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Air to water heat pumps — Testing and rating at part load conditions and calculation of seasonal coefficient of performance for space heating

Chauffe-eau à pompe à chaleur — Essais et détermination des caractéristiques à charge partielle et calcul de performance saisonnière

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document 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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This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

This second edition cancels and replaces the first edition (ISO 21978:2021), which has been technically revised.

The main changes are as follows:

— values of uncertainties have been corrected;

— descriptive terms or names have been revised following ISO/IEC Directives;

— errors in Annex A have been corrected;

— typos have been corrected.

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.

Introduction

Air to water heat pumps are, at present, selected and compared at a rated condition. This condition does not represent the usual operating conditions of the equipment over a season. This operating condition can be better assessed by comparing equipment at representative reduced capacities and determining the seasonal coefficient of performance.

This document provides part load conditions and calculation methods for calculating the seasonal coefficient of performance ($S_{COP,on}$ and $S_{COP,net}$) of such units when they are used to fulfil the heating demands.

Other energy consumptions can occur when the unit is not used to fulfil the heating demands such as those from a crankcase heater or when the unit is on standby. These consumptions are considered in the calculation methods for reference S_{COP}.

Reference S_{COP}/$S_{COP,on}$/$S_{COP,net}$ calculations may be based on calculated or tested values. For the purpose of S_{COP}/$S_{COP,on}$/$S_{COP,net}$, three design conditions average (A), colder (C) and warmer (W) are considered, as well as three temperature applications. In case of tested values, this document gives the methods for testing air to water heat pumps at part load conditions.

Air to water heat pumps — Testing and rating at part load conditions and calculation of seasonal coefficient of performance for space heating

1 Scope

This document specifies test conditions for determining the seasonal performance characteristics of air to water heat pumps for space heating with electrically driven compressors with or without supplementary heater. In the case of air to water heat pumps for space heating consisting of several parts with refrigerant or water connections, this document applies only to those designed and supplied as a complete package.

The seasonal coefficient of performance depends, inter alia, on the climate conditions and temperature regime of the space heating distribution network.

This document specifies:

— three design conditions, each of them being characterized by a design temperature which represents the lowest temperature that can occur in that design condition;

— three water temperature distribution regimes, namely "temperature application" in the text.

This document also provides a full description of three heating seasons that can be used with the associated design conditions.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
35 °C application
temperature application where an indoor heat exchanger water(brine) outlet temperature of 35 °C is met at design temperature

3.2
45 °C application
temperature application where an indoor heat exchanger water(brine) outlet temperature of 45 °C is met at design temperature

3.3
55 °C application
temperature application where an indoor heat exchanger water(brine) outlet temperature of 55 °C is met at design temperature

3.4
active mode
mode corresponding to the hours with a heating load of the building and whereby the heating function of the unit is activated

Note 1 to entry: This condition can involve on/off-cycling of the unit in order to reach or maintain a required indoor air temperature.

3.5
active mode seasonal coefficient of performance
$S_{COP,on}$
average coefficient of performance of the unit in *active mode* (3.4) for the designated design condition, determined from the part load, supplementary heating capacity (where required) and *bin-specific coefficients of performance* (3.12) and weighted by the *bin hours* (3.11) where the bin condition occurs

Note 1 to entry: For calculation of $S_{COP,on}$, the energy consumption during *thermostat-off mode* (3.47), *standby mode* (3.44), *off mode* (3.36) and *crankcase heater mode* (3.22) 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.

3.6
air to water heat pump
heat pump which consists of one or more factory-made assemblies which includes at space side refrigerant to water heat exchanger (load side), electrically driven compressor(s), and outdoor-side air-to refrigerant heat exchanger(s) (source side), including means to provide space heating and/or space cooling functions.

Note 1 to entry: It can include supplementary heater for space heating.

Note 2 to entry: This is also referred to as heat pump in this document.

3.7
annual energy consumption for heating
Q_{HE}
energy consumption required to meet the reference annual heating demand for a designated design condition and set of bin hours and calculated as the reference annual heating demand divided by the *active mode seasonal coefficient of performance* (3.5) 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.

3.8
annual heating demand
Q_H
heating demand for a designated design condition and set of bin hours, to be used as basis for calculation of *seasonal coefficient of performance* (3.43) and calculated as the product of the *design load* (3.26) for heating and the *equivalent active mode hours for heating* (3.32)

Note 1 to entry: Expressed in kWh.

3.9
available external static pressure difference
Δp_e
positive pressure difference measured between the air (or water) outlet section and the air (or water) inlet section of the unit, which is available for overcoming the pressure drop of any additional ducted air (or water) circuit

3.10
bin
outdoor temperature interval of 1 K

3.11
bin hours
h_j
hours per heating season for which an outdoor temperature occurs for each *bin* (3.10) *j*

3.12
bin-specific coefficient of performance
$C_{Pb,}(T_j)$
coefficient of performance specific for every *bin* (3.10) *j* with outdoor temperature T_j in a heating season

3.13
bin temperature
T_j
outdoor air dry bulb temperature

Note 1 to entry: Expressed in °C.

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

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

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

3.15
capacity control
ability of the unit to change its capacity by changing the volumetric flow rate of the refrigerant

Note 1 to entry: Units are indicated as '*fixed*' if the unit cannot change its volumetric flow rate, '*two-staged*' if the volumetric flow rate is changed or varied in series of not more than two steps, '*multi-stage*' if the volumetric flow rate is changed or varied in series of three or four steps or '*variable*' if the volumetric flow rate is changed or varied in series of five or more steps to represent continuously variable capacity.

Note 2 to entry: Multi-stage capacity units are considered as variable capacity units in this document.

3.16
capacity ratio
C_R
heating part load or full load divided by the declared heating capacity of the unit at the same temperature conditions

3.17
coefficient of performance at the declared capacity
C_{Pd}
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.

3.18
coefficient of performance at part load
C_{Pb}
coefficient of performance at the declared capacity (3.17), corrected with the degradation coefficient, where applicable

Note 1 to entry: When the declared capacity of the unit is higher than the heating load, the coefficient of performance- includes degradation losses. When the declared capacity of the unit is lower than the heating load (i.e. below the *bivalent temperature* (3.14) condition), the coefficient of performance of the declared capacity is used.

Note 2 to entry: Expressed in kW/kW.

3.19
compressor-off state
condition where the compressor is not running while the unit is operating in *active mode* (3.4)

Note 1 to entry: This is the "off" phase in on/off cycling.

3.20
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 design condition and set of bin hours

Note 1 to entry: Three examples of crankcase heater mode hours are given in Annex C.

Note 2 to entry: Expressed in h.

3.21
crankcase heater mode power input
P_{CK}
power input of the unit due to crankcase heater operation mode

Note 1 to entry: Expressed in W.

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
declared capacity in heating
Φ_{dh}
heating capacity a unit can provide at any temperature condition A, B, C, D, E, F or G, as declared by the manufacturer

Note 1 to entry: This is the capacity provided by the refrigerant cycle of the unit without supplementary heaters, even if those are integrated in the unit.

3.24
degradation coefficient
C_d
measure of efficiency loss due to the cycling

Note 1 to entry: If the *Cd* is not determined by measurement, the default degradation coefficient is 0,9.

3.25
design condition
condition characterized by a design temperature condition and that is to be associated with a set of bin hours

Note 1 to entry: Three design conditions are defined in this document.

3.26
design load
Φ_{dlh}
space heating load declared by the manufacturer at *design temperature* (3.27)

Note 1 to entry: It is possible to calculate the $S_{\text{COP}}/S_{\text{COP,on}}/S_{\text{COP,net}}$ of a unit for more than one Φ_{dlh} value.

Note 2 to entry: Expressed in kW.

3.27
design temperature
T_{d}
lowest outdoor air temperature considered for each design condition

3.28
effective power input during compressor-off state
P_{Coff}
total power input of the unit when the compressor is switched off in *active mode* (3.4), used for the determination of the *degradation coefficient* (3.24) including corrections for fans and pumps where applicable.

Note 1 to entry: Expressed in kW.

3.29
effective power input with declared capacity
P_{Con}
total power input when the unit is operating at part load condition, used for the determination of the *degradation coefficient* (3.24) including corrections for fans and pumps where applicable.

Note 1 to entry: Expressed in kW.

3.30
electric supplementary heater
real or assumed electric supplementary heater, with a coefficient of performance of 1, considered in the calculation of S_{COP} (3.43) and $S_{COP,on}$ (3.5)

3.31
electric supplementary heater capacity
$\Phi_{\text{esh,}}(\text{T,j})$
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* (3.13) T_j

Note 1 to entry: Expressed in kW.

3.32
equivalent active mode hours for heating
H_{HE}
assumed annual number of hours while the unit is assumed to operate at the design load for heating (Φ_{dlh}) in order to satisfy the reference annual heating demand

Note 1 to entry: Expressed in h.

3.33
fixed outlet
water(brine) outlet temperature that is used when the control of the unit has no means to automatically vary the water(brine) outlet temperature with the outdoor temperature

3.34
internal static pressure difference
Δp_i
negative pressure difference measured between the air (or water) outlet section and the air (or water) inlet section of the unit, which corresponds to the total pressure drop of all components on the air (or water) side of the unit"

3.35
net seasonal coefficient of performance
$S_{COP,net}$
seasonal efficiency of a unit in active heating mode without supplementary heaters which is determined from selected conditions

Note 1 to entry: For calculation of $S_{COP,net}$, the energy consumption during *active mode* (3.4) is used. This excludes the energy consumption during *thermostat-off mode* (3.47), *standby mode* (3.44), *off mode* (3.36) 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.

3.36
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.

3.37
off mode operating hours
H_{OFF}
annual number of hours the unit is considered to be in *off mode* (3.36), the value of which depends on the designated design condition and set of bin hours

Note 1 to entry: Three examples of off mode operating hours are given in Annex C.

Note 2 to entry: Expressed in h.

3.38
off mode power input
P_{OFF}
power input of the unit while in *off mode* (3.36)

Note 1 to entry: Expressed in W.

3.39
operation limit temperature
T_{OL}
outdoor temperature below which the declared capacity is equal to zero

Note 1 to entry: Expressed in °C.

