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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 18107

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

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This document is circulated as received from the committee secretariat.

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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.

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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC86, Refrigeration and air-conditioning, Subcommittee SC 6, Testing and rating of air conditioners and heat pumps.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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

1 Scope

For 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, this document specifies:

- the standard test conditions and the test methods for determining the capacity and efficiency ratings and,
- calculation methods for seasonal performance.

NOTE 1 Throughout this document, “heat pumps” means “air to air heat pumps” and “air conditioners” means “air-cooled air conditioners”.

This standard establishes a method for determining global variable refrigerant flow (VRF) performance with annexes addressing specific national or regional deviations.

NOTE 2 For example, regionally specific power or testing requirement will be included in an annex.

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

- water-source heat pumps or water-cooled air conditioners;
- multi-split systems where each indoor unit has dedicated piping connected directly to the outdoor unit; or
- 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 5149-1:2014/Amd 1:2015/Amd2:2021, *Refrigerating systems and heat pumps – Safety and environmental requirements – Part 1: Definitions, classification and selection criteria*

ISO 5151:2017, *Non-ducted air conditioners and heat pumps — Testing and rating for performance*

ISO 13253:2017/Amd 1:2020, *Ducted air conditioners and air-to-air heat pumps — Testing and rating for performance*

ISO 15042:2017/Amd 1:2020, *Multiple split-system air conditioners and air-to-air heat pumps — Testing and rating for performance*

ISO 16358-1:2013/Amd 1:2019, *Air-cooled air conditioners and air-to-air heat pumps – Testing and calculating methods for seasonal performance factors – Part 1: Cooling seasonal performance factor*

ISO 16358-2:2013, *Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors — Part 2: Heating seasonal performance factor*

ISO 16358-3:2013, *Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors — Part 3: Annual performance factor*

ISO 21978:2023, *Air to water heat pumps — Testing and rating at part load conditions and calculation of seasonal coefficient of performance for space heating*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5151:2017, ISO 13253:2017/Amd 1:2020, ISO 15042:2017/Amd 1:2020 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

SCOP_{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 ($COP_{bin}(t_j)$) and weighted by the bin hours where the bin condition occurs

Note 1 to entry: For calculation of SCOP_{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 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

SEER_{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 ($EER_{bin}(t_j)$) and weighted by the bin hours where the bin condition occurs

Note 1 to entry: For calculation of SEER_{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 may 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 may 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 ($SCOP_{on}$) 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 ($SEER_{on}$) 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

the 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 may be indicated by a corresponding wet bulb temperature.

3.12

bin-specific coefficient of performance

$COP_{bin}(t_j)$

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

$EER_{bin}(t_j)$

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 may 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. Each represents a separate indoor unit.

3.16

coefficient of performance at declared capacity

COP_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

COP_H

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

COP_L

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

COP_{bin}

coefficient of performance COP_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 and confidential 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

any 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

$\phi_{cyc,c}$

(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

$\phi_{cyc,h}$

(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

EER_{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

COP_{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

the 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 and confidential testing instructions

3.32

degradation coefficient

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

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

3.35

ducted system

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

3.36

electric supplementary heater capacity

elbu(t_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

EER_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

EER_{bin}

energy efficiency ratio EER_d corrected with the degradation coefficient, where applicable

Note 1 to entry: Expressed in kW/kW.

3.40

equivalent active mode hours for cooling

H_{CE}

assumed annual number of hours the unit must provide the design load for space cooling ($L_{designc}$) 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

H_{HE}

assumed annual number of hours the unit must provide the design load for heating ($L_{designh}$) in order to satisfy the reference annual heating demand

Note 1 to entry: Expressed in h.

3.42

heat recovery capacity ratio

the ratio of capacity between units in cooling mode over units in heating mode

Note 1 to entry: Expressed in kW/kW.

3.43

heat recovery control unit

a device that controls refrigerant flow between indoor units, allowing for simultaneous cooling and heating operation

3.44

heating capacity

the 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

the months of the year that require heating

3.46

heating seasonal performance factor

HSPF

for air-source systems, 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 will vary 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 basic features listed below:

- 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

manufacturer's installation instructions

MII

manufacturer's documents that come packaged with or appear in 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.

3.50

net seasonal coefficient of performance

SCOP_{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 SCOP_{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.

3.51

nominal cooling capacity

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

Note 1 to entry: Expressed in kW.

3.52

nominal point value

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

3.53

non-ducted indoor unit

an 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 may consist of the following types: wall-mounted, floor-mounted, ceiling-suspended, and ceiling cassette (standard and compact).

3.54

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 will also be considered as off mode: conditions providing only an indication of off mode condition; conditions providing only functionalities intended to ensure electromagnetic compatibility.

3.55

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.

3.56

off mode power input

P_{OFF}

power input of the outdoor unit while in off mode

Note 1 to entry: Expressed in W.

3.57

oil recovery mode

an 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

3.58

operation limit temperature

TOL

outdoor temperature below which the unit will not be able to deliver any capacity and the declared capacity is equal to zero

Note 1 to entry: Expressed in °C.

[SOURCE: ISO 21978:2021, 3.37]

3.59

outdoor coefficient of performance

COP_{outdoor}

ratio of the outdoor heating capacity to the outdoor effective power input

Note 1 to entry: Expressed in kW/kW.

3.60

outdoor cooling capacity

$\phi_{C,\text{outdoor}}$

cooling capacity of the outdoor unit measured as the cooling capacity of all indoor units

Note 1 to entry: Expressed in kW.

3.61

outdoor energy efficiency ratio

EER_{outdoor}

ratio of the outdoor cooling capacity to the outdoor effective power input

Note 1 to entry: Expressed in kW/kW.

3.62

outdoor heating capacity

$\phi_{H,\text{outdoor}}$

heating capacity of the outdoor unit measured as the heating capacity of all indoor units

Note 1 to entry: Expressed in kW.

3.63**outdoor power input** **$P_{E,outdoor}$**

effective power input measured on the outdoor unit

Note 1 to entry: Expressed in kW.

3.64**outdoor unit**

a separate assembly of a split system that transfers heat between the refrigerant and the outdoor air, and consists of an outdoor heat exchanger, compressor(s), an air moving device, and in addition for heat pumps, may 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 consists 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 the standard are based upon the use of matched assemblies.

3.65**published rating**

a statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may 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.

3.66**rated capacity**

the capacity achieved at the standard rating conditions

Note 1 to entry: Expressed in kW.

3.67**rating conditions**

any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur

3.68**reference annual cooling demand** **Q_c**

reference cooling demand to be used as basis for calculation of SEER and calculated as the product of the design load for cooling ($L_{design,c}$) and the equivalent active mode hours for cooling (H_{CE})

Note 1 to entry: Expressed in kWh.

3.69**reference annual heating demand(s)** **Q_h**

reference heating demand for a designated heating season, to be used as basis for calculation of SCOP and calculated as the product of the design load for heating ($L_{design,h}$) and the equivalent active mode hours for heating (H_{HE})

Note 1 to entry: There are three reference heating demands: "A" average, "C" colder and "W" warmer, corresponding to the three reference heating seasons.

Note 2 to entry: Expressed in kWh.

3.70

root-sum-square point total

RSS point total

instantaneous measure of critical parameter variation, the root-sum-square of the points accrued by all overridden critical parameters and applied under controls verification procedure

3.71

seasonal coefficient of performance

SCOP

overall coefficient of performance of the unit, representative for the whole designated heating season

Note 1 to entry: The value of SCOP pertains to a designated heating season. SCOP is calculated as the reference annual heating demand Q_H divided by the annual energy consumption for heating Q_{HE} .

Note 2 to entry: Expressed in kWh/kWh.

3.72

seasonal energy efficiency ratio

SEER

overall energy efficiency ratio of the unit, representative for the whole cooling season

Note 1 to entry: The seasonal energy efficiency ratio is calculated as the reference annual cooling demand Q_C divided by the annual energy consumption for cooling Q_{CE} .

Note 2 to entry: Expressed in kWh/kWh.

3.73

seasonal space cooling energy efficiency

$\eta_{s,c}$

energy efficiency of a space cooling unit while meeting the space cooling demand for the cooling season

Note 1 to entry: Expressed in %.

3.74

seasonal space heating energy efficiency

$\eta_{s,h}$

energy efficiency of a space heater while meeting the space heating demand for a designated heating season

Note 1 to entry: Expressed in %.

3.75

service tool

a manufacturer's service tool for checking system hardware/software, typically available for download from manufacturer's certified installer website or from an authorized representative

3.76

set point bias

difference between desired temperature and the nominal thermostat set point required for the thermostat to control for desired sensed temperature at the sensed location

3.77

set point offset

difference between the temperature indicated by a thermostat's temperature sensor and the actual temperature at the sensor's location

3.78

split system

split system air-conditioner

split system heat pump

refrigerating system, air conditioner, or heat pump incorporating one or more refrigerant circuits, comprising one or more factory-built indoor units providing cooling or heating to the space and one or more factory-built outdoor units

[SOURCE: ISO 5149-1:2014, 3.1.14]

3.78.1

multi-split system

multi-split air-conditioner

multi-split heat pump

split system with at least more than one indoor unit

[SOURCE: ISO 5149-1:2014, 3.1.15]

3.79

stable conditions

balanced operating conditions in the indoor and outdoor section of the test chamber where the test unit is maintaining steady-state conditions and the test chamber is maintaining test room conditions within prescribed tolerances

3.80

standard rating

rating based on tests performed at standard rating conditions

3.81

standard rating conditions

rating conditions used as the basis of comparison for performance characteristics

3.82

standard rating cooling capacity

the capacity of the system when all indoor units and outdoor units are operated in the same mode, in the standard rating cooling test conditions

Note 1 to entry: Expressed in kW.

3.83

standard rating heating capacity

the capacity of the system when all indoor units and outdoor units are operated in the same mode, in the standard rating conditions (high temperature steady state heating and low temperature steady state heating)

Note 1 to entry: Expressed in kW.

3.84

standard rating test

test performed at standard rating conditions

3.85

standby mode

mode wherein the unit is switched off partially and can be reactivated by a control device (such as a remote control), an external signal or a timer

Note 1 to entry: The unit is connected to the mains, depends on signal input to work as intended and provides only the following functions, which may persist for an indefinite time: reactivation function, or reactivation function and only an indication of enabled reactivation function, and/or information or status display.

3.86

standby mode operating hours

H_{SB}

annual number of hours the unit is considered to be in standby 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.

3.87

standby mode power input

P_{SB}

power input of the outdoor unit due to standby mode operation

Note 1 to entry: Expressed in W.

