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Variable refrigerant flow air-to-air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors and energy performance mapping approach

Climatiseurs et pompes à chaleur air/air à débit de fluide frigorigène variable — Méthodes d'essai et de calcul des facteurs de performance saisonnière et approche de la cartographie de la performance énergétique

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Foreword

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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*.

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Variable refrigerant flow air-to-air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors and energy performance mapping approach

1 Scope

This document specifies:

— the test conditions and test methods for determining capacity and efficiency ratings;

— calculation methods for seasonal performance.

This applies to factory made, electric mains operated, variable refrigerant flow air-cooled air conditioners and air-to-air heat pumps with a rated capacity above 12 kW for cooling or for heating if the product has no cooling function.

In this document, “heat pumps” means “air-to-air heat pumps” and “air conditioners” means “air-cooled air conditioners”.

This document establishes a method for determining global variable refrigerant flow (VRF) performance with annexes addressing specific national or regional deviations, such as regionally specific power or testing requirements.

This document does not apply to the testing and rating of:

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

b) multi-split systems where each indoor unit has dedicated piping connected directly to the outdoor unit;

c) individual assemblies not constituting a complete refrigeration system.

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

ISO 13253, *Ducted air-conditioners and air-to-air heat pumps — Testing and rating for performance*

ISO 15042:2017, *Multiple split-system air conditioners and air-to-air heat pumps — Testing and rating for performance*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5151, ISO 13253, ISO 15042 and the following apply.

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

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

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

3.1
active mode seasonal coefficient of performance
$S_{COP,on}$
average coefficient of performance of the unit in active mode for the designated heating season, determined from the part load, supplementary heating capacity (where required) and bin-specific coefficients of performance [$C_{OP,bin}(t_j)$] and weighted by the bin hours where the bin condition occurs

Note 1 to entry: For calculation of $S_{COP,on}$, the energy consumption during thermostat-off mode, standby mode, off mode and crankcase heater mode are excluded. The energy consumption of a supplementary heater is added for the part load conditions where the declared capacity of the unit is lower than the heating load, regardless of whether this supplementary heater is included in the unit or not included in the unit.

Note 2 to entry: Expressed in kWh/kWh.

3.2
active mode seasonal energy efficiency ratio
$S_{EER,on}$
average energy efficiency ratio of the unit in active mode for the space cooling function, determined from part load and bin-specific energy efficiency ratios [$E_{ER,bin}(t_j)$] and weighted by the bin hours where the bin condition occurs

Note 1 to entry: For calculation of $S_{EER,on}$, the energy consumption during thermostat-off mode, standby mode, off mode and that of the crankcase heater is excluded.

Note 2 to entry: Expressed in kWh/kWh.

3.3
air-cooled air conditioner
air conditioner
direct expansion system that utilizes an indoor conditioning coil, compressor and refrigerant-to-outdoor air heat exchanger to provide air cooling and can also provide air dehumidifying, air humidifying, air circulating and air cleaning

3.4
air-to-air heat pump
heat pump
direct expansion system that utilizes an indoor conditioning coil, compressor and refrigerant-to-outdoor air heat exchanger to provide air heating and can also provide air cooling, air dehumidifying, air humidifying, air circulating and air cleaning

3.5
annual energy consumption for heating
Q_{HE}
energy consumption required to meet the reference annual heating demand for a designated heating season and calculated as the reference annual heating demand divided by the active mode seasonal coefficient of performance ($S_{COP,on}$) and the energy consumption of the unit for thermostat-off-, standby-off- and crankcase heater mode during the heating season

Note 1 to entry: Expressed in kWh.

3.6
annual energy consumption for space cooling
Q_{CE}
energy consumption required to meet the reference annual space cooling demand and calculated as the reference annual space cooling demand divided by the active mode seasonal energy efficiency ratio ($S_{EER,on}$) and the energy consumption of the unit for thermostat-off-, standby-off- and crankcase heater mode during the cooling season

Note 1 to entry: Expressed in kWh.