3.40
part load for heating
$\Phi_{h,}(T,j)$
heating load at a specific *bin temperature* (3.13) T_j, calculated as the design load multiplied by the part load ratio

Note 1 to entry: Expressed in kW.

3.41
part load ratio
p_l
bin temperature (3.13) minus 16 °C divided by the design temperature minus 16 °C

Note 1 to entry: $(T_j - 16)/(T_d - 16)$

3.42
reactivation function
function facilitating the activation of other modes, including *active mode* (3.4), by remote switch including remote control, internal sensor, timer to a condition providing additional functions, including the main function, but excluding thermostats

3.43
seasonal coefficient of performance
S_{COP}
overall coefficient of performance of the unit, representative for the designated design condition and set of bin hours

Note 1 to entry: S_{COP} is calculated as the *annual heating demand* (3.8) divided by the *annual energy consumption for heating* (3.7).

Note 2 to entry: Expressed in kWh/kWh.

3.44
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* (3.42), or reactivation function and only an indication of enabled reactivation function, and/or information or status display.

3.45
standby mode operating hours
H_{SB}
annual number of hours the unit is considered to be in *standby mode* (3.44), the value of which depends on the designated design condition and set of bin hours

Note 1 to entry: Three examples of standby hours are given in Annex C.

Note 2 to entry: Expressed in h.

3.46
standby mode power input
P_{SB}
power input of the unit due to *standby mode* (3.44) operation

Note 1 to entry: Expressed in W.

3.47
thermostat-off mode
mode corresponding to the hours with no heating demand of the building, whereby the heating function of the unit is switched on, but is not operational, as there is no heating demand

Note 1 to entry: Cycling on/off in *active mode* (3.4) is not considered as thermostat-off.

3.48
thermostat-off mode operating hours
H_{TO}
annual number of hours the unit is considered to be in *thermostat-off mode* (3.47), the value of which depends on the designated design condition and set of bin hours

Note 1 to entry: Three examples of thermostat-off mode operating hours are given in Annex C.

Note 2 to entry: Expressed in h.

3.49
thermostat-off mode power input
P_{TO}
power input of the unit due to *thermostat-off mode* (3.47) operation

Note 1 to entry: Expressed in W.

3.50
variable outlet
water(brine) outlet temperature that is used when the control of the unit has means to automatically vary the water(brine) outlet temperature with the outdoor temperature

4 Symbols

Symbol	Definition	Units
C_d	Degradation coefficient	—
C_P	Coefficient of performance	kW/kW
c_p	Specific heat	kJ/(kg·K)
C_{Pb}	Coefficient of performance at part load	kW/kW
$C_{Pb,}(T_j)$	Bin-specific coefficient of performance	kW/kW
C_{Pd}	Coefficient of performance at the declared capacity	kW/kW
C_R	Capacity ratio	kW/kW
E_{EI}	Energy efficiency index of liquid pump	—
H_{CK}	Crankcase heater mode operating hours	h
H_{HE}	Equivalent active mode hours for heating	h
H_{OFF}	Off mode operating hours	h
H_{SB}	Standby mode operating hours	h
H_{TO}	Thermostat-off mode operating hours	h
h_j	Bin hours	h
j	Bin number	—
n	Total number of bin	—
P_{ASH}	Annual power input with supplementary heat	kW
P_{CK}	Crankcase heater mode power input	W
P_{Coff}	Effective power input during compressor-off state	kW
P_{Con}	Effective power input with declared capacity	kW
P_{OFF}	Off mode power input	W

Symbol	Definition	Units
P_{SB}	Standby mode power input	W
P_{TO}	Thermostat-off mode power input	W
p_l	Part load ratio	—
p_{l,T_j}	Part load ratio for bin temperature T_j	—
Q_H	Annual heating demand	kWh
Q_{HE}	Annual energy consumption for heating	kWh
S_{COP}	Seasonal coefficient of performance	kW/kW
$S_{COP,net}$	Net seasonal coefficient of performance	kW/kW
$S_{COP,on}$	Active mode seasonal coefficient of performance	kW/kW
T_{biv}	Bivalent temperature	°C
T_d	Design temperature conditions for heating	°C
T_j	Bin temperature (outdoor temperature)	°C
T_{OL}	Operation limit temperature	°C
u_{max}	Maximum uncertainty	%
$\Phi_{esh,}(T_j)$	Electric supplementary heater capacity	kW
Φ_{dh}	Declared capacity in heating	kW
Φ_{dlh}	Design load heating	kW
$\Phi_{h,}(T_j)$	Part load for heating	kW

5 Installation requirements

5.1 Test apparatus and uncertainties of measurement

The test apparatus shall be designed in such a way that all requirements for adjustment of set values, stability criteria and uncertainties of measurement according to this document can be fulfilled.

Water systems or other heat transfer liquid systems shall be sufficiently free of entrained gas as to ensure that the measured results are not significantly influenced.

The response time of the temperature sensor and the sampling interval shall be chosen to maintain the uncertainties in Table 1.

Ducted air systems shall be sufficiently airtight to ensure that the measured results are not significantly influenced by exchange of air with the surroundings.

If, in the instructions, the manufacturer indicates a value for the temperature set on the control device for a given part load conditions, this value shall be used.

Temperature and pressure measuring points shall be arranged in order to obtain mean significant values.

For free air intake temperature measurements, it is required either:

— to have at least one sensor per square metre, with not less than four measuring points and by restricting to 20 the number of sensors equally distributed on the free air surface; or

— to use a sampling device that shall be completed by four sensors for checking uniformity if the surface area is greater than 1 m^2.

Air temperature sensors shall be placed at a maximum distance of 0,25 m from the free air surface.

For water and brine, the density and specific heat in Formulae (2), (3) and (4) shall be determined in the temperature conditions measured near the volume flow measuring device.

The uncertainties of measurement shall not exceed the values specified in Table 1.

Table 1 — Uncertainties of measurement

Measured quantity	Unit	Uncertainty
Liquid		
Temperature	°C	0,15 K
Temperature difference	K	0,15 K
Volume flow	l/min	1 %
Static pressure difference	kPa	1 kPa (≤20 kPa) 5 % (>20 kPa)
Concentration (for brine)	%	2 %
Air		
Dry bulb temperature	°C	0,2 K
Wet bulb temperature	°C	0,4 K
Volume flow	m^3/h	5 %
Static pressure difference	Pa	5 Pa ($\Delta P \leq 100$ Pa) 5 % ($\Delta P > 100$ Pa)
Electrical quantities		
Electric power	W	1 %
Electrical energy	kWh	1 %
Voltage	V	0,5 %
Current	A	0,5 %

Additionally, the heating capacity measured on the liquid side shall be determined within a maximum uncertainty of 5 % at standard rating conditions for the determination of the water flowrate and calculated according to Formula (1) at part load conditions, independently of the individual uncertainties of measurements including the uncertainties on the properties of the fluid.

$$u_{max} = \left(2 + \frac{3}{p_l}\right) \tag{1}$$

5.2 Test room for the airside

The size of the test room shall be selected to avoid any resistance to air flow at the air inlet and air outlet orifices of the test object. The air flow through the room shall not be capable of initiating any short circuit between the two orifices, and therefore the velocity of air flow at these two locations shall not exceed 1,5 m/s when the test object is switched off.

Unless otherwise stated by the manufacturer, the air inlet and air outlet orifices shall not be less than 1 m from the surfaces of the test room.

Any direct heat radiation (e.g. solar radiation) onto heating units in the test room onto the heat pump or onto the temperature measuring points shall be avoided.

5.3 Installation and connection of the heat pump

The heat pump shall be installed and connected for the test as recommended by the manufacturer in the installation and operation manual. If a supplementry heater is provided (as an option or not), it shall be switched off or disconnected to be excluded from the testing.

5.4 Installation of heat pumps consisting of several parts

In the case of heat pumps consisting of several refrigeration parts (split heat pumps), the following installation conditions shall be met for the tests:

a) each refrigerant line shall be installed in accordance with the manufacturer's instructions; the length of each line shall be between 5 m and 7,5 m;

b) the lines shall be installed so that the difference in elevation does not exceed 2,5 m;

c) thermal insulation shall be applied to the lines in accordance with the manufacturer's instructions;

d) unless constrained by the design, at least half of the interconnecting lines shall be exposed to the outdoor conditions with the rest of the lines exposed to the indoor conditions.

5.5 Environment conditions for indoor unit installation and electrical power supply requirements

Temperature conditions of parts of the unit located in the indoor side shall be between 15 °C to 30 °C. The dry bulb temperature shall be measured.

For all units, electrical power voltage and frequency shall be given by the manufacturer.

6 Setting and part load test conditions

6.1 General

Set points for internal control equipment of the unit, i.e. thermostats, pressure switches or mixing valves, shall be set to the values as stated in the installation and operating instructions.

If several set points or a range are stated, the manufacturer shall indicate the one to be used for the tests.

6.2 Setting for capacity ratio

The capacity ratio to be tested shall be set according to the instructions of the manufacturer. The manufacturer shall provide laboratories with the necessary information on the setting of the unit for operating at the required capacity conditions upon request. The unit shall operate continuously during the part load test. The only discontinuity allowed is the defrost cycle of a unit.

For staged or variable capacity units, the setting of the compressor (stage, frequency) shall be done for each part load condition. The manufacturer shall provide in the documentation information instructions on how to obtain the necessary data to set the required frequencies. To set up a system with staged or variable capacity control, skilled personnel with knowledge of control software may be required. The manufacturer or his nominated agent may be present when the system is being installed and prepared for tests.

6.3 Setting the external static pressure difference for ducted units

The volume flow and the pressure difference shall be related to standard air and with dry heat exchanger. If the air flow rate is given by the manufacturer with no atmospheric pressure, temperature and humidity conditions, it shall be considered as given for standard air conditions.

The air flow rate as stated in the installation and operating instructions shall be converted into standard air conditions. The air flow rate setting shall be made when the fan only is operating.

The rated air flow rate as stated in the installation and operating instructions shall be set and the resulting external static pressure (ESP) measured.