3.88

steady-state test

a test where the controlled test parameters are regulated to remain within the specified tolerances while the unit operates continuously in the same model

3.89

supplemental testing instructions

STI

additional instructions developed by the manufacturer with specifications related to testing of the product

3.90

supplementary heater

heater that generates heat in case the heat load is greater than the declared capacity of the heat pump, using the Joule effect in electric heating elements

3.91

system capacity ratio

ratio of the total stated cooling (heating) capacity of all operating indoor units to the stated cooling or heating capacity of the outdoor unit(s) at the standard rating conditions

3.92

test condition tolerance

maximum tolerance between the average value of the measured test parameter and the specified test condition

3.93

tested combination

arrangement of indoor units and outdoor units that are production units (or for product development purposes are representative of production units) and provides representative performance values

3.94

thermally active

the state of an indoor unit in which it is cooling or heating, as indicated by the digital on/off signal from the service tool or by an electronic expansion valve position indicated by the service tool greater than the minimum position for that valve

3.95

thermally inactive

the state of an indoor unit in which it is not thermally active

3.96

thermostat-off mode

mode corresponding to the hours with no cooling or heating demand of the building, whereby the cooling or heating function of the unit is switched on, but is not operational, as there is no cooling or heating demand

Note 1 to entry: Cycling on/off in active mode is not considered as thermostat-off.

3.97**thermostat-off mode operating hours** **H_{TO}**

annual number of hours the unit is considered to be in thermostat-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.

3.98**thermostat-off mode power input** **P_{TO}**

power input of the outdoor unit due to thermostat-off mode operation

Note 1 to entry: Expressed in W.

3.99**variable capacity units**

central air cooled air conditioner or heat pump that has a compressor that uses a variable speed drive to vary the compressor speed to achieve variable capacities

3.100**variable refrigerant flow system****VRF system**

multi-split direct expansion system consisting of a single outdoor unit or a combination of outdoor units with at least one variable speed compressor connected through a single refrigerant circuit to two or more indoor units that can operate independently via expansion valves

3.101**variable speed compressor**

a compressor varying its rotational speed in multiple steps from low to intermediate to full using an inverter or variable frequency drive

3.102**variable refrigerant flow heat recovery system****VRF heat recovery system**

a VRF system that is capable of providing simultaneous heating and cooling operation, where recovered energy from the indoor units operating in one mode can be transferred to one or more other indoor units operating in the other mode

4 Symbols

Symbol	Description	Unit
C_C	coefficient for electricity generation efficiency	–
C_d	degradation coefficient	–
C_{CSE}	cooling seasonal energy consumption (CSEC)	Wh
C_{HSE}	heating seasonal energy consumption (HSEC)	Wh
C_{IAE}	inactive energy consumption (IAEC)	Wh
$C_{OP}(t)$	heating coefficient of performance (COP) at continuous outdoor temperature t	kW/kW
$C_{OP}(t_j)$	heating coefficient of performance (COP) at outdoor temperature t_j	W/W
$C_{OP,ext}(t_h)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating extended capacity ($COP_{ext}(t_h)$)	W/W
$C_{OP,ext,f}(t_f)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating extended capacity ($COP_{ext,f}(t_f)$)	W/W
$C_{OP,fe}(t_j)$	heating coefficient of performance (COP) in non-frosting variable operation between full and extended capacity at outdoor temperature t_j ($COP_{fe}(t_j)$)	W/W
$C_{OP,fe,f}(t_j)$	heating coefficient of performance (COP) in frosting variable operation between full and extended capacity at outdoor temperature t_j ($COP_{fe,f}(t_j)$)	W/W

Symbol	Description	Unit
$C_{OP,ful}(t_a)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating full capacity ($COP_{ful}(t_a)$)	W/W
$C_{OP,ful,f}(t_g)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating full capacity ($COP_{ful,f}(t_g)$)	W/W
$C_{OP,haf}(t_d)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating half capacity ($COP_{haf}(t_d)$)	W/W
$C_{OP,haf,f}(t_e)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating half capacity ($COP_{haf,f}(t_e)$)	W/W
$C_{OP,hf}(t_j)$	heating coefficient of performance (COP) in non-frosting variable operation between half and full capacity at outdoor temperature t_j ($COP_{hf}(t_j)$)	W/W
$C_{OP,hf,f}(t_j)$	heating coefficient of performance (COP) in frosting variable operation between half and full capacity at outdoor temperature t_j ($COP_{hf,f}(t_j)$)	W/W
$C_{OP,mh}(t_j)$	heating coefficient of performance (COP) in non-frosting variable operation between minimum and half capacity at outdoor temperature t_j ($COP_{mh}(t_j)$)	W/W
$C_{OP,mh,f}(t_j)$	heating coefficient of performance (COP) in frosting variable operation between minimum and half capacity at outdoor temperature t_j ($COP_{mh,f}(t_j)$)	W/W
$C_{OP,min}(t_q)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating minimum capacity ($COP_{min}(t_q)$)	W/W
$C_{OP,min,f}(t_r)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating minimum capacity ($COP_{min,f}(t_r)$)	W/W
$C_{OP,bin}(t_j)$	COP value of the unit for the corresponding bin temperature t_j ($COP_{bin}(t_j)$)	kW/kW
$C_{OP,Carnot}$	theoretical energy efficiency for heating (COP_{Carnot})	K/K
$C_{OP,continuous}$	continuous energy efficiency for heating ($COP_{continuous}$)	kWh/kWh
$C_{OP,cyc}$	cyclic interval efficiency for heating (COP_{cyc})	kWh/kWh
$C_{OP,d}$	coefficient of performance at the declared capacity (COP_d)	kW/kW
$D_{PP,i,\tau}$	absolute parameter percent difference at time τ ($PPD_{i,\tau}$)	%
$e_{lbu}(t_j)$	required capacity of an electric supplementary heater for the corresponding bin temperature t_j ($e_{lbu}(t_j)$)	kW
$E_{ER}(t)$	energy efficiency ratio (EER) at continuous outdoor temperature t	kW/kW
$E_{ER}(t_j)$	energy efficiency ratio (EER) at outdoor temperature t_j	W/W
$E_{ER,adj}$	adjusted energy efficiency ratio (EER_{adj}) derived from the adjusted sensible cooling capacity	kW/kW
$E_{ER,bin}(t_j)$	energy efficiency ratio (EER) value of the unit for the corresponding bin temperature t_j ($EER_{bin}(t_j)$)	kW/kW
$E_{ER,Carnot}$	theoretical energy efficiency for cooling (EER_{Carnot})	K/K
$E_{ER,continuous}$	continuous energy efficiency for cooling ($EER_{continuous}$)	kWh/kWh
$E_{ER,cyc}$	cycling interval efficiency for cooling (EER_{cyc})	kWh/kWh
$E_{ER,d}$	energy efficiency ratio (EER) at the declared capacity (EER_d)	kW/kW
$E_{ER,ful}(t_b)$	energy efficiency ratio (EER) when cooling load is equal to cooling full capacity ($EER_{ful}(t_b)$)	W/W
$E_{ER,haf}(t_c)$	energy efficiency ratio (EER) when cooling load is equal to cooling half capacity ($EER_{haf}(t_c)$)	W/W
$E_{ER,hf}(t_j)$	energy efficiency ratio (EER) in variable operation between half and full capacity at outdoor temperature t_j ($EER_{hf}(t_j)$)	W/W
$E_{ER,mh}(t_j)$	energy efficiency ratio (EER) in variable operation between minimum and half capacity at outdoor temperature t_j ($EER_{mh}(t_j)$)	W/W
$E_{ER,min}(t_p)$	energy efficiency ratio (EER) when cooling load is equal to cooling minimum capacity ($EER_{min}(t_p)$)	W/W
$\dot{E}_{tot}$	total power input	kW
$f_{\eta,ex}(t)$	correction factor for part load operation	–
F	correction that accounts for a negative contribution to the seasonal space heating energy efficiency of heaters due to adjusted contributions of temperature controls	%

Symbol	Description	Unit
F_{AP}	annual performance factor (APF)	–
F_{CSP}	cooling seasonal performance factor (CSPF)	–
F_{HSP}	heating seasonal performance factor (HSPF)	–
F_{TAP}	total annual performance factor (TAPF)	–
F_{TCSP}	total cooling seasonal performance factor (TCSPF)	–
F_{THSP}	total heating seasonal performance factor (THSPF)	–
$F_{PL}(t_j)$	part load factor (PLF) at outdoor temperature t_j	–
F_L	fractional ON time for last stage at the load point under test, load factor (LF)	–
H_{ia}	number of hours of inactive mode	h
H_{CE}	number of equivalent active mode hours for cooling	h
H_{CK}	numbers of hours the unit is considered to work in crankcase heater mode	h
H_{HE}	number of equivalent active mode hours for heating	h
H_{OFF}	numbers of hours the unit is considered to work in off mode	h
H_{SB}	numbers of hours the unit is considered to work in standby mode	h
H_{TO}	numbers of hours the unit is considered to work in thermostat-off mode	h
I_{EER}	integrated energy efficiency ratio (IEER)	–
L_{CST}	cooling seasonal total load (CSTL)	Wh
L_{HST}	heating seasonal total load (HSTL)	Wh
$L_c(t_j)$	defined cooling load at outdoor temperature t_j	W or kW
$L_h(t_j)$	defined heating load at outdoor temperature t_j	W or kW
$L_{design,c}$	design cooling load of the building the unit is suitable for as declared by the manufacturer	kW
$L_{design,h}$	design heating load of the building the unit is suitable for as declared by the manufacturer	kW
$L_{required,c}$	required system cooling load at part load ratio	kW
$L_{required,h}$	required system heating load at part load ratio	kW
n_j	bin hours	h
k, p, n, m, j	number of temperature bins	–
$p_{e,std}$	static pressure difference for ducted units in standard air conditions as declared by the manufacturer	Pa
$p_{e,test}$	available external static pressure difference at testing	Pa
$P(t)$	cooling or heating power input calculated by equation of $P(t_j)$ at continuous outdoor temperature t	W
$P(t_j)$	cooling or heating power input applicable to any capacity at outdoor temperature t_j	W
P_C	compressor power at the lowest machine unloading point operating at the part-load rating condition under test	W
P_{CD}	condenser section power, if applicable at the part-load rating condition under test — for air-source heat pumps this is the power of the fan(s) and compressor(s)	W
P_{CK}	power inputs during crankcase heater mode	kW
P_{CT}	control circuit power and any auxiliary loads	W
$P_{elec,c}(t)$	electrical consumption of the system in cooling mode	kW
$P_{elec,h}(t)$	electrical consumption of the system in heating mode	kW
$P_{elec,c,IU}(t)$	electrical consumption of the indoor unit in cooling mode	kW
$P_{elec,h,IU}(t)$	electrical consumption of the indoor unit in heating mode	kW
$P_{ext}(t_j)$	non-frosting range heating extended power input at outdoor temperature t_j	W
$P_{ext,f}(t_j)$	frosting range heating extended power input at outdoor temperature t_j	W
$P_{fe}(t_j)$	heating power input in variable operation between full and extended capacity at outdoor temperature t_j	W