3.7
annual performance factor
APF
ratio of the total annual amount of heat that the equipment can remove from and add to the indoor air when operated for cooling and heating, respectively, in active mode to the total amount of energy consumed by the equipment during the same period

[SOURCE: ISO 16358-3:2013, 3.6]

3.8
approach temperature
refrigerant temperature at the outdoor liquid service port minus the outdoor ambient temperature

3.9
bin
outdoor temperature interval of 1 K

3.10
bin hours
n_j
hours per season for which an outdoor temperature occurs for each bin j

3.11
bin temperature
t_j
outdoor air dry bulb temperature at bin j

Note 1 to entry: Expressed in °C.

Note 2 to entry: The relative humidity can be indicated by a corresponding wet bulb temperature.

3.12
bin-specific coefficient of performance
$C_{OP,bin}(t_j)$

coefficient of performance specific for every bin j with outdoor temperature t_j in a season

Note 1 to entry: Expressed in kW/kW.

3.13
bin-specific energy efficiency ratio
$E_{ER,bin}(t_j)$
energy efficiency ratio specific for every bin j with outdoor temperature t_j in a season

Note 1 to entry: Expressed in kW/kW.

3.14
bivalent temperature
t_{biv}
lowest outdoor bin temperature at which the unit is declared to have a capacity able to meet 100 % of the heating load without supplementary heater, whether it is integrated in the unit or not

Note 1 to entry: Below this point, the unit can still provide capacity, but additional supplementary heating is necessary to fulfil the full heating load.

Note 2 to entry: Expressed in °C.

3.15
ceiling cassette
non-ducted indoor units intended to be installed flush mounted with the ceiling

Note 1 to entry: These indoor units can have configurations of indoor airflow coming from one, two, four or circular direction(s). Each represents a separate indoor unit.

3.16
coefficient of performance at declared capacity
$C_{OP,d}$
declared heating capacity of the unit divided by the effective power input of the unit at specific temperature conditions, A, B, C, D, E, F and G, where applicable

Note 1 to entry: Expressed in kW/kW.

3.17
coefficient of performance at high temperature
C_{OPH}
coefficient of performance not including supplementary resistance heat, obtained at the 8,3 °C temperature rating condition

Note 1 to entry: Expressed in kW/kW.

3.18
coefficient of performance at low temperature
C_{OPL}
coefficient of performance obtained at the −8,3 °C temperature rating condition

Note 1 to entry: Expressed in kW/kW.

3.19
coefficient of performance at part load
$C_{OP,bin}$
coefficient of performance $C_{OP,d}$ corrected with the degradation coefficient where applicable

Note 1 to entry: Expressed in kW/kW.

3.20
control setting
system configurations specified in the manufacturer's installation instructions or supplemental testing instructions

3.21
controls verification procedure
CVP
procedure intended to verify the control settings for critical parameters used during the test

3.22
crankcase heater mode
condition where the unit has activated a heating device to avoid the refrigerant migrating to the compressor in order to limit the refrigerant concentration in oil at compressor start

3.23
crankcase heater mode operating hours
H_{CK}
annual number of hours the unit is considered to be in crankcase heater mode, the value of which depends on the designated season and type of unit and operating mode(s)

Note 1 to entry: Expressed in h.

3.24
crankcase heater mode power input
P_{CK}
power input of the outdoor unit due to crankcase heater mode

Note 1 to entry: Expressed in W.

3.25
critical parameter
operating state or position for a component, either set manually or automatically by system controls, which significantly impacts system performance

Note 1 to entry: Critical parameter is one (or more) key variable(s) affecting the measured result.

3.26
cycling interval capacity for cooling
$\boldsymbol{\phi_{cyc,c}}$
(time-weighted) average cooling capacity output over the cycling interval test

Note 1 to entry: Expressed in kW.

3.27
cycling interval capacity for heating
$\boldsymbol{\phi_{cyc,h}}$
(time-weighted) average heating capacity output over the cycling interval test

Note 1 to entry: Expressed in kW.

3.28
cycling interval efficiency for cooling
$\boldsymbol{E_{ER,cyc}}$
average energy efficiency ratio over the cycling interval test (compressor switching on and off)

Note 1 to entry: The cycling interval efficiency for cooling is calculated as the integrated cooling capacity over the interval divided by the integrated power input over that same interval.

Note 2 to entry: Expressed in kWh/kWh.

3.29
cycling interval efficiency for heating
$\boldsymbol{C_{OP,cyc}}$

average coefficient of performance over the cycling interval test (compressor switching on and off)

Note 1 to entry: The cycling interval efficiency for heating calculated as the integrated heating capacity over the interval divided by the integrated power input over that same interval.