If ESP is lower than 30 Pa, the fan speed shall be adjusted to reach this minimum value. If no fan speed is available, the air flow rate shall be decreased.

If the installation and operating instructions state that the maximum allowable duct length is for inlet and outlet together less than 2 m, the unit shall be tested with the duct length and the ESP is considered to be 0.

6.4 Setting of units with integral pumps

For units with integral water or brine pumps, the external static pressure shall be set at the same time as the temperature difference.

In case of liquid pump with several fixed speeds or with variable speed, the manufacturer shall provide information on the settings of the pump (speed or external static pressure to achieve).

6.5 Part load test conditions

For the part load tests, the appropriate test conditions shall be chosen from Tables 4 to 6 depending on the selected design conditions and temperature applications. One or several design conditions and temperature applications can be applied.

Three design conditions average (A), colder (C) and warmer (W) are considered as well as three temperature applications, 35 °C, 45 °C and 55 °C, as given in Table 2 and Table 3, respectively.

Table 2 — Design conditions

Design temperature T_d	Design conditions		
	Average (A)	Warmer (W)	Colder (C)
Dry bulb Wet bulb	−10 °C −11 °C	2 °C 1 °C	−22 °C —

Table 3 — Temperature applications

	Temperature application		
Water (brine) outlet temperature	35 °C	45 °C	55 °C

For each temperature application, the heat pump can either operate with a fixed or a variable water outlet temperature.

For outdoor air dry bulb temperatures higher or equal to −10 °C the wet bulb temperature equals the dry bulb temperature −1 K. For dry bulb temperatures below −10 °C, the wet bulb temperature is not defined.

If the declared T_{OL} is lower than T_d, then the outdoor dry bulb temperature is equal to T_d for the part load condition E in Table 4, Table 5 and Table 6.

The part load ratios shall be based on the part load ratio formulae and not on the rounded values given for each condition in Table 4 to 6.

Table 4 — 35 °C application — Part load conditions for air-to-water(brine) units

Condition	Part load ratio in %				Outdoor heat exchanger	Indoor heat exchanger			
					Inlet dry (wet) bulb temperature °C	Fixed outlet °C	Variable outlet[d] °C		
	Formula	A	W	C	Outdoor air	A/W/C	A	W	C
A	(−7 − 16)/ (T_d −16)	88	n/a	61	−7(−8)	[a]/35	[a]/34	n/a	[a]/30
B	(+2 − 16)/ (T_d −16)	54	100	37	2(1)	[a]/35	[a]/30	[a]/35	[a]/27
C	(+7 − 16)/ (T_d −16)	35	64	24	7(6)	[a]/35	[a]/27	[a]/31	[a]/25
D	(+12 − 16)/ (T_d −16)	15	29	11	12(11)	[a]/35	[a]/24	[a]/26	[a]/24
E	(T_{OL} − 16)/(T_d − 16)				T_{OL}	[a]/35	[a]/[b]	[a]/[b]	[a]/[b]
F	(T_{biv} − 16) / (T_d − 16)				T_{biv}	[a]/35	[a]/[c]	[a]/[c]	[a]/[c]
G	(−15 − 16) / (T_d −16)	n/a	n/a	82	−15	[a]/35	n/a	n/a	[a]/32

[a] With the water flow rate as determined at the standard rating conditions: outdoor air +7 °C/+6 °C (dry bulb/wet bulb), water (brine) +30 °C/+35 °C (inlet/outlet water temperature) for units with a fixed water flow rate, and with a fixed delta T of 5 K for units with a variable flow rate. If the resulting flow rate is below the minimum flow rate, then this minimum flow rate is used with the outlet temperature.

[b] Variable outlet shall be calculated by interpolation from T_d and the temperature which is closest to T_{OL}.

[c] Variable outlet shall be calculated by interpolation between the upper and lower temperatures which are closest to the bivalent temperature.

[d] If the variable outlet temperature is below the minimum of the operation range of the unit, the minimum should be considered.

Table 5 — 45 °C application — Part load conditions for air-to-water(brine) units

Condition	Part load ratio in %				Outdoor heat exchanger	Indoor heat exchanger			
					Inlet dry (wet) bulb temperature °C	Fixed outlet °C	Variable outlet[d] °C		
	Formula	A	W	C	Outdoor air	A/W/C	A	W	C
A	$(-7-16)/(T_d-16)$	88	n/a	61	−7(−8)	[a]/45	[a]/43	n/a	[a]/38
B	$(+2-16)/(T_d-16)$	54	100	37	2(1)	[a]/45	[a]/37	[a]/45	[a]/33
C	$(+7-16)/(T_d-16)$	35	64	24	7(6)	[a]/45	[a]/33	[a]/39	[a]/30
D	$(+12-16)/(T_d-16)$	15	29	11	12(11)	[a]/45	[a]/28	[a]/31	[a]/26
E	$(T_{OL}-16)/(T_d-16)$				T_{OL}	[a]/45	[a]/[b]	[a]/[b]	[a]/[b]
F	$(T_{biv}-16)/(T_d-16)$				T_{biv}	[a]/45	[a]/[c]	[a]/[c]	[a]/[c]
G	$(-15-16)/(T_d-16)$	n/a	n/a	82	−15	[a]/45	n/a	n/a	[a]/41

[a] With the water flow rate as determined at the standard rating conditions: outdoor air +7 °C/+6 °C (dry bulb/wet bulb), water (brine) +40 °C/+45 °C (inlet/outlet water temperature) for units with a fixed water flow rate, and with a fixed delta T of 5 K for units with a variable flow rate. If the resulting flow rate is below the minimum flow rate, then this minimum flow rate is used with the outlet temperature.

[b] Variable outlet shall be calculated by interpolation from T_d and the temperature which is closest to T_{OL}.

[c] Variable outlet shall be calculated by interpolation between the upper and lower temperatures which are closest to the bivalent temperature.

[d] If the variable outlet temperature is below the minimum of the operation range of the unit, the minimum should be considered.

Table 6 — 55 °C application — Part load conditions for air-to-water(brine) units

Condition	Part load ratio in %				Outdoor heat exchanger	Indoor heat exchanger			
					Inlet dry (wet) bulb temperature °C	Fixed outlet °C	Variable outlet[d] °C		
	Formula	A	W	C	Outdoor air	A/W/C	A	W	C
A	$(-7 - 16)/(T_d - 16)$	88	n/a	61	−7(−8)	[a]/55	[a]/52	n/a	[a]/44
B	$(+2 - 16)/(T_d - 16)$	54	100	37	2(1)	[a]/55	[a]/42	[a]/55	[a]/37
C	$(+7 - 16)/(T_d - 16)$	35	64	24	7(6)	[a]/55	[a]/36	[a]/46	[a]/32
D	$(+12 - 16)/(T_d - 16)$	15	29	11	12(11)	[a]/55	[a]/30	[a]/34	[a]/28
E	$(T_{OL} - 16)/(T_d - 16)$				T_{OL}	[a]/55	[a]/[b]	[a]/[b]	[a]/[b]
F	$(T_{biv} - 16)/(T_d - 16)$				T_{biv}	[a]/55	[a]/[c]	[a]/[c]	[a]/[c]
G	$(-15 - 16)/(T_d - 16)$	n/a	n/a	82	−15	[a]/55	n/a	n/a	[a]/49

[a] With the water flow rate as determined at the standard rating conditions: outdoor air +7 °C/+6 °C (dry bulb/wet bulb), water (brine) +47 °C/+55 °C (inlet/outlet water temperature) for units with a fixed water flow rate, and with a fixed delta T of 8 K for units with a variable flow rate. If the resulting flow rate is below the minimum flow rate, then this minimum flow rate is used with the outlet temperature.

[b] Variable outlet shall be calculated by interpolation T_d and the temperature which is closest to T_{OL}.

[c] Variable outlet shall be calculated by interpolation between the upper and lower temperatures which are closest to the bivalent temperature.

[d] If the variable outlet temperature is below the minimum of the operation range of the unit, the minimum should be considered.

For fixed capacity unit with a variable outlet temperature and for variable capacity units at part load conditions where their minimum heating capacity is higher than the heating load, the inlet and/or outlet water temperatures for testing shall be recalculated in order to obtain an average outlet temperature ($T_{out,av}$) equal to the variable outlet temperature as specified in the Tables 4, 5 and 6 of part load conditions, as applicable.

The inlet and outlet water temperatures, $T_{in.test}$ and $T_{out,test}$ respectively are determined using Formula (2) in an iterative process until a convergence of less than or equal to the value of permissible deviation of the mean value $T_{out,test}$ defined in Table 7 is reached.

$$T_{out,av} = T_{in,test} + (T_{out,test} - T_{in,test}) \times C_R \quad (2)$$

C_R calculation is described in 8.5.1.

7 Space heating test

7.1 Heating capacity test

The heating capacity of heat pumps shall be determined in accordance with the direct method at the water or brine heat exchanger, by determination of the volume flow of the heat transfer medium, and the inlet and outlet temperatures, taking into consideration the specific heating capacity and density of the heat transfer medium.

For steady state operation, the heating capacity shall be determined using Formula (3):

$$\Phi_H = q \times \rho \times c_p \times \Delta T \tag{3}$$

where

Φ_H is the heating capacity, expressed in watts;

q is the volume flow rate, expressed in cubic metres per second;

ρ is the density, measured at the flow meter location, expressed in kilograms per cubic metre;

c_p is the specific heat, measured at the flow meter location, at constant pressure, expressed in joules per kilogram and kelvin;

ΔT is the difference between inlet and outlet temperatures, expressed in kelvin.

NOTE 1 The mass flow rate can be determined directly instead of the term $(q \times \rho)$.

NOTE 2 The enthalpy change ΔH can be directly measured instead of the item $(C_p \times \Delta T)$.

7.2 Heating capacity correction

7.2.1 General

The capacity shall include the correction due to the heat output of indoor liquid pump, integrated into the unit or not as follows.

7.2.2 Capacity correction due to indoor liquid pump

7.2.2.1 Units with integrated liquid pump

If the liquid pump is an integrated part of the unit, the capacity correction as defined in 7.2.2.3 or 7.2.2.4 shall be subtracted from the measured heating capacity.