Symbol	Description	Unit
$P_{\text{ful}}(t_j)$	cooling full power input at outdoor temperature t_j or non-frosting range heating full power input at outdoor temperature t_j	W
$P_{\text{ful,f}}(t_j)$	frosting range heating full power input at outdoor temperature t_j	W
$P_{\text{haf}}(t_j)$	cooling half power input at outdoor temperature t_j or non-frosting range heating half power input at outdoor temperature t_j	W
$P_{\text{haf,f}}(t_j)$	frosting range heating half power input at outdoor temperature t_j	W
$P_{\text{hf}}(t_j)$	cooling power input in variable operation between half and full capacity at outdoor temperature t_j or heating power input in variable operation between half and full capacity at outdoor temperature t_j	W
$P_{\text{mh}}(t_j)$	cooling power input in variable operation between minimum and half capacity at outdoor temperature t_j or heating power input in variable operation between minimum and half capacity at outdoor temperature t_j	W
$P_{\text{min}}(t_j)$	cooling minimum power input at outdoor temperature t_j or heating minimum power input at outdoor temperature t_j	W
$P_{\text{min,f}}(t_j)$	frosting range heating minimum power input at outdoor temperature t_j	W
P_{OFF}	power inputs during off mode	kW
$P_{\text{RH}}(t_j)$	make-up heating energy at outdoor temperature t_j	Wh
P_{IF}	indoor fan power	W
P_{SB}	power inputs during standby mode	kW
P_{TO}	power inputs during thermostat-off mode	kW
P_{ia}	weighted average power consumption	W
$q_{\text{v,declared}}$	declared air volume flow rate	m ³ /h
$q_{\text{v,test}}$	air volume flow rate at testing	m ³ /h
Q_{C}	reference annual heating demand	kWh
Q_{CE}	annual energy consumption for heating	kWh
Q_{H}	reference annual heating demand	kWh
Q_{HE}	annual energy consumption for heating	kWh
R_{C}	capacity ratio	–
R_{PL}	part load ratio	%
$R_{\text{PL,required}}$	building required part load ratio	%
$R_{\text{PL,required,c}}$	building required part load ratio in cooling	%
$R_{\text{PL,required,h}}$	building required part load ratio in heating	%
$R_{\text{PL,system,c}}$	part load ratio of the system in cooling	%
$R_{\text{PL,system,h}}$	part load ratio of the system in heating	%
S_{COP}	seasonal coefficient of performance (SCOP)	kWh/kWh
$S_{\text{COP,net}}$	net seasonal coefficient of performance (SCOP _{net})	kWh/kWh
$S_{\text{COP,on}}$	active mode seasonal coefficient of performance (SCOP _{on})	kWh/kWh
S_{EER}	seasonal energy efficiency ratio (SEER)	kWh/kWh
$S_{\text{EER,on}}$	active mode seasonal energy efficiency ratio (SEER _{on})	kWh/kWh
$S_{\text{HR,req}}$	required sensible heat ratio (SHR _{req})	–
t_{biv}	bivalent temperature	°C

Symbol	Description	Unit
t_{cond}	condensation temperature of the refrigerant	°C
$t_{design,c}$	reference design temperature for cooling	°C
$t_{design,h}$	reference design temperature for heating	°C
t_{evap}	evaporation temperature of the refrigerant	°C
t_j	outdoor temperature corresponding to each temperature bin	°C
$t_{measured,\tau}$	measured indoor room temperature at time τ	°C
$t_{target,\tau}$	target indoor room dry bulb temperature at time τ	°C
t_{out}	outdoor ambient temperature	°C
$t_{WB,room}$	wet bulb room air temperature	°C
$t_{DB,room}$	dry bulb room air temperature	°C
t	general continuous outdoor temperature	°C
t_0	0 % load outdoor temperature	°C
t_{100}	100 % load outdoor temperature	°C
t_a	outdoor temperature when heating load is equal to non-frosting range heating full capacity	°C
t_b	outdoor temperature when cooling load is equal to cooling full capacity	°C
t_c	outdoor temperature when cooling load is equal to cooling half capacity	°C
t_d	outdoor temperature when heating load is equal to non-frosting range heating half capacity	°C
t_e	outdoor temperature when heating load is equal to frosting range heating half capacity	°C
t_f	outdoor temperature when heating load is equal to frosting range heating extended capacity	°C
t_g	outdoor temperature when heating load is equal to frosting range heating full capacity	°C
t_h	outdoor temperature when heating load is equal to non-frosting range heating extended capacity	°C
t_p	outdoor temperature when cooling load is equal to cooling minimum capacity	°C
t_q	outdoor temperature when heating load is equal to non-frosting range heating minimum capacity	°C
t_r	outdoor temperature when heating load is equal to frosting range heating minimum capacity	°C
$v_{NP,i}$	nominal point value for critical parameter i	–
$v_{CP,i,\tau}$	average value across all instances of critical parameter as measured during the CVP at time τ ($CP_{i,\tau}$)	–
$v_{CP,max}$	maximum value for critical parameter as measured during a CVP conducted at 100 % load conditions (CP_{max})	–
$v_{CP,STI,i}$	average value across all instances of critical parameter as reported in the STI for the corresponding load point ($CP_{STI,i}$)	–
V_{NC}	normalized coil volume	m ³ /kW
$X(t_j)$	ratio of load to capacity at outdoor temperature t_j	–
$Z_{i,\tau}$	accumulated point for a critical parameter i at time τ ($Points_{i,\tau}$)	–
$Z_{RSS,\tau}$	root-sum-square point total at time τ	–
α_D	heat exchanger (coil) depth	m
α_L	heat exchanger (coil) length	m
α_W	heat exchanger (coil) width	m
$\% \Delta t$	dry bulb temperature change for the indoor coil from the first 5 min of the data collection period	%
$\Delta t_i(\tau)$	difference between the dry bulb temperature of the air leaving and entering the indoor coil at time τ .	K
η	fan's efficiency declared by the fan's manufacturer	%
η_{ex}	exergy efficiency	%

Symbol	Description	Unit
$\eta_{s,c}$	seasonal space cooling efficiency	%
$\eta_{s,h}$	seasonal space heating efficiency	%
ρ_{std}	density of standard air (20 °C (dry bulb), 15 °C (wet bulb), 101 325 Pa)	kg/m ³
ρ_{test}	density at the actual atmospheric conditions at the measuring point of the air flow rate	kg/m ³
$\tau_{27,8}$	the time at which the measured indoor room dry bulb temperature first crosses from above 27,8 °C to below 27,8 °C	h
τ_{OFF}	the time when any indoor unit that was designated thermally active at the start of the CVP goes thermally inactive	h
$\phi_{ext}(t_j)$	non-frosting range heating extended capacity at outdoor temperature t_j	W
$\phi_{ext,f}(t_j)$	frosting range heating extended capacity at outdoor temperature t_j	W
$\phi_{ful}(t_j)$	cooling full capacity at outdoor temperature t_j or non-frosting range heating full capacity at outdoor temperature t_j	W
$\phi_{ful,f}(t_j)$	frosting range heating full capacity at outdoor temperature t_j	W
$\phi_{haf}(t_j)$	cooling half capacity at outdoor temperature t_j or non-frosting range heating half capacity at outdoor temperature t_j	W
$\phi_{haf,f}(t_j)$	frosting range heating half capacity at outdoor temperature t_j	W
$\phi_{min}(t_j)$	cooling minimum capacity at outdoor temperature t_j or non-frosting range heating minimum capacity at outdoor temperature t_j	W
$\phi_{min,f}(t_j)$	frosting range heating minimum capacity at outdoor temperature t_j	W
$\phi_{continuous}$	time averaged heating or cooling capacity that would have been delivered by the unit	kW
ϕ_{cyc}	averaged heating capacity during cycling	kW
ϕ_{dc}	declared capacity in cooling mode	kW
ϕ_{dh}	declared capacity in heating mode	kW
$\phi_{system,c}$	calculated system cooling capacity at part load ratio	kW
$\phi_{system,h}$	calculated system heating capacity at part load ratio	kW
$\phi_{sens,adj}$	adjusted sensible cooling capacity	kW
ϕ_{latent}	latent cooling capacity	kW
ϕ_{nom}	nominal indoor cooling capacity	kW
ϕ_{FULL}	full load net capacity	kW
ϕ_{PL}	part load net capacity	kW

5 Cooling mode

5.1 Test

5.1.1 General

The test settings and methods conform to ISO 15042:2017/Amd 1:2020 except those specified in this clause. The accuracy of the instruments used for tests shall conform to [clause 7](#) in this standard.

5.1.2 Test requirements

5.1.2.1 General

The length of piping between indoor and outdoor units shall be determined by manufacturer's specifications, but not less than 7,5 m.

Options for the piping length are specified in [Annex I](#).

Indoor units of the same capacity shall be taken to reach a system capacity ratio of 100 % ± 5 % based on the cooling mode.

The airflow for indoor units shall not exceed 275 m³/h/kW based on the rated cooling capacity, i.e. under full load. The air flow rate setting shall be based on the measured air flow rate with dry heat exchanger and standard air conditions. The same airflow rate setting shall be applied at all part load points. The airflow rate limit shall apply to each indoor unit individually.

The setting and measurement of the airflow rate shall be conducted as described in [Annex K](#).

The total indoor unit power shall be measured during the test. Unless stated otherwise elsewhere in the standard, such as [Annexes D, E and F](#), this total indoor unit power shall be included in the declared power input and in the calculation of efficiencies. Individual indoor unit power shall also be measured and declared separately. If identical indoor units are used during testing, the indoor unit power measurement shall be taken collectively for such indoor units and divided by the total number of the identical indoor units. Standard ratings of capacities shall include the effects of circulating-fan heat, but shall not include supplementary heat.

5.1.2.2 Capacity correction due to indoor fan power input

5.1.2.2.1 General

Based on national deviations a capacity correction due to indoor fan for ducted indoor units can be applied.

The capacity shall include the correction due to the heat output of the indoor fan, integrated into the unit as follows.

5.1.2.2.2 Capacity correction due to indoor fan for non-ducted units

In the case of units which are not designed for duct connection, i.e. which do not permit any external pressure difference, and which are equipped with an integral fan, no capacity correction due to heat provided by the fan shall apply.

5.1.2.2.3 Capacity correction due to indoor fan for ducted units

The power input correction of the fan, as calculated with [Formula \(1\)](#) shall be:

- subtracted from the measured heating capacity;
- added to the measured cooling capacity.

$$\frac{q_{v, \text{test}} \times p_{e, \text{test}}}{\eta} \quad (1)$$

where

$q_{v, \text{test}}$ is the air volume flow rate, expressed in m³/s and set according to [Annex K](#);

$p_{e, \text{test}}$ is the available external static pressure difference, expressed in Pa;

η is equal to fan's efficiency declared by the fan's manufacturer;

5.1.3 Temperature and humidity condition

Temperature and humidity conditions as well as default values for calculation shall be as specified in [Table 1](#) or [Table 3](#) for moderate climate condition, or [Table 2](#) for high ambient temperature regions.

[Table 1](#) and [Table 2](#) are the test conditions for CSPF, and [Table 3](#) is the test conditions for IEER and SEER.