Note 2 to entry: Expressed in kWh/kWh.

3.30
defrost control
capability defined by the manufacturer to monitor and manage a heat pumps operating conditions to initiate and terminate defrost protection for the outdoor unit

3.31
defrost control system
system configurations specified in the manufacturer's installation instructions or supplemental testing instructions

3.32
degradation coefficient
$\boldsymbol{C_D}$
measure of efficiency loss due to the cycling

Note 1 to entry: If C_D is not determined by measurement, then the default degradation coefficient for air-to-air units is 0,25 for both heating and cooling mode of operation.

3.33
direct expansion system
system that uses vapor-compression refrigeration cycle in which the inside and outside air is cooled or heated by the heat exchange with a coil where the refrigerant evaporates or condenses respectively

3.34
ducted indoor unit
indoor unit designed to be permanently installed and deliver all conditioned air through ductwork

3.35
ducted system
system with only indoor units designed to be permanently installed and to deliver all conditioned air through ductwork

3.36
electric supplementary heater capacity
$\boldsymbol{e_{\mathrm{lbu}}(t_{\mathrm{j}})}$
heating capacity of a real or assumed electric supplementary heater supplementing the declared capacity for heating when the capacity of the unit is lower than the heat load for a specific bin temperature t_{j}

Note 1 to entry: Expressed in kW.

3.37
energy efficiency ratio
EER
ratio of the cooling capacity in kW to the total power in kW at any given set of rating conditions

Note 1 to entry: Expressed in kW/kW.

3.38
energy efficiency ratio at declared capacity
$\boldsymbol{E_{\mathrm{ER,d}}}$
declared cooling capacity of the unit divided by the effective power input of a unit at specific temperature conditions A, B, C, D

Note 1 to entry: Expressed in kW/kW.

3.39
energy efficiency ratio at part load
$\boldsymbol{E_{\mathrm{ER,bin}}}$
energy efficiency ratio $E_{\mathrm{ER,d}}$ corrected with the degradation coefficient, where applicable

Note 1 to entry: Expressed in kW/kW.

3.40
equivalent active mode hours for cooling
$\boldsymbol{H_{\mathrm{CE}}}$
assumed annual number of hours the unit provides the design load for space cooling ($L_{\mathrm{design,c}}$) in order to satisfy the reference annual space cooling demand

Note 1 to entry: Expressed in h.

3.41
equivalent active mode hours for heating
$\boldsymbol{H_{\mathrm{HE}}}$
assumed annual number of hours the unit provides the design load for heating ($L_{\mathrm{design,h}}$) in order to satisfy the reference annual heating demand

Note 1 to entry: Expressed in h.

3.42
heat recovery capacity ratio
ratio of capacity during simultaneous cooling and heating operation between indoor units in cooling mode over indoor units in heating mode

Note 1 to entry: Expressed in kW/kW.

3.43
heat recovery control unit
device that controls refrigerant flow between indoor units, allowing for simultaneous cooling and heating operation

3.44
heating capacity
rate of heat that the equipment adds to the conditioned space in a defined interval of time

Note 1 to entry: Expressed in kW.

3.45
heating season
months of the year that require heating

3.46
heating seasonal performance factor
HSPF
the total space heating required during the space heating season, kWh, divided by the total electrical energy, kWh, consumed by the heat pump system during the same season

Note 1 to entry: Expressed in kWh/kWh.

Note 2 to entry: HSPF varies depending on the region and design heating requirement.

3.47
indoor unit
separate assembly of a split system that is individually controlled and includes the following basic features:

— arrangement of refrigerant-to-air heat transfer coil(s) for transfer of heat between the refrigerant and the indoor air;

— integrated indoor blower (i.e. a device to move air including its associated motor)

3.48
integrated energy efficiency ratio
IEER
weighted calculation of mechanical cooling efficiencies at full load and part load standard rating conditions as defined by regional requirements

3.49
load ratio
ratio of the actual heat power output divided by the maximum power output of the heat pump at the same source and sink temperature conditions

3.50
manufacturer's installation instructions
MII
manufacturer's documents that come packaged with or appear on the labels applied to the unit(s)

Note 1 to entry: Online manuals are acceptable if referenced on the unit label or in the documents that come packaged with the unit.