7.2.2.2 Units with non-integrated liquid pump

If the liquid pump is not an integrated part of the unit, the capacity correction as defined in 7.2.2.5 shall be added to the measured heating capacity.

7.2.2.3 Capacity correction for integrated glandless circulators

If the unit is equipped with a glandless circulator, the capacity correction is calculated using Formula (4):

$$(q \times \Delta p_e) \times \left[\frac{(1-\eta)}{\eta}\right] \tag{4}$$

where

η is the global efficiency of the pump calculated according to Annex B;

Δp_e is the measured available external static pressure difference, in pascals;

q is the measured liquid flow rate, in cubic metres per second.

7.2.2.4 Capacity correction for integrated dry motor pumps

If the unit is equipped with a dry-motor pump, the capacity correction is calculated using Formula (5):

$$(q \times \Delta p_e) \times \left[\frac{(IE - \eta)}{\eta}\right] \quad (5)$$

where

- η is the global efficiency of the pump calculated according to Annex B;
- Δp_e is the measured available external static pressure difference, in pascals;
- q is the measured liquid flow rate, in cubic metres per second;
- IE is the motor efficiency in IEC 60034-30-1.

7.2.2.5 Capacity correction for non-integrated liquid pumps

If the measured hydraulic power according to Annex B is ≤300 W, the liquid pump is considered as a glandless circulator. The capacity correction is calculated using Formula (6):

$$\lfloor q \times (-\Delta p_i) \rfloor \times \left[\frac{(1 - \eta)}{\eta}\right] \quad (6)$$

where

- η is the global efficiency of the pump calculated according to Annex B;
- Δp_i is the measured internal static pressure difference, in pascals;
- q is the measured liquid flow rate, in cubic metres per second.

If the measured hydraulic power according to Annex B is >300 W, the liquid pump is considered as a dry-motor pump. The capacity correction is calculated using Formula (7):

$$\lfloor q \times (-\Delta p_i) \rfloor \times \left[\frac{(IE - \eta)}{\eta}\right] \quad (7)$$

where

- η is the global efficiency of the pump calculated according to Annex B;
- Δp_i is the measured internal static pressure difference, in pascals;
- q is the measured liquid flow rate, in cubic metres per second;
- IE is equal to 0,88 (the average of the motor efficiency for IE3 efficiency in IEC 60034-30-1)

7.2.3 Effective power input

7.2.3.1 General

The effective power input shall include the correction due to the power input of indoor liquid pump and outdoor fan (if applicable), integrated or not in the unit as follows.

7.2.3.2 Power input correction of fans for units without duct connection

In the case of units which are not designed for duct connection, i.e. which do not permit any external pressure differences, and which are equipped with an integral fan, the power absorbed by the fan shall be included in the effective power absorbed by the unit.

7.2.3.3 Power input correction of fans for units with duct connection

7.2.3.3.1 Power input correction for integrated fans

If a fan is an integral part of the unit, only a fraction of the power input of the fan motor shall be included in the effective power absorbed by the unit. The fraction that shall be excluded from the total power absorbed by the unit shall be calculated using Formula (8):

$$\frac{(q \times \Delta p_e)}{\eta} \tag{8}$$

where

η	is 0,3 by convention;
Δp_e	is the measured available external static pressure difference, in pascals;
q	is the nominal air flow rate, in cubic metres per second.

7.2.3.3.2 Power input correction for non-integrated fans

If no fan is provided with the unit, the proportional power input which is to be included in the effective power absorbed by the unit shall be calculated using the Formula (9):

$$\frac{[q \times (-\Delta p_i)]}{\eta} \tag{9}$$

where

η	is 0,3 by convention;
Δp_i	is the measured internal static pressure difference, in pascals;
q	is the nominal air flow rate, in cubic metres per second.

7.2.3.4 Power input correction of liquid pumps

7.2.3.4.1 Power input correction for integrated liquid pumps

When the liquid pump is integrated into the unit, it shall be connected for operation. When the liquid pump is delivered by the manufacturer apart from the unit, it shall be connected for operation according to the manufacturer's instructions and be then considered as an integral part of the unit.

For an integrated liquid pump, only a fraction of the input to the pump motor shall be included in the effective power absorbed by the unit. The fraction which is to be excluded from the total power absorbed by the unit shall be calculated using Formula (10):

$$\frac{(q \times \Delta p_e)}{\eta} \tag{10}$$

where

η is the efficiency of the pump calculated according to Annex B;

Δp_e is the measured available external static pressure difference, in pascals;

q is the measured liquid flow rate, in cubic metres per second.

In case the liquid pump is not able to provide any external static pressure difference, this correction does not apply but the correction shall be made according to 7.2.3.4.2.

7.2.3.4.2 Power input correction for non-integrated liquid pumps

If no liquid pump is provided with the unit, the proportional power input which is to be included in the effective power absorbed by the unit shall be calculated using Formula (11):

$$\frac{[q \times (-\Delta p_i)]}{\eta} \tag{11}$$

where

η is the efficiency of the pump calculated according to Annex B;

Δp_i is the measured internal static pressure difference, in pascals;

q is the measured liquid flow rate, in cubic metres per second.

7.3 Test procedure

7.3.1 General

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. The heating capacity test procedure shall be as specified in Annex A.

7.3.2 Permissible deviations

Deviations from set values shall not exceed values indicated in Table 7. Variations from specified conditions shall not exceed values indicated in Table 8.

Table 7 — Permissible deviations from set values for steady-state operation

Measured quantity	Permissible deviation of the arithmetic mean values from set values	Permissible deviations of individual measured values from set values
Liquid		
inlet temperature	±0,2 K	±0,5 K
outlet temperature	±0,3 K	±0,6 K
volume (mass) flow[a]	±1 %	±2,5 %
static pressure difference	—	±10 %

[a] For units with outdoor heat exchanger surfaces greater than 5 m^2, the permissible deviation is double. When testing single duct units, the arithmetic mean value of the difference between the dry bulb temperature of the indoor compartment and of the air introduced from the outdoor compartment should have a maximum permissible deviation of 0,3 K. This requirement also applies to the wet bulb temperature difference.

[b] This variation applies to the set temperature difference. If equal to 1 K, the temperature difference is thus allowed to vary between 0,7 K and 1,3 K.

Table 7 *(continued)*

Measured quantity	Permissible deviation of the arithmetic mean values from set values	Permissible deviations of individual measured values from set values
Air		
inlet temperature (dry bulb)[a]	±0,3 K	±1 K
inlet temperature (wet bulb)[a]	±0,4 K	±1 K
(dry bulb - wet bulb)	±0,3 K	—
temperature difference[b]		
— volume flow	±5 %	±10 %
— static pressure difference	—	±10 %
Refrigerant		
— liquid temperature	±1 K	±2 K
— saturated liquid/bubble point temperature	±0,5 K	±1 K
Voltage	±4 %	±4 %

[a] For units with outdoor heat exchanger surfaces greater than 5 m^2, the permissible deviation is double. When testing single duct units, the arithmetic mean value of the difference between the dry bulb temperature of the indoor compartment and of the air introduced from the outdoor compartment should have a maximum permissible deviation of 0,3 K. This requirement also applies to the wet bulb temperature difference.

[b] This variation applies to the set temperature difference. If equal to 1 K, the temperature difference is thus allowed to vary between 0,7 K and 1,3 K.

Table 8 — Permissible deviations from set values for transient operation

Readings	Variations 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]
Air (entering outdoor-side)				
dry-bulb temperature [a]	±0,6 K	±1,5 K	±1,0 K	±5,0 K
wet-bulb temperature [a]	±0,4 K	±1,0 K	±1,0 K	—
temperature difference (dry bulb-wet bulb)[d]	±0,6 K	—	—	—
Liquid				
inlet temperature	±0,2 K [c]	—	±0,5 K [c]	[b]
outlet temperature	±0,5 K	—	—	—

[a] For units with outdoor heat exchanger surfaces greater than 5 m^2, the allowed deviation is doubled.

[b] The variation shall not exceed – 5,0 K and +2,0 K of the arithmetic mean value measured during the previous interval H.

[c] Only applies to units tested with a fixed temperature difference between water inlet and outlet temperatures.

[d] This variation applies to the set temperature difference. If equal to 1 K, The temperature difference is thus allowed to vary between 0,4 K and 1,6 K.

7.3.3 Preconditioning period

The test room reconditioning apparatus and the heat pump under test shall be operated until the permissible deviations specified in Table 7 are attained for at least 10 min. 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.

It is recommended that the preconditioning ends with an automatic or manually induced defrost cycle when testing at any part load conditions for outdoor air stated in Table 4, Table 5 and Table 6.

7.3.4 Equilibrium period

A complete equilibrium period is 1 h in duration. Except as specified in transient test, the heat pump shall operate while meeting the permissible deviations in Table 7.

7.3.5 Data collection period

The data collection period immediately follows the equilibrium period. Data shall be collected as specified for the test method(s).

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.

7.4 Heating capacity calculation

7.4.1 Steady state capacity test

An average heating capacity shall be determined from the set of heating capacities recorded over the data collection period or on the basis of average values of temperature and volume flow recorded over the data collection period.

7.4.2 Transient capacity test

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.

For equipment where no complete cycle occurs during the data collection period, the following shall apply. The average heating capacity shall be determined by using the integrated capacity and the elapsed time corresponding to the total data collection period.

7.5 Effective power input calculation

7.5.1 Steady state test

An average electric power input shall be determined from the integrated electrical power over the same data collection period than the one used for the heating capacity calculation.

7.5.2 Transient capacity test

An average electric power input shall be determined on the basis of the integrated electrical power and the time corresponding to the total number of complete cycles during the same data collection period as the one used for the heating capacity calculation.

For equipment where no complete cycle occurs during the data collection period, the following shall apply. An average electric power input shall be determined on the basis of the integrated electrical power and the time corresponding to the same data collection period as the one used for the heating capacity calculation.

7.6 Determination of degradation coefficient C_d

The degradation due to the pressure equalization effect when the unit restarts can be considered as negligible.

The only effect that impacts the C_P when cycling is the remaining power input when the compressor is switching off.