Table 1 — Temperature and humidity conditions and default values for cooling at T1 moderate climate condition of ISO 15042:2017/Amd 1:2020

Test	Characteristics	Variable	Default value
Standard cooling capacity Indoor DB/WB 27 °C /19 °C Outdoor DB/WB 35 °C /24 °C	Full capacity ϕ_{ful} (35) Full power input P_{ful} (35)	•	
	Half capacity ϕ_{haf} (35) Half power input P_{haf} (35)	•	
	Minimum capacity ϕ_{min} (35) Minimum power input P_{min} (35)	◦	$\phi_{\text{min}} (29) /1,077$ $P_{\text{min}} (29) /0,914$
	Low temperature cooling capacity Indoor DB/WB 27 °C /19 °C Outdoor DB/WB 29 °C /19 °C	Full capacity ϕ_{ful} (29) Full power input P_{ful} (29)	-
	Half capacity ϕ_{haf} (29) Half power input P_{haf} (29)	◦	$1,077 \times \phi_{\text{haf}} (35)$ $0,914 \times P_{\text{haf}} (35)$
	Minimum capacity ϕ_{min} (29) Minimum power input P_{min} (29)	◦	-
Test frequency ^a	Rated frequency		
Test voltage	See Table 4		
• required test; ◦ optional test; NOTE If the minimum capacity test is measured, min(29) test is conducted first. Min(35) test may be measured or may be calculated by using default value. ^a Equipment with dual-rated frequencies shall be tested at each frequency.			

Table 2 — Temperature and humidity conditions and default values for cooling at T3 hot climate condition of ISO 15042:2017/Amd 1:2020

Test	Characteristics	Variable	Default value
Standard cooling capacity Indoor DB/WB 29 °C /19 °C Outdoor DB/WB 46 °C /24 °C	Full capacity ϕ_{ful} (46) Full power input P_{ful} (46)	•	—
	Half capacity ϕ_{haf} (46) Half power input P_{haf} (46)	◦	$0,859 \times \phi_{\text{haf}}$ (35) $1,25 \times P_{\text{haf}}$ (35)
	Minimum capacity ϕ_{min} (46) Minimum power input P_{min} (46)	◦	$0,859 \times \phi_{\text{min}}$ (35) $1,25 \times P_{\text{min}}$ (35)
Medium cooling capacity test Indoor DB/WB 27 °C /19 °C Outdoor DB/WB 35 °C /24 °C	Full capacity ϕ_{ful} (35) Full power input P_{ful} (35)	•	—
	Half capacity ϕ_{haf} (35) Half power input P_{haf} (35)	•	—
	Minimum capacity ϕ_{min} (35) Minimum power input P_{min} (35)	◦	—
Low cooling capacity test Indoor DB/WB 27 °C /19 °C Outdoor DB/WB 29 °C /19 °C	Full capacity ϕ_{ful} (29) Full power input P_{ful} (29)	—	$1,077 \times \phi_{\text{ful}}$ (35) $0,914 \times P_{\text{ful}}$ (35)
	Half capacity ϕ_{haf} (29) Half power input P_{haf} (29)	◦	$1,077 \times \phi_{\text{haf}}$ (35) $0,914 \times P_{\text{haf}}$ (35)
	Minimum capacity ϕ_{min} (29) Minimum power input P_{min} (29)	◦	$1,077 \times \phi_{\text{min}}$ (35) $0,914 \times P_{\text{min}}$ (35)
Test frequency ^a	Rated frequency		
Test voltage	See Table 4		
• required test; ◦ optional test; NOTE If the minimum capacity test is measured, min(35) test is conducted first. Min(29) and min(46) tests may be measured or may be calculated by using default value. ^a Equipment with dual-rated frequencies shall be tested at each frequency.			

Table 3 — Temperature and humidity conditions and default values for cooling for IEER and SEER

Parameter	Standard rating conditions IEER	Standard rating conditions SEER
Temperature of air entering indoor-side: — dry-bulb — wet-bulb	26,7 °C 19,4 °C	27 °C 19 °C
Temperature of air entering outdoor-side — dry-bulb (part load ratio) — wet-bulb	35 °C (100 %) 27,5 °C (75 %) 20 °C (50 %) 18,3 °C (25 %) (None)	$t_{\text{out}} \text{ °C } ((t_{\text{out}}-16)/(t_{\text{design,c}}-16) \text{ \%})$ 35 °C (100,00 % ^a) - A 30 °C (73,68 % ^a) - B 25 °C (47,37 % ^a) - C 20 °C (21,05 % ^a) - D (None)
Test frequency ^b	Rated frequency	
Test voltage	See Table 4	
^a Part load ratio is a fraction of $L_{\text{design,c}}$. $L_{\text{design,c}}$ is load declared by the manufacturer at $t_{\text{design,c}}$ (35 °C) condition. The part load ratio is calculated as the bin temperature minus 16 °C divided by the reference design temperature minus 16 °C.		
^b Equipment with dual-rated frequencies shall be tested at each frequency.		

Table 4 — Voltages for capacity and performance tests (except maximum cooling)

Rated (nameplate) voltages ^a V	Test voltage ^b V
90 to 109	100
110 to 127	115
180 to 207	200
208 to 253	230
254 to 341	265
342 to 420	400
421 to 506	460
507 to 633	575

^a For equipment with dual-rated voltages such as 115/230 and 220/440, the test voltages would be 115 V and 230 V in the first example, and 230 V and 460 V in the second example. For equipment with an extended voltage range, such as 110 V to 120 V or 220 V to 240 V, the test voltage would be 115 V or 230 V, respectively. Where the extended voltage range spans two or more of the rated voltage ranges, the mean of the rated voltages shall be used to determine the test voltage from the table.

EXAMPLE For equipment with an extended voltage range of 200 V to 220 V, the test voltage would be 230 V, based on the mean voltage of 210 V.

^b The voltages in this table are for capacity and performance tests other than the maximum cooling and maximum heating performance tests.

5.1.4 Test conditions

5.1.4.1 Preconditions

The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained. Equilibrium conditions by [clause 7.3](#) shall be maintained for not less than 60 minutes before capacity test data are recorded.

5.1.4.2 Testing requirements

The test capacity shall include the determination of the sensible, latent and total cooling capacity as determined on the indoor-side.

5.1.4.3 Duration of test

The data shall be recorded at equal intervals that span 30 seconds or less. The recording of the data shall continue for at least a 35 min period during which the tolerances specified in [7.3](#) shall be met.

5.1.5 Test methods

The test method shall be in accordance with this clause, [Clause 7](#) and any additional requirements as specified in:

- [Annex G](#) for the tests of CSPF, or
- [Annex D](#) for the tests of IEER, or
- [Annex E](#) for the tests of SEER

The cooling capacity and effective power input shall be measured during the full load and part load capacity tests.

The specific setting that is needed to give full-load and part load capacities shall be set and the equipment shall be maintained at those settings. The manufacturer shall provide information on how to set the capacity if requested by the testing laboratories.

If the equipment cannot be maintained at steady-state conditions by its normal controls, then the manufacturer can modify or override such controls so that steady-state conditions are achieved.

System parameters during performance testing shall be part of the normal control operation.

As required, the controls verification procedure (CVP) shall be used to verify the operation of the unit under test, using either:

- [Annex M](#) - one critical parameter, i.e. compressor(s) frequency or,
- [Annex N](#) - three critical parameters, i.e. compressor(s) frequency, outdoor fan speed(s) and outdoor variable valve position(s).

For the 50 % or less part load tests, at least half of the total indoor units, as calculated per the total capacity of the connected indoor units, can remain thermally inactive. The laboratory shall prevent forced air circulation through any indoor unit that is thermally inactive (e.g. block the inlet and outlet). For the indoor unit(s) that are thermally inactive, the indoor unit control settings (e.g., using remote or wireless thermostat) shall be set to "OFF".

5.1.6 Cooling capacity test results

5.1.6.1 The electrical energy supplied to the heat pump during the applicable test period specified in [5.1.4.3](#) shall be measured along with the corresponding elapsed time, in minutes, of the test period.

5.1.6.2 Average cooling capacity and average electrical power input shall be calculated in accordance with [5.1.6.3](#) and [5.1.6.4](#)

5.1.6.3 An average cooling capacity shall be determined from the set of cooling capacities recorded over a data collection period in accordance with [5.1.4.3](#).

5.1.6.4 An average electrical power input shall be determined from the set of electrical power inputs recorded over the data collection period in accordance with [5.1.4.3](#) or from the integrated electrical power for the same interval in cases where an electrical energy meter is used.

The test shall be conducted with the equipment functioning at full-load operation, as defined in 3.20 of ISO 15042:2017/Amd 1:2020

Standard ratings of capacities shall include the effects of circulating-fan heat.

5.2 Calculations

The cooling seasonal performance evaluation shall be at least one of:

- cooling seasonal performance factor (CSPF),
- integrated energy efficiency ratio (IEER), or
- seasonal energy efficiency ratio (SEER).

CSPF shall be calculated according to [Annex A](#) or [Annex B](#) for hot climates, IEER shall be calculated according to [Annex D](#), and SEER shall be calculated according to [Annex E](#).

6 Heating mode

6.1 Test

6.1.1 General

The test setting and methods conform to ISO 15042:2017/Amd 1:2020 except those specified in this clause.

The accuracy of the instruments used for tests shall conform to [clause 7](#).

6.1.2 Test requirements

6.1.2.1 General

The length of piping between indoor and outdoor units shall be determined by manufacturer's specifications, but not less than 7,5 m.

Options for the piping length are specified in [Annex I](#).

Indoor units of the same capacity shall be taken to reach:

- a system capacity ratio of 100 % $\pm$ 5 % based on the cooling mode for reversible units;
- a system capacity ratio in heating of 100 % $\pm$ 5 % based on the heating mode for heating only units.

The airflow for indoor units shall not exceed the airflow limitation according to the [clause 5.1.2](#). If cooling mode is not applicable, the air flow rate shall not exceed 275 m³/h/kW based on rated heating capacity. The air flow rate setting shall be based on the measured air flow rate with dry heat exchanger and standard air conditions. The same airflow rate setting shall be applied at all part load points. The airflow rate limit shall apply to each indoor unit individually.

The setting and measurement of the airflow rate shall be conducted as described in [Annex K](#).

The total indoor unit power shall be measured during the test. Unless stated otherwise elsewhere in the standard, such as [Annexes D, E and F](#), this total indoor unit power shall be included in the declared power input and in the calculation of efficiencies. Individual indoor unit power shall also be measured and declared separately. If identical indoor units are used during testing, the indoor unit power measurement shall be taken collectively for such indoor units and divided by the total number of the identical indoor units. Standard ratings of capacities shall include the effects of circulating-fan heat, but shall not include supplementary heat.

6.1.2.2 Capacity correction due to indoor fan power input

Based on national deviations a capacity correction due to indoor fan for ducted indoor units can be applied for heating mode, as specified in [clause 5.1.2.2](#).

6.1.3 Temperature conditions

Temperature and humidity conditions as well as default values for calculation shall be as specified in [Table 5](#) or [Table 6](#).

[Table 5](#) is the test conditions for HSPF and [Table 6](#) is the test conditions for SCOP.

