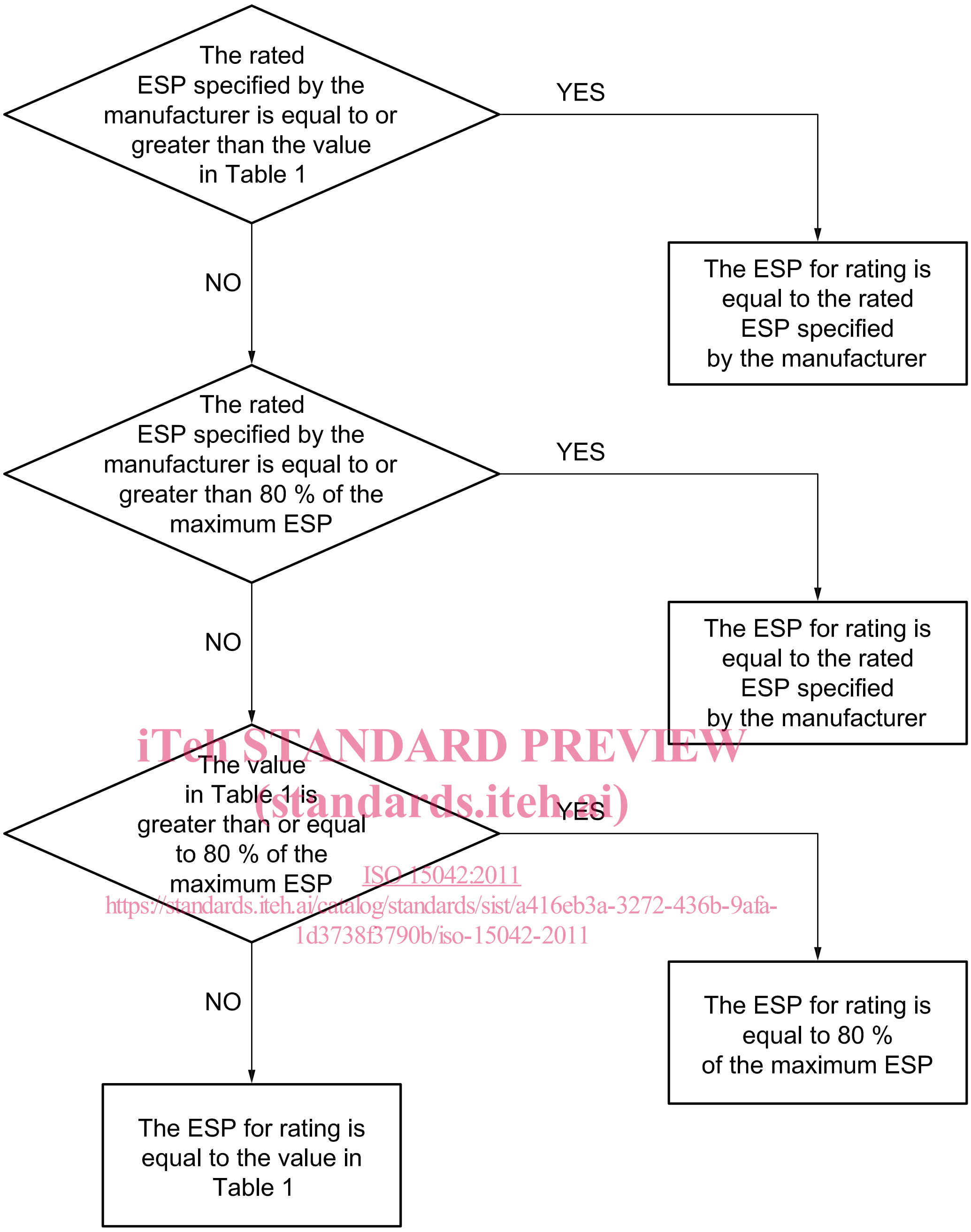

Figure 1 — Flowchart for selecting ESP for rating