The electrical power input during the compressor-off state of the unit is measured during 5 min after the compressor has been switched off for 10 min after the end of the part load test for which the C_d degradation coefficient shall be determined. The compressor shall be switched off by lowering the setpoint in heating mode.

NOTE The change of the setpoint can be achieved by changing the heat curve or the indoor temperature setpoint.

The degradation coefficient (C_d) is determined for each part load ratio by Formula (12):

$$C_d = 1 - \frac{P_{Coff}}{P_{Con}} \tag{12}$$

where

P_{Coff} is the effective power input during compressor-off state;

P_{Con} is the effective power input measured during the corresponding part load test.

In order to measure a power input that is consistent with the definition of the effective power input, if the liquid pump or the fan is an integral part of the unit and in operation during compressor-off state, the available static pressure shall also be measured and the total compressor-off power input be corrected from the power input of the liquid pump or fan to provide this available static pressure, as described in Clause 7. In case the correction obtains a larger value than the measured value for the electric power input during compressor-off state, the electric power input during compressor off state is set to zero.

If the liquid pump or fan is not an integral part of the unit, the compressor-off power input shall be corrected from the fraction of the pump or fan power input that is necessary to overcome the internal static pressure difference as described in Clause 7, in order to measure a pump or fan power input that is consistent with the definition of effective power input. To determine if the liquid pump or fan is operating the control signal shall be measured. If no control signal is available, it shall be assumed that the liquid pump or fan is operating.

If the degradation coefficient C_d is not measured, a default value of 0,9 shall be used.

7.7 Test methods for electric power input during thermostat-off mode, standby mode, crankcase heater mode and off mode

7.7.1 Uncertainties of measurement

The maximum uncertainty of the measurement of the power input for off, thermostat-off, standby and crankcase heater modes shall be as follows:

— 0,3 W up to 10 W,

— 3 % for powers greater than 10 W.

7.7.2 Measurement of electric power input during thermostat-off mode

After the unit has been running for 30 min in “D” test condition, the thermostat set point should be decreased until the compressor stops. The time-averaged power input of the unit is measured over a time period of 60 min starting 10 min after the compressor stops.

In case the unit is not controlled by an indoor sensor but by a heat curve related to the outdoor temperature, an increase in the outdoor temperature shall be simulated. This can either be done by increasing the local temperature around the outdoor sensor, e.g. putting it into a water bath, or by replacing it by a resistor. The simulated outdoor temperature shall be increased until the compressor stops.

In order to measure a power input that is consistent with the definition of the effective power input, if the liquid pump is an integral part of the unit and in operation during thermostat-off mode, the available static pressure shall also be measured and the total thermostat-off power input be corrected from the power input of the liquid pump to provide this available static pressure, as described in Clause 7. In case the correction obtains a larger value than the measured value for the electric power input during thermostat-off mode, the electric power input during thermostat-off mode is set to zero.

If the liquid pump is not an integral part of the unit, the thermostat-off power input shall be corrected from the fraction of the pump power input that is necessary to overcome the internal static pressure difference as described in Clause 7. To determine if the liquid pump is operating, the control signal shall be measured. If no control signal is available, it shall be assumed that the liquid pump is operating.

7.7.3 Measurement of electric power input during standby mode

After the unit has been running for 30 min in “D” test condition, stop the unit with the control device. After 10 min, measure the residual energy consumption during the next 10 min and assume the standby mode consumption. The standby mode power input is the ratio of the measured energy consumption and the duration of test.

In case it is not possible to stop the unit by any control device, set the standby mode power input equal to the thermostat-off mode power input.

7.7.4 Measurement of electric power input during crankcase heater mode

After the unit has been running for 30 min in “D” test condition, stop the unit with the control device. The energy consumption of the unit shall be measured for 8 h starting 10 min after all compressors stop. The power input in crankcase heater mode is the ratio of the measured energy consumption and the duration of the test.

Deduct the standby power input from this measured power input to determine the crankcase heater operation power input.

7.7.5 Measurement of electric power input during off mode

Following the standby mode test, the unit shall be switched in off mode while remaining plugged. After 10 min, measure the residual power input during the next 10 min and assume the average value during this period to be the off mode power input.

In case no off mode switch is available on the unit (e.g. on the indoor unit(s) for split units), the off mode power input is supposed to be equal to the standby mode power input. In case it is neither possible to set the unit in off mode nor in standby mode, assume the off mode power input to be equal to the thermostat-off mode power input.

8 Calculation methods for seasonal coefficient of performance (S_{COP})

8.1 General formula for calculation of S_{COP}

The S_{COP} is defined as the reference annual heating demand Q_H divided by the annual energy consumption for heating Q_{HE} according to Formula (13):

$$S_{COP} = \frac{Q_H}{Q_{HE}} \tag{13}$$

where

Q_H is the reference annual heating demand, expressed in kWh;

Q_{HE} is the annual energy consumption for heating, expressed in kWh.

A set of bin hours for each design condition is provided in Annex C and may be used for S_{COP} calculations. Any other set of bin hours where available may be used.

Annexes D and E are provide examples of S_{COP} calculation for a fixed and a variable capacity unit, respectively.

8.2 Calculation of the reference annual heating demand, Q_H

The annual heating demand Q_H is expressed in kWh and is calculated according to Formula (14):

$$Q_H = \Phi_{dlh} \times H_{HE} \quad (14)$$

where

Φ_{dlh} is the design heating load the unit is suitable for as declared by the manufacturer, expressed in kW;

H_{HE} is the number of equivalent active mode hours for heating. Hours for H_{HE} provided in Annex C or any other hours may be used.

8.3 Calculation of the annual energy consumption, Q_{HE}

The annual energy consumption for heating Q_{HE}, expressed in kWh, includes the energy consumption during active mode, thermostat-off mode, standby mode, off mode and that of the crankcase heater based on Formula (15).

The energy consumption during active mode is derived from the calculation of the $S_{COP,on}$; for determination of $S_{COP,on}$, see 8.4.

$$Q_{HE} = \frac{Q_H}{S_{COP,on}} + H_{TO} \times P_{TO} + H_{SB} \times P_{SB} + H_{CK} \times P_{CK} + H_{OFF} \times P_{OFF} \quad (15)$$

where

Q_H is the annual heating demand, expressed in kWh;

H_{TO}, H_{SB}, H_{CK}, H_{OFF} are the number of hours the unit is considered to work in thermostat-off mode, standby mode, crankcase heater mode and off mode respectively, expressed in h;

P_{TO}, P_{SB}, P_{CK}, P_{OFF} are the power inputs during thermostat-off mode, standby mode, crankcase heater mode and off mode respectively, expressed in kW;

$S_{COP,on}$ is the active mode seasonal coefficient of performance, see 8.4.

Hours for H_{TO}, H_{SB}, H_{CK}, H_{OFF} provided in Annex C or any other hours may be used.

8.4 Calculation of $S_{COP,on}$ and $S_{COP,net}$

The $S_{COP,on}$ and $S_{COP,net}$ are determined according to Formula (16) and Formula (17), respectively.

For units with real or assumed electrical supplementary heater:

$$S_{\text{COP,on}} = \frac{\sum_{j=1}^{n} h_j \left[\Phi_{\text{h}}(T_j) \right]}{\sum_{j=1}^{n} h_j \left[\frac{\Phi_{\text{h}}(T_j) - \Phi_{\text{esh}}(T_j)}{C_{\text{Pb}}(T_j)} + \Phi_{\text{esh}}(T_j) \right]} \quad (16)$$

$$S_{\text{COP,net}} = \frac{\sum_{j=1}^{n} h_j \left[\Phi_{\text{h}}(T_j) - \Phi_{\text{esh}}(T_j) \right]}{\sum_{j=1}^{n} h_j \left[\frac{\Phi_{\text{h}}(T_j) - \Phi_{\text{esh}}(T_j)}{C_{\text{Pb}}(T_j)} \right]} \quad (17)$$

where

T_j	is the bin temperature;
j	is the bin number;
n	is the total number of bins;
$\Phi_{\text{h}}(T_j)$	is the heating load of the building for the corresponding temperature T_j, expressed in kW;
h_j	is the number of bin hours occurring at the corresponding temperature T_j;
$C_{\text{Pb}}(T_j)$	is the C_{P} value of the unit for the corresponding temperature T_j;
$\Phi_{\text{esh}}(T_j)$	is the required capacity of an electric supplementary heater for the corresponding temperature T_j, expressed in kW.

T_j and h_j given in Annex C may be used for the purpose of the calculation.

The heating demand $\Phi_{\text{h}}(T_j)$ is determined by multiplying the design heating load value (Φ_{dlh}) with the part load ratio for each corresponding bin. This part load ratio $p_l(T_j)$ is calculated according to Formula (18):

$$p_l(T_j) = (T_j - 16) / (T_d - 16) \quad (18)$$

where

j	is the bin number;
T_j	is the bin temperature;
T_{d}	is the design temperature for heating.

The C_{Pb} values and capacity values at each bin are determined via interpolation of the C_{Pb} and capacity values at part load conditions A, B, C, D, E, F and G where applicable. Interpolation of C_{Pb} and capacities are done between the two closest part load conditions (as mentioned in Tables 4, 5 and 6).

The C_{Pb} values and capacity values for part load conditions above D are extrapolated from the C_{Pb} values and capacity values at part load conditions C and D.

If the capacity of the unit is lower than the value of $\Phi_{\text{h}}(T_j)$, correction shall be made for the missing capacity with an electric supplementary heater with a C_{P} of 1.

The unit does not run below T_{OL} (operation limit). The capacity of the unit at outside air temperatures below T_{OL} is 0 kW. Correction shall be made for the missing capacity with an electric supplementary heater with a C_{P} of 1.

8.5 Calculation procedure for determination of C_{Pb} values at part load conditions A to G

8.5.1 General

In part load conditions A to G, where applicable, there are two possibilities:

— if the declared capacity of a unit is matching with or lower than the required heating demand, the corresponding C_{Pd} value of the unit is to be used;

— if the declared capacity of a unit is higher than the required heating load, the unit has to cycle on/off. This may occur with fixed capacity or staged or variable units. In such cases, a degradation factor(C_d) has to be used to calculate the corresponding C_{Pb} value. The calculation shall be done according to Formula (20).