Table 5 — Temperature and humidity conditions and default values for heating at H1 moderate cold condition of ISO 15042:2017/Amd 1:2020

Test	Characteristics	Variable	Default value
Standard heating capacity Indoor DB/WB 20 °C /15 °C Max. Outdoor DB/WB 7 °C /6 °C	Full capacity $\phi_{\text{ful}} (7)$ Full power input $P_{\text{ful}} (7)$	•	
	Half capacity $\phi_{\text{haf}} (7)$ Half power input $P_{\text{haf}} (7)$	•	
	Minimum capacity $\phi_{\text{min}} (7)$ Minimum power input $P_{\text{min}} (7)$	◦	
Low temperature heating capacity Indoor DB/WB 20 °C /15 °C Max. Outdoor DB/WB 2 °C /1 °C	Extended capacity $\phi_{\text{ext},f} (2)$ Extended power input $P_{\text{ext},f} (2)$	• ^a	
	Calculated extended capacity $\phi_{\text{ext}} (2)$ Calculated extended power input $P_{\text{ext}} (2)$	b	$1,12 \times \phi_{\text{ext},f} (2)$ $1,06 \times P_{\text{ext},f} (2)$
	Full capacity $\phi_{\text{ful},f} (2)$ Full power input $P_{\text{ful},f} (2)$	■ ^{a,c}	$\phi_{\text{ful}} (2) / 1,12^{\text{d}}$ $P_{\text{ful}} (2) / 1,06^{\text{d}}$
	Half capacity $\phi_{\text{haf},f} (2)$ Half power input $P_{\text{haf},f} (2)$	◦ ^c	$\phi_{\text{haf}} (2) / 1,12^{\text{d}}$ $P_{\text{haf}} (2) / 1,06^{\text{d}}$
	Minimum capacity $\phi_{\text{min},f} (2)$ Minimum power input $P_{\text{min},f} (2)$	—	$\phi_{\text{min}} (2) / 1,12^{\text{d}}$ $P_{\text{min}} (2) / 1,06^{\text{d}}$
Extra-low temperature heating capacity Indoor DB/WB 20 °C /15 °C Max. Outdoor DB/WB -7 °C /-8 °C	Extended capacity $\phi_{\text{ext}} (-7)$ Extended power input $P_{\text{ext}} (-7)$	◦	$0,734 \times \phi_{\text{ext}} (2)$ $0,877 \times P_{\text{ext}} (2)$
	Full capacity $\phi_{\text{ful},f} (-7)$ Full power input $P_{\text{ful},f} (-7)$	◦	$0,64 \times \phi_{\text{ful}} (7)$ $0,82 \times P_{\text{ful}} (7)$
	Half capacity $\phi_{\text{haf},f} (-7)$ Half power input $P_{\text{haf},f} (-7)$	◦	$0,64 \times \phi_{\text{haf}} (7)$ $0,82 \times P_{\text{haf}} (7)$
	Minimum capacity $\phi_{\text{min},f} (-7)$ Minimum power input $P_{\text{min},f} (-7)$	—	$0,64 \times \phi_{\text{min}} (7)$ $0,82 \times P_{\text{min}} (7)$
Test frequency ^e	Rated frequency		
Test voltage	See Table 4		
• required test; ◦ optional test; ■ test required when there is not an extended mode; ^a When the equipment has an extended mode, low temperature extended capacity measurement is mandatory and low temperature full capacity measurement is optional. When the equipment does not have an extended mode, low temperature full capacity measurement is mandatory. ^b This value shall be calculated using default value. ^c When this value is measured, $\phi_{\text{x}} (2)$ and/or $P_{\text{x}} (2)$ shall not be calculated from this value, but the equations in foot NOTE d shall be used instead. ^d The following two equations apply to the full capacity, half capacity and minimum capacity data when $\phi_{\text{x},f} (2)$ and $P_{\text{x},f} (2)$ are calculated: $\phi_{\text{x}} (2) = \phi_{\text{x}} (-7) + \frac{\phi_{\text{x}} (7) - \phi_{\text{x}} (-7)}{7 - (-7)} \times (2 - (-7)), P_{\text{x}} (2) = P_{\text{x}} (-7) + \frac{P_{\text{x}} (7) - P_{\text{x}} (-7)}{7 - (-7)} \times (2 - (-7))$ ^e Equipment with dual-rated frequencies shall be tested at each frequency.			

Table 6 — Temperature and humidity conditions for heating

Parameter	SCOP			COP _H and COP _L	
Temperature of air entering indoor-side:					
— dry-bulb	20 °C			21 °C	
— wet-bulb	15 °C			15,5 °C (maximum)	
Temperature of air entering outdoor-side ^f :	Average climate	Warmer climate	Colder climate	COP _H	COP _L
	$t_{\text{design,h}} = -10\text{ °C}$	$t_{\text{design,h}} = 2\text{ °C}$	$t_{\text{design,h}} = -22\text{ °C}$		
— dry-bulb/wet-bulb (part load ratio)	-7 °C /-8 °C - A(88,46 % ^a) 2 °C /1 °C - B(53,85 % ^a) 7 °C /6 °C - C(34,62 % ^a) 12 °C /11 °C - D(15,38 % ^a) TOL ^b - E t_{biv} ^c - F n.a. - G	n.a. - A 2 °C /1 °C - B(100,00 % ^a) 7 °C /6 °C - C(64,29 % ^a) 12 °C /11 °C - D(28,57 % ^a) TOL ^b - E t_{biv} ^c - F n.a. - G	-7 °C /-8 °C - A(60,53 % ^a) 2 °C /1 °C - B(36,84 % ^a) 7 °C /6 °C - C(23,68 % ^a) 12 °C /11 °C - D(10,53 % ^a) TOL ^b - E t_{biv} ^c - F -15(81,58 % ^a) - G ^d	8,3 °C /6 °C (100 %)	-8,3 °C /-9,4 °C (100 %)
Test frequency ^e	Rated frequency				
Test voltage	See Table 4				
^a Part load ratio is a fraction of $L_{\text{design,h}}$. $L_{\text{design,h}}$ is load declared by the manufacturer at $t_{\text{design,h}}$.					
^b For heat pumps, the relevant <i>TOL</i> is defined as follows: — Average climate: the dry bulb temperature is -7 °C or lower; — Colder climate: the dry bulb temperature is -15 °C or lower; — Warmer climate: the dry bulb temperature is +2 °C or lower. Part load ratio shall be calculated by $(\text{TOL} - 16)/(t_{\text{design,h}} - 16)$. If $\text{TOL} < t_{\text{design,h}}$ then <i>TOL</i> shall be replaced by $t_{\text{design,h}}$.					
^c The relevant t_{biv} is defined as follows: — Average climate: the dry bulb temperature is +2 °C or lower; — Colder climate: the dry bulb temperature is -7 °C or lower; — Warmer climate: the dry bulb temperature is +7 °C or lower. Part load ratio shall be calculated by $(t_{\text{biv}} - 16)/(t_{\text{design,h}} - 16)$.					
^d In case of colder climate and if TOL is below -20 °C, an additional part load condition G at -15 °C shall be applied.					
^e Equipment with dual-rated frequencies shall be tested at each frequency.					
^f Where maximum operating conditions test is required, it shall be performed under 23,8 °C /18,3 °C (DB/WB) air temperature of air entering outdoor side or as specified in subclauses 6.2 and 7.2 of ISO 15042:2017/Amd 1:2022.					
n.a. means not applicable					

6.1.4 Test conditions

6.1.4.1 Defrost operations

6.1.4.1.1 Overriding of automatic defrost controls shall be prohibited. The controls may only be overridden when manually initiating a defrost cycle during preconditioning.

6.1.4.1.2 Any defrost cycle, whether automatically or manually initiated, that occurs while preparing for or conducting a heating capacity test, shall always be automatically terminated by the action of the heat pump's defrost controls.

6.1.4.1.3 If the heat pump turns the indoor fan off during the defrost cycle, airflow through the indoor coil shall cease.

Defrost controls are explained in [Annex T](#).

6.1.4.2 Test procedure — General

6.1.4.2.1 The test procedure consists of three periods: a preconditioning period, an equilibrium period and a data collection period. The duration of the data collection period differs depending on whether the heat pump's operation is steady-state or transient.

6.1.4.2.2 Annex P of ISO 15042:2017/Amd 1:2020 pictorially represents most of the different test sequences which are possible when conducting a heating capacity test.

6.1.4.3 Preconditioning period

6.1.4.3.1 The test room preconditioning apparatus and the heat pump under test shall be operated until the test tolerances specified in [7.2](#) are attained for at least 10 min.

6.1.4.3.2 A defrost cycle may end a preconditioning period. If a defrost cycle does end a preconditioning period, the heat pump shall operate in the heating mode for at least 10 min after defrost termination prior to beginning the equilibrium period.

6.1.4.3.3 It is recommended that the preconditioning period ends with an automatic or manually induced defrost cycle.

6.1.4.4 Equilibrium period

6.1.4.4.1 The equilibrium period immediately follows the preconditioning period. During an equilibrium period of 60 min, the equipment under test shall operate while meeting the tolerances specified in Table 13 of ISO 15042:2017/Amd 1:2020.

6.1.4.4.2 Except as specified in [6.1.4.8.3](#), the heat pump shall operate while meeting the [7.2](#) test tolerances.

6.1.4.5 Data collection period

6.1.4.5.1 The data collection period immediately follows the equilibrium period.

6.1.4.5.2 Heating capacity shall be calculated as specified in Annex E of ISO 15042:2017/Amd 1:2020. For cases where one of the confirmative test methods of 9.1.3.1 a) and b) of ISO 15042:2017/Amd 1:2020 is used, heating capacity shall be calculated as specified in Annex I and Annex J of ISO 15042:2017/Amd 1:2020.

6.1.4.5.3 An integrating electrical power (watt-hour) meter or measuring system shall be used for measuring the electrical energy supplied to the equipment. During defrost cycles and for the first 10 min following a defrost termination, the meter or measuring system shall have a sampling rate of at least every 10 s.

6.1.4.5.4 Except as specified in [6.1.4.5.3](#) and [6.1.4.5.5](#), data shall be sampled at equal intervals that span 30 s or less.

6.1.4.5.5 During defrost cycles, plus the first 10 min following defrost termination, certain data used in evaluating the integrated heating capacity of the heat pump shall be sampled at equal intervals that span 10 s or less. These more frequently sampled data include the change in indoor-side dry-bulb temperature.

6.1.4.5.6 For heat pumps that automatically cycle off the indoor fan during a defrost, the contribution of the net heating delivered and/or the change in indoor-side dry-bulb temperature shall be assigned the value of zero when the indoor fan is off.

6.1.4.5.7 The difference between the dry bulb temperature of the air leaving and entering the indoor coil shall be measured. For each 5 min interval during the data collection period, an average temperature difference shall be calculated, $\Delta t_i(\tau)$. The average temperature difference for the first 5 min of the data collection period, $\Delta t_i(\tau = 0)$, shall be saved for the purpose of calculating the change, Δt , expressed as a percentage, as given in [Formula \(2\)](#):

$$\% \Delta t = \left[\frac{\Delta t_{i(\tau=0)} - \Delta t_{i(\tau)}}{\Delta t_{i(\tau=0)}} \right] \times 100 \% \quad (2)$$

6.1.4.6 Test procedure when a defrost cycle (whether automatically or manually initiated) ends the preconditioning period ([6.1.4.3](#))

6.1.4.6.1 If the quantity $\% \Delta t$ exceeds 2,5 % during the first either 35 min or 70 min of the data collection period, based on national legislation or standards, the heating capacity test shall be designated as a transient test (see [6.1.4.9](#)). Likewise, if the heat pump initiates a defrost cycle during the equilibrium period or during the first either 35 min or 70 min of the data collection period, based on national legislation or standards, the heating capacity test shall be designated as a transient test.