Note 2 to entry: All references to "manufacturer's instructions," "manufacturer's published instructions," "manufacturer's installation instructions," "manufacturer's published recommendations," "manufacturer installation and operation manuals," "installation instructions", "manufacturer-specified", and other similar references means manufacturer's installation instructions.

3.51
net seasonal coefficient of performance
$S_{COP,net}$
seasonal coefficient of performance of a unit in active heating mode without supplementary heaters which is determined from mandatory conditions given in this document

Note 1 to entry: For calculation of $S_{COP,net}$, the energy consumption during active mode is used. This excludes the energy consumption during thermostat-off mode, standby mode, off mode or that of the crankcase heater. For the part load conditions where the declared capacity of the unit is lower than the heating load, the energy consumption of a supplementary heater is not included.

Note 2 to entry: Expressed in kWh/kWh.

3.52
nominal cooling capacity
cooling capacity tested at standard rating conditions, as published in product literature

Note 1 to entry: Expressed in kW.

3.53
nominal point value
value corresponding to a 1 % variation in the given critical parameter as given in this document

3.54
non-ducted indoor unit
indoor unit designed to operate at 0 ESP, to be permanently installed, mounted on room walls, floors and/or ceilings, which directly heats or cools air within the conditioned space

Note 1 to entry: Non-ducted indoor units can consist of the following types: wall-mounted, floor-mounted, ceiling-suspended and ceiling cassette (standard and compact).

3.55
off mode
mode wherein the unit is completely switched off and cannot be reactivated by control device, external signal or by a timer

Note 1 to entry: Off mode means a condition in which the equipment is connected to the mains and is not providing any function. The following is also considered as off mode: conditions providing only an indication of off mode condition; conditions providing only functionalities intended to ensure electromagnetic compatibility.

3.56
off mode operating hours
H_{OFF}
annual number of hours the unit is considered to be in off mode, the value of which depends on the designated season, type of unit and operating mode(s)

Note 1 to entry: Expressed in h.

3.57
off mode power input
P_{OFF}
power input of the outdoor unit while in off mode

Note 1 to entry: Expressed in W.

3.58
oil recovery mode
automatic system operation that returns oil to the compressor crankcase when the control system determines that the oil level in the outdoor unit is low

3.59
operation limit temperature
TOL
outdoor temperature below which the unit cannot deliver any capacity, and the declared capacity is equal to zero

Note 1 to entry: Expressed in °C.

3.60
outdoor coefficient of performance
$C_{OP,outdoor}$
ratio of the outdoor heating capacity to the outdoor effective power input

Note 1 to entry: Expressed in kW/kW.

3.61
outdoor cooling capacity
$\phi_{C,outdoor}$
cooling capacity of the outdoor unit measured as the cooling capacity of all indoor units

Note 1 to entry: Expressed in kW.

3.62
outdoor energy efficiency ratio
$E_{ER,outdoor}$
ratio of the outdoor cooling capacity to the outdoor effective power input

Note 1 to entry: Expressed in kW/kW.

3.63
outdoor heating capacity
$\phi_{H,outdoor}$
heating capacity of the outdoor unit measured as the heating capacity of all indoor units

Note 1 to entry: Expressed in kW.

3.64
outdoor power input
$P_{E,outdoor}$
effective power input measured on the outdoor unit

Note 1 to entry: Expressed in kW.

3.65
outdoor unit
separate assembly of a split system that transfers heat between the refrigerant and the outdoor ai, and consists of an outdoor heat exchanger, compressor(s), an air moving device and, for heat pumps, can include a heating mode expansion device, reversing valve and/or defrost controls

Note 1 to entry: An outdoor unit can be either single module or combined modules.

Note 2 to entry: A single module consists of a single outdoor unit that is assembled with multiple indoor units and controls to form a system.

Note 3 to entry: Combined modules consist of two or more single modules that are mechanically and electronically joined together to operate as a single outdoor unit that is assembled with multiple indoor units to form a system. When such equipment is provided in more than one assembly, the separated assemblies shall be designed to be used together, and the requirements of rating outlined in this document are based on the use of matched assemblies.

3.66
published rating
statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit can be chosen to fit its application and apply to all units of like nominal size and type (identification) produced by the same manufacturer

Note 1 to entry: As used in this document, the term published rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated rating conditions.