C_R is the ratio of the heating load over the declared capacity (Φ_{dh}) of the unit at the same temperature conditions, calculated according to Formula (19):

$$C_R = p_l\left(T_j\right) \times \frac{\Phi_{dlh}}{\Phi_{dh}} \tag{19}$$

where

Φ_{dlh}	is the design heating load of the building the unit is suitable for as declared by the manufacturer, expressed in kW;
$p_l(T_j)$	is the part load ratio as given in Formula (18);
Φ_{dh}	is the declared capacity of the unit at the same temperature conditions as for part load conditions A to G where applicable.

NOTE If the value of C_R is greater than 1, C_R is equal to 1.

8.5.2 Calculation procedure for fixed capacity units

For part load conditions A to G in Tables 4 to 6, where applicable, the C_{Pb} is calculated according to Formula (20):

$$C_{Pb} = C_{Pd} \times \frac{C_R}{C_d \times C_R + (1 - C_d)} \tag{20}$$

where

C_{Pd}	is the C_P corresponding to the declared capacity (Φ_{dh}) of the unit at the same temperature conditions as for part load conditions A to G, where applicable;
C_d	is the degradation coefficient;
C_R	is the capacity ratio.

For determination of the C_d value, see 7.6. If C_d is not determined by test, the default degradation coefficient C_d shall be 0,9.

8.5.3 Calculation procedure for staged and variable capacity units

8.5.3.1 For temperatures above or equal to T_{biv}

The capacity, effective power input and C_P shall be determined at the closest step or increment of the capacity control of the unit to reach the required heating load.

If the resulting capacity is within ±10 % of the required heating load (e.g. between 9,9 kW and 8,1 kW for a required heating load of 9 kW), the required heating load is considered achieved. The resulting capacity and C_P are considered as Φ_{dh} and C_{Pd}. C_{Pd} shall be used as C_{Pb} and no supplementary heat is to be considered.

If the resulting capacity is deviating from the required heating load by more than ±10 %, then another capacity and effective power input shall be determined at the same part load conditions for the step or increment of the capacity control on the opposite side of the required heating load. The part load effective power input at the required heating load is determined by linear interpolation between the two effective power input values obtained at these two steps. The C_{Pb} is determined by dividing the required heating load and the interpolated part load effective power input. The declared capacity Φ_{dh} is equal to the required heating load.

If the resulting capacity achieved with the smallest step of the capacity control exceeds the required heating load by more than 10 %, then the procedure for the determination of C_{Pb} described in 8.5.2 shall apply. The resulting capacity is considered as Φ_{dh}.

NOTE For temperatures above or equal to T_{biv} the declared capacity Φ_{dh} cannot be lower than 90 % of the required heating load.

8.5.3.2 For temperatures below T_{biv}

The capacity, effective power input and C_P shall be determined at the closest step or increment of the capacity control of the unit to reach the required heating load.

The required heating load cannot be achieved by the heat pump.

The resulting capacity and C_P are considered as Φ_{dh} and C_{Pd}. Φ_{dh} shall be supplemented by $\Phi_{esh}(T_j)$ in the calculation of the annual energy consumption. The declared C_{Pd} shall be used as C_{Pb}.

NOTE For temperatures below T_{biv} the declared capacity Φ_{dh} cannot exceed the required heating load.

9 Test results and test report

9.1 Data

The data that shall be recorded for each part load test are given in Table 9. Table 9 identifies the general information required but is not intended to limit the data to be recorded. These data shall be the mean values taken over the data collection period, with the exception of time measurement.

Table 9 — Data to be recorded

Measured quantity of result	Unit	Water enthalpy method – Nonducted	Water enthalpy method – Ducted
Ambient conditions			
Air temperature, dry bulb	°C	*x*	*x*
Atmospheric pressure	kPa	*x*	*x*
Electrical quantities			
Voltage	V	*x*	*x*
Total current	A	*x*	*x*
Total power input, P_T	W	*x*	*x*
Effective power input, P_E	W	*x*	*x*
Thermodynamic quantities			
a) Water or brine			
inlet temperature	°C	x	x

Table 9 *(continued)*

Measured quantity of result	Unit	Water enthalpy method – Nonducted	Water enthalpy method – Ducted
outlet temperature	°C	x	x
volume flow	l/min	x	x
pressure difference	kPa	x	x
b) Air source heat exchanger			
Air			
inlet temperature, dry bulb	°C	x	x
inlet temperature, wet bulb	°C	x	x
For duct connection			
external/internal static pressure difference	Pa		x
volume flow rate, q	m^3/s		x
c) Compressor			
rotational speed of open type	r/min	x	x
power input of motor	W	x	x
d) Defrost			
defrost period	s	x	x
Operating cycle with defrost	min	x	x
Data collection period	min	x	x
Heating capacities	W	x	x

9.2 Test report

The test report shall at least contain the following elements:

a) date;

b) test institute;

c) test location;

d) test method;

e) test supervisor;

f) test object designation:

1) type;

2) serial number;

3) name of the manufacturer;

g) type of refrigerant;

h) mass of refrigerant;

i) properties of fluids.

10 Marking provisions

10.1 General

National legislation for marking provisions of products within the scope of this document shall prevail. If such legislation does not exist, the following requirements shall apply.

10.2 Nameplate requirements

Each air to water heat pump, whether composed of a single package or separate assemblies, shall have a durable nameplate, firmly attached to each separate assembly in a location accessible for reading.

10.3 Nameplate information

The nameplate shall provide the following minimum information in addition to the information required by safety standards:

a) the manufacturer's name or trademark;

b) distinctive type or model designation and serial number;

c) rated voltage(s);

d) rated frequency(ies);

e) refrigerant designation.

NOTE The manufacturer is considered to be the firm identified on the nameplate.

Annex A
(normative)

Heating capacity test procedures given in 7.3

A.1 General

A.1.1 Preconditioning period

The test room reconditioning apparatus and the heat pump under test shall be operated until the permissible deviations specified in Table 7 are attained for at least 10 min. 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.

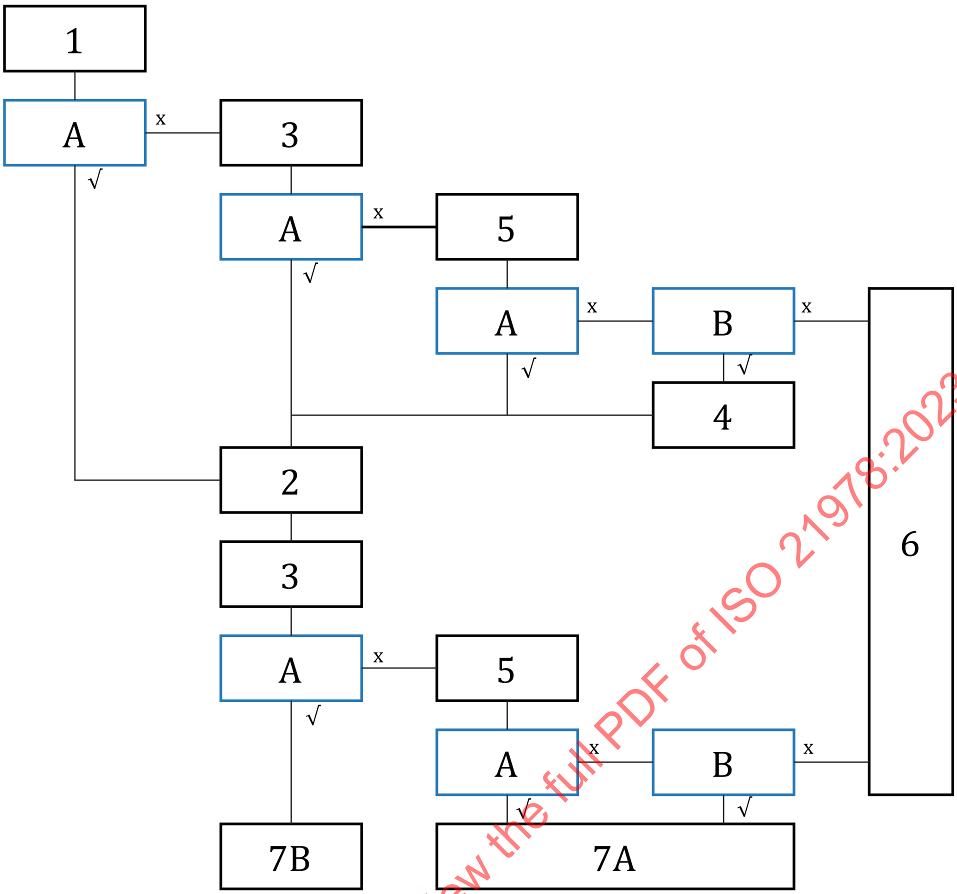
A.1.2 Equilibrium period

A complete equilibrium period is 1 h in duration. Except as specified in transient test, the heat pump shall operate while meeting the permissible deviations in Table 7.

A.1.3 Data collection period

The data collection period immediately follows the equilibrium period. Data shall be collected as specified for the test method(s).

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 the sampling rate for data collection of at least every 10 s.



Key

✓	yes	3	Step 3: Equilibrium period
×	no	4	Step 4: Defrost cycle
A	Did a defrost cycle occur?	5	Step 5: Data collection
B	Did the quantity % ΔT exceed 2,5 %?	6	Step 6: Steady-state operation
1	Step 1: Preconditioning	7A	Step 7A: Transient operation
2	Step 2: End of defrost cycle	7B	Step 7B: Transient operation

Figure A.1 — Flowchart of steps procedure

The test procedure shall identify whether the data collection will occur in steady-state operation of the unit or will integrate transient operation of the unit (due to defrost cycles that may occur depending on the operating conditions).

A defrost cycle starts when the operation of the unit is modified to manage the defrost of the outdoor heat exchanger.

NOTE 1 The following are examples of modified operation which define the start of a defrost cycle:

— the 4-way valve signal indicates a change of state;

— the water temperature difference between inlet and outlet is smaller than 0,2 K;

— one or several compressor(s) stop(s).

A defrost cycle ends when the operation of the unit comes back to heating.