6.1.4.6.2 If the conditions specified in [6.1.4.6.1](#) do not occur and the test tolerances given in [7.2](#) are satisfied during both the equilibrium period and the first either 35 min or 70 min of the data collection period, based on national legislation or standards, then the heat capacity test shall be designated a steady-state test. Steady-state tests shall be terminated after either 35 min or 70 min of the data collection, based on national legislation or standards.

6.1.4.7 Test procedure when a defrost cycle does not end the preconditioning period ([6.1.4.3](#))

6.1.4.7.1 If the heat pump initiates a defrost cycle during the equilibrium period or during the first either 35 min or 70 min of the data collection period, based on national legislation or standards, the heating capacity test shall be restarted as specified in [6.1.4.7.3](#).

6.1.4.7.2 If the quantity $\% \Delta t$ exceeds 2,5 % any time during the first either 35 min or 70 min of the data collection period, based on national legislation or standards, the heating capacity test shall be restarted as specified in [6.1.4.7.3](#). Prior to the restart, a defrost cycle shall occur. This defrost cycle may be manually initiated or delayed until the heat pump initiates an automatic defrost.

6.1.4.7.3 If either [6.1.4.7.1](#) or [6.1.4.7.2](#) apply, then the restart shall begin 10 min after the defrost cycle terminates with a new, 60-minute-long equilibrium period. This second attempt shall follow the requirements of [6.1.4.4](#) and [6.1.4.5](#), and the test procedure of [6.1.4.6](#).

6.1.4.7.4 If the conditions specified in [6.1.4.7.1](#) or [6.1.4.7.2](#) do not occur and the test tolerances given in [7.3](#) are satisfied during both the equilibrium period and the first either 35 min or 70 min of the data collection period, based on national legislations or standards, then the heat capacity test shall be designated as a steady-state test. Steady-state tests shall be terminated after either 35 min or 70 min of the data collection, based on national legislations or standards,.

6.1.4.8 Test procedure for transient tests

6.1.4.8.1 When, in accordance with [6.1.4.6.1](#), a heating capacity test is designated as a transient test, the adjustments specified in [6.1.4.8.2](#) to [6.1.4.8.6](#) shall apply.

6.1.4.8.2 The outdoor air-enthalpy test method shall not be used and its associated outdoor-side measurement apparatus shall be disconnected from the heat pump. In all cases, the normal outdoor-side airflow of the heat pump shall not be disturbed. The use of other confirming test methods is not required.

6.1.4.8.3 To constitute a valid transient heating capacity test, the test tolerances specified in [Table 7](#) shall be achieved during both the equilibrium period and the data collection period. As noted in [Table 7](#), the test tolerances are specified for two subintervals. Interval H consists of data collected during each heating interval, with the exception of the first 10 min after defrost termination. Interval D consists of data collected during each defrost cycle plus the first 10 min of the subsequent heating interval.

6.1.4.8.4 The test tolerance parameters in [Table 7](#) shall be sampled throughout the equilibrium and data collection periods. All data collected during each interval, H or D, shall be used to evaluate compliance with the [Table 7](#) test tolerances. Data from two or more H intervals or two or more D intervals shall not be combined and then used in evaluating [Table 7](#) compliance. Compliance is based on evaluating data from each interval separately.

6.1.4.8.5 The data collection period shall be extended until 3 h have elapsed or until the heat pump completes three complete cycles during the period, whichever occurs first. If, at an elapsed time of 3 h, the heat pump is conducting a defrost cycle, the cycle shall be completed before terminating the collection of data. A complete cycle consists of a heating period and a defrost period, from defrost termination to defrost termination.

6.1.4.8.6 Because of the confirming test method requirement of 9.1.3.1 of ISO 15042:2017/Amd 1:2020, the outdoor air enthalpy test apparatus may have to be disconnected from the heat pump, as specified in [6.1.4.8.2](#), during a heating capacity test. If removal during a test is required, the changeover interval shall not be counted as part of the elapsed time of the equilibrium or data collection periods. The changeover interval shall be defined as starting the instant the heating capacity test is designated a transient test and ending when the test tolerances from [Table 7](#) are first re-established after the outdoor air-enthalpy apparatus is disconnected from the heat pump.

Table 7 — Variations allowed in heating capacity tests when using transient (T) test procedure

Reading	Variation of arithmetical mean values from specified test conditions		Variation of individual readings from specified test conditions	
	Interval H ^a	Interval D ^b	Interval H ^a	Interval D ^b
Temperature of air entering indoor-side:				
— dry-bulb	±0,6 K	±1,5 K	±1,0 K	±2,5 K
— wet-bulb	—	—	—	—
Temperature of air entering outdoor-side:				
— dry-bulb	±0,6 K	±1,5 K	±1,0 K	±5,0 K
— wet-bulb	±0,3 K	±1,0 K	±0,6 K	—
Voltage	—	—	±2 %	±2 %
^a Applied when the appliance is in the heating mode, except for the first 10 min after termination of a defrost cycle				
^b Applies during a defrost cycle and during the first 10 min after the termination of a defrost cycle when the appliance is operating in the heating mode				

6.1.4.9 Heating capacity test results

6.1.4.9.1 General

The electrical energy supplied to the heat pump during the applicable test period specified in [6.1.4.5](#) shall be measured along with the corresponding elapsed time, in hours, of the test period.

Average heating capacity and average electrical power input shall be calculated in accordance with [6.1.4.9.2](#) using data from the total number of complete cycles that are achieved before data collection is terminated. In the event that the equipment does not undergo a defrost cycle during the data collection period of a transient test, the entire data set shall be used for the calculations.

The test shall be conducted with the equipment functioning at full-load operation, as defined in 3.20 of ISO 15042:2017/Amd 1:2020.

6.1.4.9.2 Steady-state capacity tests

If the heating capacity test is conducted in accordance with the provisions of [6.1.4.7.2](#) or [6.1.4.8.4](#), a heating capacity shall be calculated using data from each data sampling in accordance with Annex E of ISO 15042:2017/Amd 1:2020.

An average heating capacity shall be determined from the set of heating capacities recorded over either 35 min or 70 min of the data collection period, based on national legislation or standards.

An average electrical power input shall be determined from the set of electrical power inputs recorded over either 35 min or 70 min of the data collection period, based on national legislation or standards or from the integrated electrical power for the same data collection period.

6.1.4.9.3 Transient capacity tests

If the heating capacity test is conducted in accordance with the provisions of [6.1.4.9](#), an average heating capacity shall be determined (see Example 1 in Annex P of ISO 15042:2017/Amd 1:2020). This average heating capacity shall be calculated as specified in Annex E of ISO 15042:2017/Amd 1:2020.

For equipment where one or more complete cycles occur during the data collection period, the following shall apply. The average heating capacity shall be determined using the integrated capacity and the elapsed time corresponding to the total number of complete cycles that occurred over the data collection period (see Examples 4, 5 and 6 in Annex P of ISO 15042:2017/Amd 1:2020). The average electrical power input shall be determined using the integrated power input and the elapsed time corresponding to the total number of complete cycles during the same data collection period as the one used for the heating capacity.

NOTE A complete cycle consists of a heating period and a defrost period from defrost termination to defrost termination.

For equipment that does not conduct a complete cycle during the data collection period, the following shall apply. The average heating capacity shall be determined using the integrated capacity and the elapsed time corresponding to the total data collection period. The average electrical power input shall be determined using the integrated power input and the elapsed time corresponding to the same data collection period as the one used for the heating capacity (see Example 2 in Annex P of ISO 15042:2017/Amd 1:2020).

For equipment in which a single defrost occurs during the test period, the following shall apply. The average heating capacity shall be determined using the integrated capacity and the elapsed time corresponding to the total test period. The average electrical power input shall be determined using the integrated power input and the elapsed time corresponding to the total test period (see Example 3 in Annex P of ISO 15042:2017/Amd 1:2020).

6.1.5 Test methods

The test method shall be in accordance with this clause, [Clause 7](#) and any additional requirements as specified in:

- [Annex H](#) for the tests of HSPF, or
- [Annex F](#) for the tests of SCOP.

The heating capacity and effective power input shall be measured during the full-load and part load capacity tests. Resistive elements used for heating indoor air other than those used for defrosting shall be prevented from operating during the heating capacity tests.

Standard ratings of capacities shall include the effects of circulating-fan heat, but shall not include supplementary heat.

The specific setting that is needed to give full-load and part load capacities shall be set and the equipment shall be maintained at those settings. The manufacturer shall provide information on how to set the capacity if requested by the testing laboratories.

If the equipment cannot be maintained at steady-state conditions by its normal controls, then the manufacturer can modify or override such controls so that steady-state conditions are achieved.

As required, the compressor speed during the part load test shall be verified by the controls verification procedure (CVP) described in [Annex M](#).

For the 50 % or less part load tests, at least half of the total indoor units, as calculated per the total capacity of the connected indoor units, can remain thermally inactive. The laboratory shall prevent forced air circulation through any indoor unit that is thermally inactive (e.g. block the inlet and outlet). For the indoor unit(s) that are thermally inactive, the indoor unit control settings (e.g. using remote or wireless thermostat) shall be set to "OFF".

6.2 Calculations

The heating seasonal performance evaluation shall be at least one of:

- Heating seasonal performance factor (HSPF) according to [Annex A](#), or
- Seasonal coefficient of performance (SCOP) according to [Annex F](#).

7 Test methods and uncertainties of measurements

7.1 Test methods

Capacity tests shall be conducted in accordance with the testing requirements specified in Annex B of ISO 15042:2017/Amd 1:2020 using the indoor air-enthalpy test method in Annex E of ISO 15042:2017/Amd 1:2020, subject to the provision that the test results are within the limits of uncertainties of measurements as in [7.2](#).

7.2 Uncertainty of measurement

The uncertainty of measurement shall not exceed the values specified in Table 12 of ISO 15042:2017/Amd 1:2020.

7.3 Test tolerances

7.3.1 The maximum tolerance of any individual observation from a specific test condition during a steady-state cooling and heating capacity test is listed in column 3 of Table 13 of ISO 15042:2017/Amd 1:2020. If a test condition is not specified, the values in column 3 of Table 13 of ISO 15042:2017/Amd 1:2020 represent the greatest tolerance between maximum and minimum instrument observations during the test. When expressed as a percentage, the maximum tolerance is the specified percentage of the arithmetical average of the observations.

7.3.2 The maximum tolerances of the average (arithmetical mean) of the test observations from this standard or of specified test conditions are shown in column 2 of Table 13 of ISO 15042:2017/Amd 1:2020.