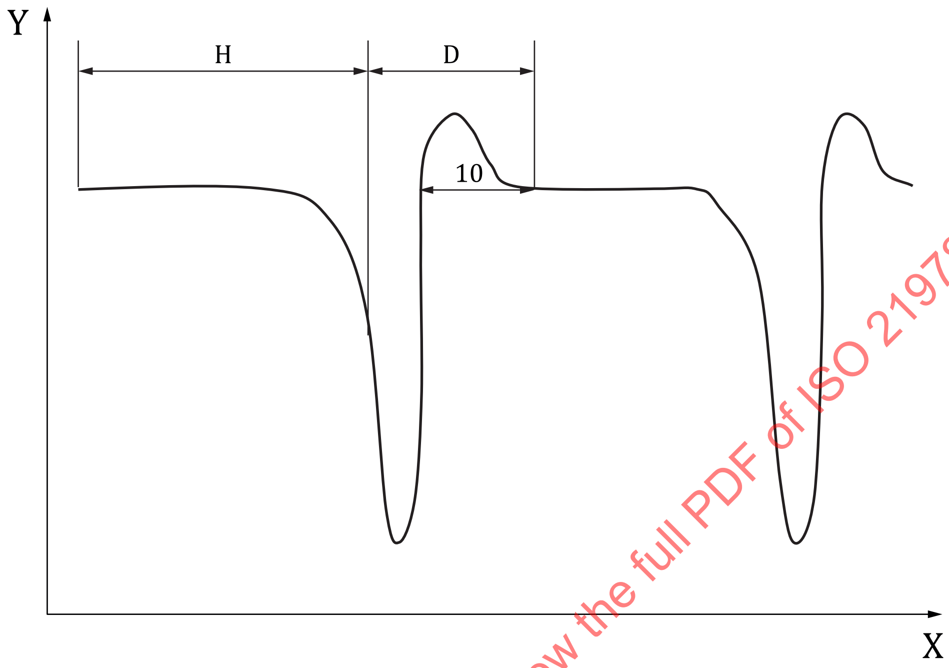
NOTE 2 The following are examples of modified operation which define the end of a defrost cycle:

— the 4-way valve signal indicates a change of state;

— the water temperature difference between inlet and outlet is larger than 0,2 K;

— one or several compressor(s) start(s).

In transient regime, an interval H is defined as a heating period with the exception of the first 10 min after defrost termination. An interval D consists of a defrost cycle plus the first 10 min of heating operation after the termination of the defrost cycle (see Figure A.2).



Key

X time, in min

Y water temperature, in °C

Figure A.2 — Example of defrost cycle with intervals H and D

During intervals H, data shall be sampled at equal intervals that span every 30 s or less.

During intervals D, data used in evaluating the integrated heating capacity and the integrated power input of the heat pump shall be sampled more frequently, at equal intervals that span every 10 s or less.

The test procedure is applicable to both the air enthalpy and the calorimeter room methods.

The test procedure is described by the following flowchart (see Figure A.1). The steps of the flowchart shall immediately follow each other.

The different steps of the procedure are explained in A.2 to A.8.

For air-to-water units which are tested with a fixed temperature difference between inlet and outlet temperatures, the setting of the water flowrate shall be done as follows.

a) The water flow rate is set during the preconditioning period (Step 1).

b) When and if the unit undergoes the first defrost cycle at any step of the procedure, it shall be checked if the permissible deviations specified in Table 8 are fulfilled on a 5-min period starting 20 min after the end of this defrost cycle.

c) If the above requirement is not fulfilled, the water flowrate shall be adapted and the whole procedure shall be restarted from Step 1 with this new water flowrate.

A.2 Step 1: Preconditioning

The test room reconditioning apparatus and the heat pump under test shall start and operate until the permissible deviations specified in Table 7 are attained for at least 10 min.

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

Question A : Did a defrost cycle occur ?

— If Step 1 ends with a defrost cycle, then go to Step 2.

— If Step 1 does not end with a defrost cycle, go to Step 3.

A.3 Step 2: End of defrost cycle

As the previous Step terminates with a defrost cycle, wait 10 min after this defrost cycle before to continue with Step 3.

Defrost cycle of the previous step and these 10 min constitute an interval D for which permissible deviations specified in Table 8 apply.

A.4 Step 3: Equilibrium period

During an equilibrium period of 60 min, the heat pump shall operate, while meeting the permissible deviations specified in Table 7. If a defrost occurs during this period, the permissible deviations specified in Table 8 apply.

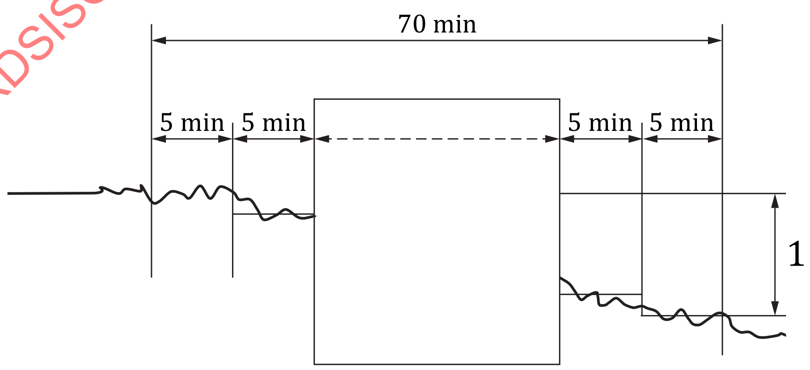
Question A: Did a defrost cycle occur?

— If Step 3 ends with a defrost cycle, then go to next Step, either Step 2 or Step 7B.

— If Step 3 does not end with a defrost cycle, go to Step 5.

NOTE If a defrost occurs before the end of Step 3, it is not necessary to wait for the complete duration of this step. The test can continue directly with the next step of the flowchart.

A.5 Step 5: Data collection



Key

1 %ΔT

Figure A.3 — Data collection

Data shall be collected for a duration of 70 min.

The difference between the leaving and entering temperatures of the heat transfer medium at the indoor heat exchanger shall be measured during this Step 5 of data collection. For each interval of 5 min during the data collection period, an average temperature difference shall be calculated, ΔTi (t). The average temperature difference for the first 5 min of the data collection period, ΔTi (t = 0), shall be saved for the purpose of calculating the following percent change, [see Formula (A.1)]:

$$\%\Delta T = \frac{\Delta T_i\,(t=0) - \Delta T_i\,(t)}{\Delta T_i\,(t=0)} \tag{A.1}$$

Question A: Did a defrost cycle occur?

— If Step 5 does not terminate with a defrost cycle, check Question B.

— If Step 5 does terminate with a defrost cycle, go to next Step, either Step 2 or Step 7A.

NOTE If a defrost occurs before the end of Step 5, it is not necessary to wait for the complete duration of this step. The test can continue directly with the next step of the flowchart.

Question B: Did the quantity $\%\Delta T$ exceed 2,5 %?

— If the quantity $\%\Delta T$ did not exceed 2,5 %, then go to Step 6.

— If the quantity $\%\Delta T$ did exceed 2,5 %, then go to next step, either Step 4 or Step 7A.

A.6 Step 4: Defrost cycle

As the previous Step does not terminate with a defrost cycle, wait for a defrost cycle prior to continue with Step 2.

A.7 Step 6: Steady state operation

The test is considered to be steady state and shall be terminated after the data collection (Step 5) during which permissible deviations specified in Table 7 were fulfilled.

Periodic fluctuations of measured quantities caused by the operation of regulation and control devices are permissible on condition the mean value of such fluctuations does not exceed the permissible deviations listed in Table 7.

Data from the 70 min of the data collection is used for calculating the heating capacity of the unit.

A.8 Step 7: Transient operation

A.8.1 General

The test is considered to be a transient test and defrost cycles might occur.

As noted in Table 8, the permissible deviations are specified for the two sub-intervals H and D.

All data collected during each interval, H or D, shall be used to evaluate compliance with the Table 8 permissible deviations. Data from two or more H intervals or two or more D intervals shall not be combined and then used in evaluating Table 8 compliance. Compliance is based on evaluating data from each interval separately.

A.8.2 Step 7A

The data collection, including the duration of previous Step 5, is extended until 3 hours have elapsed or until the heat pump completes three complete cycles during the period, whichever occurs first. In Step 7A, the permissible deviations specified in Table 8 shall be achieved during the total duration.

Only the data from the completed cycles that occurred during the 3 hours, are used for performance calculation. If no complete cycle occurs during 3 hours, then the performance is calculated from the average data over the 3 hours.

If at an elapsed time of 3 hours, the heat pump is conducting a defrost cycle, the cycle shall be completed before ending the data recording. A complete cycle consists of a heating period and a defrost period; from defrost termination to defrost termination.

For a multiple refrigerant circuit unit, the data is recorded and calculated over a 3 hours duration whatever the state of cycling of the different refrigerant circuits.

A.8.3 Step 7B

In Step 7B, the data shall be recorded until 3 hours have elapsed or until the heat pump completes three complete cycles during the period, whichever occurs first, as no data collection (Step 5) occurred after the latest equilibrium period (Step 3). In Step 7B, the test tolerances specified in Table 8 shall be achieved during the total duration.

Only the data from the completed cycles that occurred during the 3 hours, are used for performance calculation. If no complete cycle occurs during 3 hours, then the performance is calculated from the average data over the 3 hours.

If at an elapsed time of 3 hours, the heat pump is conducting a defrost cycle, the cycle shall be completed before ending the data recording. A complete cycle consists of a heating period and a defrost period; from defrost termination to defrost termination.

For a multiple refrigerant circuit unit, the data is recorded and calculated over a 3 hours duration whatever the state of cycling of the different refrigerant circuits.

Annex B
(normative)

Determination of the liquid pump efficiency

B.1 General

The method for calculating the efficiency of the liquid pump, whether the pump is an integral part of the unit or not, is based on the relationship between the efficiency of the pump and its hydraulic power.

B.2 Hydraulic power of the liquid pump

B.2.1 When the liquid pump is an integral part of the unit

When the liquid pump is an integral part of the unit, the hydraulic power of the pump, expressed in W is defined as Formula (B.1):

$$P_{hyd} = q \times \Delta p_e \quad \text{(B.1)}$$

where

q is the measured liquid volume flow rate, in cubic metres per second;

Δp_e is the measured available external static pressure difference, expressed in pascal.