7.3.3 For the preconditioning period, equilibrium shall be defined as an interval of specified duration where the applicable test tolerances in Table 14 of ISO 15042:2017/Amd 1:2020 are satisfied. When a defrost cycle occurs during the preconditioning period of a heating capacity test, the parameters sampled between defrost initiation and 10 min after defrost termination shall be excluded when evaluating compliance to the test tolerances in Table 14 of ISO 15042:2017/Amd 1:2020. As noted in [6.1.4.5.5](#), the sampling frequency of

the indoor dry-bulb temperature is subject to change during defrost cycles, if using the indoor air enthalpy test method.

7.3.4 For the data collection period used in determining the equipment's measured space conditioning capacity, compliance with the applicable test tolerances in Table 14 of ISO 15042:2017/Amd 1:2020 shall be achieved.

8 Test report

8.1 General

The results of a capacity test shall express quantitatively the effects produced upon air by the equipment being tested. For given test conditions, the capacity test results shall include the following quantities as are applicable to cooling or heating:

- a) total cooling capacity, in watts;
- b) sensible cooling capacity, in watts;
- c) latent cooling capacity, in watts;
- d) heating capacity, in watts;
- e) indoor-side airflow rate, in cubic metres per second of standard air;
- f) external resistance to indoor airflow, in pascals;
- g) effective power input to the equipment or individual power inputs to each of the electrical equipment components, in watts.

NOTE For determination of latent cooling capacity, see Annex E of ISO 15042:2017/Amd 1:2020.

8.2 Adjustments

Test results shall be used to determine capacities without adjustment for tolerances in test conditions. Air enthalpies, specific volumes and isobaric specific heat capacities shall be based on the measured barometric pressure.

8.3 Data to be recorded

The data to be recorded for the capacity tests is given in [Table 8](#). The table identifies the general information required, but is not intended to limit the data to be obtained. Electrical input values used for rating purposes shall be those measured during the capacity tests.

Table 8 — Data to be recorded for capacity test

No.	Data
1	Date
2	Observers
3	Barometric pressure, in kPa
4	Time of tests
5	Power input to equipment ^a , in W
6	Energy input to equipment ^b , in Wh
7	Applied voltage(s), in V
^a	Total power input and, where required, input to equipment components.
^b	Energy input to equipment is required only during defrost operations.

Table 8 (continued)

No.	Data
8	Total current input to equipment, in A
9	Frequency, in Hz
10	External resistance to airflow for each indoor unit, in Pa
11	Fan speed setting for each indoor and outdoor units
12	Setting of variable capacity compressor at full load
13	Dry-bulb temperature of air entering equipment, in °C
14	Wet-bulb temperature of air entering equipment, in °C
15	Dry-bulb temperature of air leaving measuring device, in °C
16	Wet-bulb temperature of air leaving measuring device, in °C
17	Outdoor dry-bulb and wet-bulb temperatures, in °C
18	Volume flow rate of air and all relevant measurements for its calculation, in m ³ /s
19	Refrigerant charge added by the test house, in kg
20	Value of C (for adjusted exhaust fan setting method)
21	External static pressure ESP, in Pa (for fixed duct resistance method)
22	Factory charge, in kg
a	Total power input and, where required, input to equipment components.
b	Energy input to equipment is required only during defrost operations.

9 Publication of ratings

9.1 Standard ratings

9.1.1 Standard ratings shall be published for cooling capacities, heating capacity, APF (CSPF and HSPF), IEER, SEER, and SCOP, as appropriate, for all systems produced in conformance with this document. These ratings shall be based on data obtained at the established rating conditions in accordance with the provisions of this document.

9.1.2 The values of standard rating capacities, partial load capacities, the power input of the measurements, shall be expressed in kilowatts, rounded based on the table below.

EXAMPLE 1,23 kW; 5,00 kW; 16,2 kW; 53,0 kW; 132 kW

9.1.3 The values of EER, COP, APF (CSPF and HSPF), IEER, SEER, SCOP, $\eta_{s,c}$ and, $\eta_{s,h}$ shall be rounded to three significant figures.

EXAMPLE 2,63; 5,60; 10,1

9.1.4 The values of the test methods for electric power input described in [Annex L](#) shall be expressed in watts, rounded to three significant figures.

EXAMPLE 300 W; 12,3 W; 102 W; 5,67 W

9.2 Other ratings

Additional ratings may be published based on conditions other than those specified as standard rating conditions, or based on conditions specified in national legislation and standards, or based on the testing of various combinations of operating evaporators and/or compressors, if they are clearly specified and if the data are determined by the methods specified in this document, or by analytical methods which are verifiable by the test methods specified in this document.

10 Energy performance mapping approach for building simulation purposes

The energy performance mapping approach uses declared performance data published by the manufacturer under the part load test points at different ambient temperatures in cooling and heating as indicated in [Clauses 5](#) and [6](#), in order to create the full performance map of the unit over the whole outdoor bin temperature range.

The mapping approach is described in [Annex Q](#).

The energy performance mapping approach is to be used for building simulation purposes. It may also be used as a guidance to convert energy performance indices using the declared performance data.

NOTE Energy performance indices are as considered by this standard EER, COP, APF (CSPF and HSPF), IEER, SEER, SCOP.

Annex A (normative)

Calculations of Annual Performance Factor (APF)

A.1 APF background

A.1.1 General requirements

The APF has been developed to represent a single metric for the annualized performance of the mechanical cooling and heating systems. It is widely used globally for equipment, such as air-source VRF, rooftop units, and unitary air conditioners. It is used to calculate the annual energy consumption of a specific building in a given climate zone based on the building defined cooling and/or heating load curve and the bin hours corresponding to the temperature. In order to be applied locally and to better understand, evaluate and estimate the energy consumption of a specific building, an energy analysis using a temperature bin- hour analysis program should be performed for the intended building using the local weather data.

This Annex is given to establish a minimum, representative cooling load and to show an evaluation method of the equipment operating at the conditions fixed by this load. For the local region, the following calculation methods can be used based on the corresponding cooling and/or heating load and temperature bin-hours to acquire a more accurate result.

A.1.2 General APF equations

APF metric is based on the ratio of the total annual amount of heat (CSTL) that the equipment can remove from the indoor air when operated for cooling in active mode and the total annual amount of heat (HSTL) that the equipment, including make-up heat, can add to the indoor air when operated for heating in active mode to the total annual amount of energy consumed by the equipment during the same period, including the cooling seasonal energy consumption (CSEC) and heating seasonal energy consumption (HSEC). The APF shall be calculated using test derived data and [Formula \(A.1\)](#). For cooling only or heating only equipment, APF shall be equal to CSPF (refer to [Formula \(A.3\)](#)) for cooling, or HSPF (refer to [Formula \(A.12\)](#)) for heating. Calculation of CSTL, L_{CST} , and CSEC, C_{CSE} , is according to [Formulae \(A.10\)](#) and [\(A.11\)](#), and calculation of HSTL, L_{HST} , and HSEC, C_{HSE} , is according to [Formulae \(A.40\)](#) and [\(A.41\)](#).

In case of calculating the total annual performance factor (TAPF), refer to [Annex C](#)

$$F_{AP} = \frac{L_{CST} + L_{HST}}{C_{CSE} + C_{HSE}} \quad (A.1)$$

A.2 Cooling Seasonal Performance Factor (CSPF)

A.2.1 General requirements

The accuracy of the instruments used for tests shall conform to the test methods and uncertainties of measurements specified in [Clause 7](#). Temperature and humidity conditions as well as default values for calculation shall be as specified in [Table 1](#).

A.2.2 Calculations

A.2.2.1 Setting of a specific cooling load, $L_c(t_j)$

- a) An outdoor temperature at 100 % cooling load shall be set.

- b) The highest outdoor temperature occurred is determined from the outdoor temperature bin distribution, such as [Table A.1](#) but it is desirable to exclude the abnormal condition which is thought to be unusual.
- c) A load of a specific building is calculated to determine the required cooling capacity at the 100 % load outdoor temperature (t_{100}).
- d) 0 % load outdoor temperature (t_0) shall be set based on the calculated load of the specific building and the purpose of using the equipment.
- e) The defined cooling load shall be represented by a value and the assumption that it is linearly changing depending on the change in outdoor temperature.
- f) Defined cooling load $L_c(t_j)$ at outdoor temperature t_j is necessary to calculate the cooling seasonal energy consumption. In this Annex, t_{100} will be 35 °C as the full-load designed outdoor temperature and t_0 will be 20 °C for the reference. From these, a load curve is obtained by using [Formula \(A.2\)](#). The specific cooling load widely varies from region to region globally depending on climate conditions, building structures and the situations in which equipment are used.

$$L_c(t_j) = \phi_{\text{ful}}(t_{100}) \times \frac{t_j - t_0}{t_{100} - t_0} \quad (\text{A.2})$$

A.2.2.2 Setting of bin distribution for cooling

Bin hours of each outdoor temperature which requires cooling during the cooling season shall be set. In this Annex, the cooling seasonal performance factor (CSPF) can be calculated at the reference outdoor temperature bin distribution as below [Table A.1](#). CSPF calculations may also be done for other climate conditions.

Table A.1 — Reference outdoor temperature bin distribution

Bin number(j)	1	2	3	4	5	6	7	8
OT (t_j) °C	21	22	23	24	25	26	27	28
Fractional bin hours	0,055	0,076	0,091	0,108	0,116	0,118	0,116	0,100
Bin hours n_j	n_1	n_2	n_3	n_4	n_5	n_6	n_7	n_8
Reference bin hours(n_j) h	100	139	165	196	210	215	210	181
Bin number(j)	9	10	11	12	13	14	15	Total
OT (t_j) °C	29	30	31	32	33	34	35	-
Fractional bin hours	0,083	0,066	0,041	0,019	0,006	0,003	0,002	-
Bin hours n_j	n_9	n_{10}	n_{11}	n_{12}	n_{13}	n_{14}	n_{15}	-
Reference bin hours(n_j) h	150	120	75	35	11	6	4	1 817

A.2.2.3 Calculation of Cooling Seasonal Performance Factor (CSPF)

A.2.2.3.1 Cooling seasonal performance factor (CSPF) and total cooling seasonal performance factor (TCSPF)

The cooling seasonal performance factor (CSPF), F_{CSP} , of the equipment shall be calculated by [Formula \(A.3\)](#).

$$F_{\text{CSP}} = \frac{L_{\text{CST}}}{C_{\text{CSE}}} \quad (\text{A.3})$$

In case of calculating the total cooling seasonal performance factor (TCSPF), refer to [Annex C](#).