B.2.2 When the liquid pump is not an integral part of the unit

When the liquid pump is not an integral part of the unit, the hydraulic power of the pump, expressed in W is defined as Formula (B.2):

$$P_{hyd} = q \times (-\Delta p_i) \quad \text{(B.2)}$$

where

q is the measured liquid volume flow rate, in cubic metres per second;

Δp_i is the measured internal static pressure difference, expressed in pascal.

B.3 Efficiency of integrated pumps

B.3.1 Glandless circulators

For glandless circulators, the calculation of the global efficiency η is based on the energy efficiency index (E_{EI}) and using Formula (B.3):

$$\eta = \frac{0{,}358\,44 \times P_{hyd}}{1{,}7 \times P_{hyd} + 17 \times \left(1 - e^{-0{,}3 \times P_{hyd}}\right)} \times \frac{C_{20}}{E_{EI}} \quad \text{(B.3)}$$

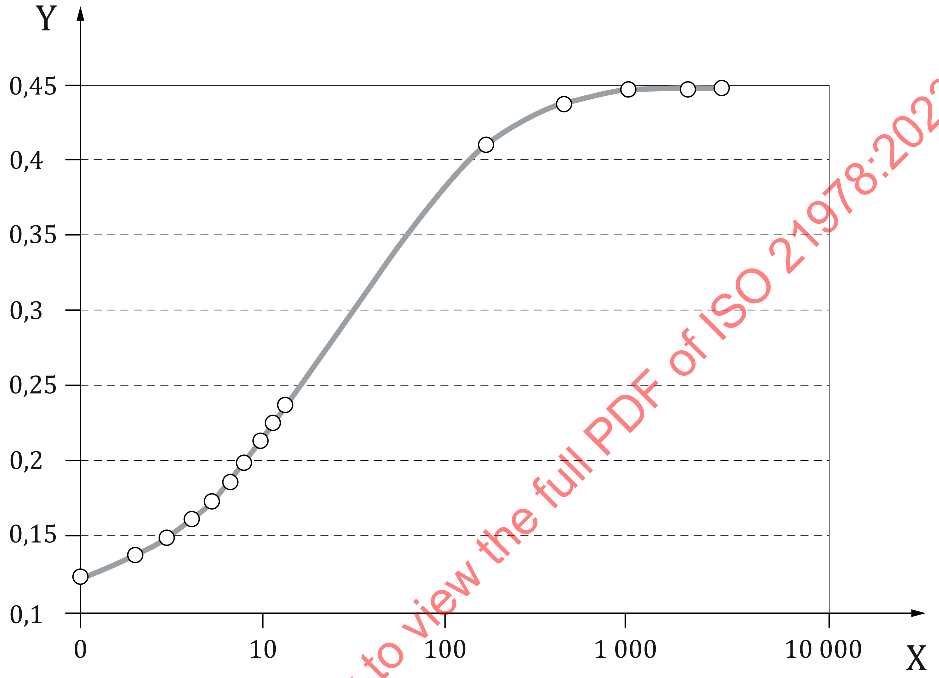
where

P_{hyd} is the hydraulic power of the pump, expressed in W;

C_{20} is a scaling factor equal to 0,49;

E_{EI} is the energy efficiency index equal to 0,23.

For information, the graphs of efficiency of the pump versus its hydraulic power are given in Figure B.1.



Key

X hydraulic power P_{hyd} (W) [1 W≤ P_{hyd} ≤2 500 W]

Y efficiency η(-) [0,125 0≤ η ≤0,447 4]

Figure B.1 — Dependence of the efficiency of the glandless circulators on the hydraulic power

B.3.2 Dry motor pumps

For dry motor pumps, the global efficiency, η, shall be calculated using either Formula (B.4) or Formula (B.5) with respect of the hydraulic power of the pump.

a) When the hydraulic power of the liquid pump, calculated according to Formula (B.1), is lower than or equal to 500 W, the efficiency of the pump is determined using Formula (B.4):

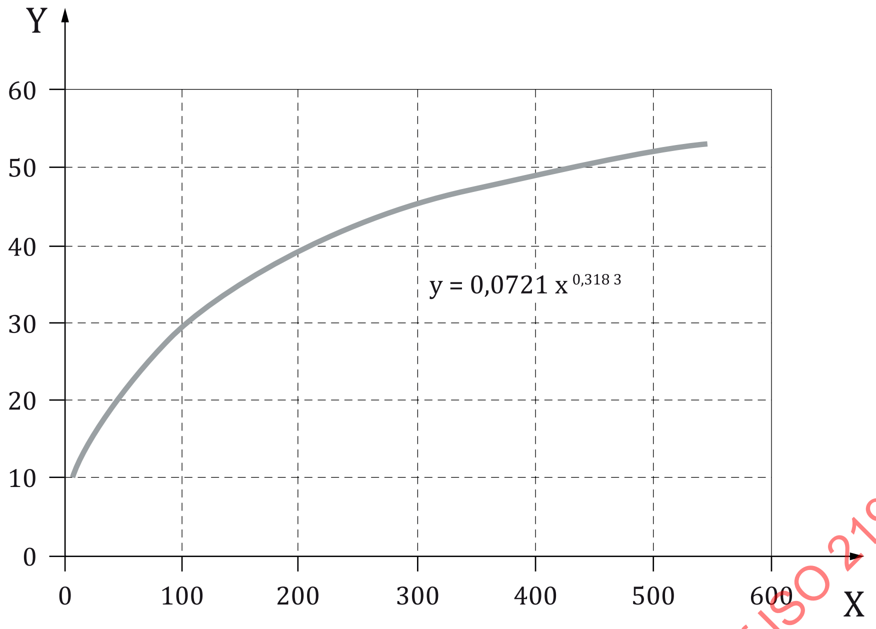
$$\eta = 0{,}0721 P_{hyd}^{0{,}3183} \quad \text{(B.4)}$$

b) When the hydraulic power of the liquid pump, calculated according to Formula (B.1), is greater than 500 W, the global efficiency η of the pump is determined using Formula (B.5):

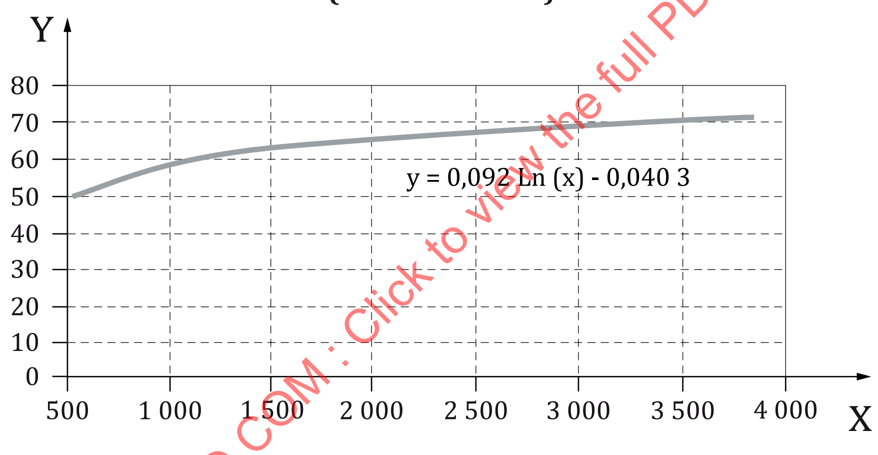
$$\eta = 0{,}092 Ln\left(P_{hyd}\right) - 0{,}0403 \quad \text{(B.5)}$$

where P_{hyd} is the measured hydraulic power of the pump, expressed in W.

For information, the graphs of the efficiency of the pump versus its hydraulic power are given in Figure B.2.



a) Efficiency of circulating pumps with a hydraulic power lower than or equal to 500 W (source: COSTIC)



b) Efficiency of circulating pumps with a hydraulic power greater than 500 W (extrapolation of COSTIC curve above 1 kW)

Key

X hydraulic power P_{hyd} (W)

Y efficiency η (%)

Figure B.2 — Efficiency of the pump versus its hydraulic power graphs

B.4 Efficiency of non-integrated pumps

When the liquid pump is not an integral part of the unit, the calculation of the global efficiency to be taken into account in the pump correction is as follows.

a) When the hydraulic power calculated according to Formula (B.2) is lower than or equal to 300 W, determine the efficiency of the pump using Formula (B.3).

b) When the hydraulic power calculated according to Formula (B.2) is greater than 300 W but lower than or equal to 500 W, determine the efficiency of the pump using Formula (B.4).

c) When the hydraulic power calculated according to Formula (B.2) is greater than 500 W, determine the efficiency of the pump using Formula (B.5).

Annex C
(informative)

Examples of set of bin hours and hours for active mode, thermostat-off mode, standby mode, off mode and crankcase heater mode

The bins given in Table C.1 may be used for the calculations for determination of S_{COP}, $S_{COP,on}$, $S_{COP,net}$ as a reference. If different hours are available, they may be used.

Table C.1 — Bin number *j*, outdoor temperature T_j in °C and number of hours per bin h_j corresponding to the design conditions “warmer”, “average”, “colder”

j #	T_j °C	Warmer h_{jW} h	Average h_{jA} h	Colder h_{jC} h
1 to 8	−30 to −23	0	0	0
9	−22	0	0	1
10	−21	0	0	6
11	−20	0	0	13
12	−19	0	0	17
13	−18	0	0	19
14	−17	0	0	26
15	−16	0	0	39
16	−15	0	0	41
17	−14	0	0	35
18	−13	0	0	52
19	−12	0	0	37
20	−11	0	0	41
21	−10	0	1	43
22	−9	0	25	54
23	−8	0	23	90
24	−7	0	24	125
25	−6	0	27	169
26	−5	0	68	198
27	−4	0	91	278
28	−3	0	89	306
29	−2	0	165	454
30	−1	0	173	385
31	0	0	240	490
32	1	0	280	533
33	2	3	320	380
34	3	22	357	228
35	4	63	356	261
36	5	63	303	279