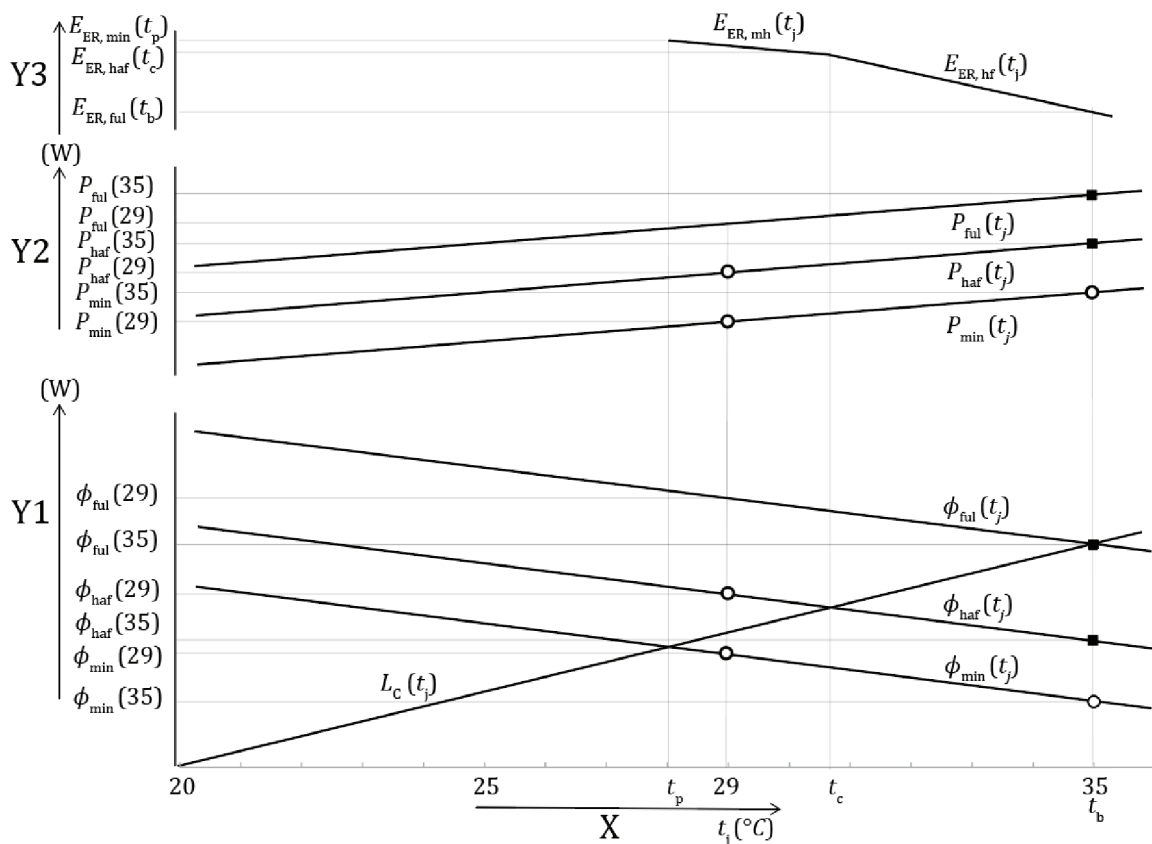
A.2.2.3.2 Capacity and power characteristics against outdoor temperature

Capacity $\phi_{\text{ful}}(t_j)$ (W) of the equipment when it is operated for cooling full capacity at outdoor temperature t_j linearly changes depending on outdoor temperatures as shown in [Figure A.1](#), and it is determined by below [Formula \(A.4\)](#) from two characteristics, one at 35 °C and the other at 29 °C. The solid dots showed in the [Figure A.1](#) are the required test points.

$$\phi_{\text{ful}}(t_j) = \phi_{\text{ful}}(35) + \frac{\phi_{\text{ful}}(29) - \phi_{\text{ful}}(35)}{35 - 29} \times (35 - t_j) \quad (\text{A.4})$$

Power input $P_{\text{ful}}(t_j)$ (W) of the equipment when it is operated for cooling at outdoor temperature t_j linearly changes depending on outdoor temperatures as shown in [Figure A.1](#), and it's determined by below [Formula \(A.5\)](#).

$$P_{\text{ful}}(t_j) = P_{\text{ful}}(35) + \frac{P_{\text{ful}}(29) - P_{\text{ful}}(35)}{35 - 29} \times (35 - t_j) \quad (\text{A.5})$$



Key

- X outdoor temperature
- Y1 capacity or load
- Y2 power input

Figure A.1 — Capacity and power characteristics against outdoor temperature (for CSPF)

Capacities, $\phi_{\text{haf}}(t_j)$ and $\phi_{\text{min}}(t_j)$ (W) of the equipment when it is operated for cooling at outdoor temperature t_j and shall be determined by following Formulae:

$$\phi_{\text{haf}}(t_j) = \phi_{\text{haf}}(35) + \frac{\phi_{\text{haf}}(29) - \phi_{\text{haf}}(35)}{35 - 29} \times (35 - t_j) \quad (\text{A.6})$$

$$\phi_{\min}(t_j) = \phi_{\min}(35) + \frac{\phi_{\min}(29) - \phi_{\min}(35)}{35 - 29} \times (35 - t_j) \quad (\text{A.7})$$

Accordingly, the power inputs, $P_{\text{haf}}(t_j)$ and $P_{\min}(t_j)$ (W) shall be determined by following Formulae:

$$P_{\text{haf}}(t_j) = P_{\text{haf}}(35) + \frac{P_{\text{haf}}(29) - P_{\text{haf}}(35)}{35 - 29} \times (35 - t_j) \quad (\text{A.8})$$

$$P_{\min}(t_j) = P_{\min}(35) + \frac{P_{\min}(29) - P_{\min}(35)}{35 - 29} \times (35 - t_j) \quad (\text{A.9})$$

A.2.2.3.3 Calculation of cooling seasonal total load (CSTL)

Cooling seasonal total load (CSTL), L_{CST} , shall be determined using [Formula \(A.10\)](#) from the total sum of cooling load at each outdoor temperature t_j multiplied by bin hours n_j .

$$L_{\text{CST}} = \sum_{j=1}^m L_c(t_j) \times n_j + \sum_{j=m+1}^n \phi_{\text{ful}}(t_j) \times n_j \quad (\text{A.10})$$

a) In the range of $L_c(t_j) \leq \phi(t_j)$, $j = 1$ to m :

$L_c(t_j)$ shall be calculated by [Formula \(A.2\)](#).

b) In the range of $L_c(t_j) > \phi_{\text{ful}}(t_j)$, $j = m+1$ to n :

$\phi_{\text{ful}}(t_j)$ shall be calculated by [Formula \(A.4\)](#).

A.2.2.3.4 Calculation of cooling seasonal energy consumption (CSEC)

When the minimum capacity data are available, then the cooling seasonal energy consumption (CSEC), C_{CSE} , shall be calculated by [Formula \(A.11\)](#).

$$C_{\text{CSE}} = \sum_{j=1}^k \frac{X(t_j) \times P_{\min}(t_j) \times n_j}{F_{\text{PL}}(t_j)} + \sum_{j=k+1}^p P_{\text{mh}}(t_j) \times n_j \quad (\text{A.11})$$

$$+ \sum_{j=p+1}^m P_{\text{hf}}(t_j) \times n_j + \sum_{j=m+1}^n P_{\text{ful}}(t_j) \times n_j$$

When the minimum capacity data are not available, then the cooling seasonal energy consumption (CSEC), C_{CSE} , shall be calculated alternatively by [Formula \(A.12\)](#).

$$C_{\text{CSE}} = \sum_{j=1}^p \frac{X(t_j) \times P_{\text{haf}}(t_j) \times n_j}{F_{\text{PL}}(t_j)} + \sum_{j=p+1}^m P_{\text{hf}}(t_j) \times n_j + \sum_{j=m+1}^n P_{\text{ful}}(t_j) \times n_j \quad (\text{A.12})$$

Calculation methods for each term of [Formula \(A.11\)](#) are as follows:

a) Cyclic operation $L_c(t_j) \leq \phi_{\min}(t_j)$, $j = 1$ to k :

In [Formula \(A.11\)](#), $X(t_j)$ shall be calculated by [Formula \(A.13\)](#). $\text{PLF}(t_j)$ shall be calculated by [Formula \(A.14\)](#). The default value of C_d equals to 0,25

$$X(t_j) = \frac{L_c(t_j)}{\phi(t_j)} \quad (\text{A.13})$$

$$F_{\text{PL}}(t_j) = 1 - C_d \times (1 - X(t_j)) \quad (\text{A.14})$$

In [Formula \(A.13\)](#), $\phi(t_j) = \phi_{\min}(t_j)$.

- b) Operation between minimum and half capacity $\phi_{\min}(t_j) < L_c(t_j) \leq \phi_{\text{haf}}(t_j)$, $j = k+1$ to p :

t_p is outdoor temperature when cooling load is equal to cooling minimum capacity. (The calculation method for the crossing point is described in [Figure A.1](#).)

$EER_{\min}(t_p)$ shall be calculated from $\phi_{\min}(t_p)$ and $P_{\min}(t_p)$.

$$E_{ER,\min}(t_p) = \frac{\phi_{\min}(t_p)}{P_{\min}(t_p)} \quad (\text{A.15})$$

t_c is outdoor temperature when cooling load is equal to cooling half capacity.

$EER_{\text{haf}}(t_c)$ shall be calculated from $\phi_{\text{haf}}(t_c)$ and $P_{\text{haf}}(t_c)$.

$$E_{ER,\text{haf}}(t_c) = \frac{\phi_{\text{haf}}(t_c)}{P_{\text{haf}}(t_c)} \quad (\text{A.16})$$

It is assumed that EER linearly changes depending on outdoor temperature when the capacity of equipment changes continuously.

$$E_{ER,\text{mh}}(t_j) = E_{ER,\min}(t_p) + \frac{E_{ER,\text{haf}}(t_c) - E_{ER,\min}(t_p)}{(t_c - t_p)} \times (t_j - t_p) \quad (\text{A.17})$$

$P_{\text{mh}}(t_j)$, power input between minimum and half capacity operation, shall be calculated from $L_c(t_j)$ cooling load and $EER_{\text{mh}}(t_j)$ by [Formula \(A.16\)](#).

$$P_{\text{mh}}(t_j) = \frac{L_c(t_j)}{E_{ER,\text{mh}}(t_j)} \quad (\text{A.18})$$

- c) Operation between half and full capacity $\phi_{\text{haf}}(t_j) < L_c(t_j) \leq \phi_{\text{ful}}(t_j)$, $j = p+1$ to m :

$EER_{\text{ful}}(t_b)$ shall be calculated from $\phi_{\text{ful}}(t_b)$ and $P_{\text{ful}}(t_b)$.

$$E_{ER,\text{ful}}(t_b) = \frac{\phi_{\text{ful}}(t_b)}{P_{\text{ful}}(t_b)} \quad (\text{A.19})$$

It is assumed that EER linearly changes depending on outdoor temperature when the capacity of equipment changes continuously.

$$E_{ER,\text{hf}}(t_j) = E_{ER,\text{haf}}(t_c) + \frac{E_{ER,\text{ful}}(t_b) - E_{ER,\text{haf}}(t_c)}{(t_b - t_c)} \times (t_j - t_c) \quad (\text{A.20})$$

$P_{\text{hf}}(t_j)$, power input between half and full capacity operation, shall be calculated from $L_c(t_j)$ cooling load and $EER_{\text{hf}}(t_j)$ by [Formula \(A.21\)](#).

$$P_{\text{hf}}(t_j) = \frac{L_c(t_j)}{E_{ER,\text{hf}}(t_j)} \quad (\text{A.21})$$

- d) Full capacity operation $L_c(t_j) > \phi_{\text{ful}}(t_j)$, $j = m+1$ to n :

$P_{\text{ful}}(t_j)$ shall be calculated by [Formula \(A.5\)](#).