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Heat pump water heater — 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 classification à charge partielle et calcul du coefficient de performance saisonnier

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Foreword

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

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

Heat pumps water heaters 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 standard provides part load conditions and calculation methods for calculating the Seasonal Coefficient of Performance ($SCOP_{on}$ and $SCOP_{net}$) 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 *SCOP*.

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

Heat pump water heater — Testing and rating at part load conditions and calculation of seasonal coefficient of performance for space heating

1 Scope

The document specifies test conditions for determining the seasonal performance characteristics of air source heat pump water heaters for space heating with electrically driven compressors with or without supplementary heater. The purpose of this document is to rate performance of the heat pump water heaters for space heating with no operation of any supplementary heater. In the case of heat pump water heaters 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 defines:

— 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.

The user of this document is free to determine the seasonal coefficient of performance for one or more of the defined design conditions and for one or more of the defined temperature applications.

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 terminological databases for use in standardization at the following addresses:

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

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

3.1
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.

3.2
active mode seasonal coefficient of performance
$SCOP_{on}$
average coefficient of performance of the unit in *active mode* (3.1) for the designated design condition, determined from the part load, supplementary heating capacity (where required) and *bin-specific coefficients of performance* (3.7) and weighted by the *bin hours* (3.6) where the bin condition occurs

Note 1 to entry: For calculation of $SCOP_{on}$, the energy consumption during *thermostat-off mode* (3.45), *standby mode* (3.42), *off mode* (3.34) and *crankcase heater mode* (3.17) 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.

3.3
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* (3.2) 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/kWh.

3.4
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* (3.41) and calculated as the product of the *design load* (3.21) for heating and the *equivalent active mode hours for heating* (3.27)

Note 1 to entry: Expressed in kWh

3.5
bin
outdoor temperature interval of 1 K

3.6
bin hours
h_j
hours per heating season for which an outdoor temperature occurs for each *bin* (3.5) *j*

3.7
bin-specific coefficient of performance
COP_{bin} (T_j)
coefficient of performance specific for every *bin* (3.5) *j* with outdoor temperature T_j in a heating season

3.8
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.

3.9
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.

3.10
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.

3.11
capacity ratio
CR
heating part load or full load divided by the declared heating capacity of the unit at the same temperature conditions

3.12
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.

3.13
coefficient of performance at part load
COP_{bin}
coefficient of performance at the declared capacity, 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 *COP* includes degradation losses. When the declared capacity of the unit is lower than the heating load (i.e. below the *bivalent temperature* (3.9) condition), the *COP* of the declared capacity is used.

Note 2 to entry: Expressed in kW/kW.

3.14
compressor-off state
condition where the compressor is not running while the unit is operating in *active mode* (3.1)

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

3.15
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.

3.16
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.

3.17
crankcase heater (operation) 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

3.18
declared capacity in heating
Pdh
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.

3.19
degradation coefficient
Cd
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.

3.20
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.

3.21
design load
$P_{designh}$
space heating load declared by the manufacturer at *design temperature* (3.22)

Note 1 to entry: It is possible to calculate the $SCOP/SCOP_{on}/SCOP_{net}$ of a unit for more than one $P_{designh}$ value.

Note 2 to entry: Expressed in kW.

3.22
design temperature
$T_{designh}$
lowest outdoor air temperature considered for each design condition

3.23
effective power input during compressor-off state
Pc_{off}
total power input of the unit when the compressor is switched off in *active mode* (3.1), used for the determination of the *degradation coefficient* (3.19)

Note 1 to entry: Expressed in kW.

3.24
effective power input with declared capacity
Pc_{on}
total power input when the unit is operating at part load condition, used for the determination of the *degradation coefficient* (3.19)

Note 1 to entry: Expressed in kW.

3.25
electric supplementary heater
real or assumed electric supplementary heater, with a *COP* of 1, considered in the calculation of *SCOP* (3.41) and *SCOPon* (3.2)

3.26
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* (3.8) T_j

Note 1 to entry: Expressed in kW.

3.27
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 ($P_{designh}$) in order to satisfy the reference annual heating demand

Note 1 to entry: Expressed in h.

3.28
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

3.29
heat pump water heater for space heating
air source heat pump water heater with electrically driven compressor(s) with or without supplementary heater for space heating purpose

Note 1 to entry: This is also referred to as heat pump in this document.

3.30
high temperature application
temperature application where the indoor heat exchanger water(brine) outlet temperature of 55 °C is met at design temperature

3.31
low temperature application
temperature application where the indoor heat exchanger water(brine) outlet temperature of 35 °C is met at design temperature

3.32
medium temperature application
temperature application where the indoor heat exchanger water(brine) outlet temperature of 45 °C is met at design temperature

3.33
net seasonal coefficient of performance
$SCOP_{net}$
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 $SCOP_{net}$, the energy consumption during *active mode* (3.1) is used. This excludes the energy consumption during *thermostat-off mode* (3.45), *standby mode* (3.42), *off mode* (3.34) 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.

3.34
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.

3.35
off mode operating hours
H_{OFF}
annual number of hours the unit is considered to be in *off mode* (3.34), 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.

3.36
off mode power input
P_{OFF}
power input of the unit while in *off mode* (3.34)

Note 1 to entry: Expressed in W.

3.37
operation limit temperature
TOL
outdoor temperature below which the declared capacity is equal to zero

Note 1 to entry: Expressed in °C.

3.38
part load for heating
$P_h(T_j)$
heating load at a specific *bin temperature* (3.8) T_j, calculated as the design load multiplied by the part load ratio

Note 1 to entry: Expressed in kW.

3.39
part load ratio
$pl(T_j)$
bin temperature (3.8) minus 16 °C divided by the design temperature minus 16 °C

3.40
reactivation function
function facilitating the activation of other modes, including *active mode* (3.1), by remote switch including remote control, internal sensor, timer to a condition providing additional functions, including the main function, but excluding thermostats

3.41
seasonal coefficient of performance
SCOP
overall coefficient of performance of the unit, representative for the designated design condition and set of bin hours

Note 1 to entry: *SCOP* is calculated as the *annual heating demand* (3.4) divided by the *annual energy consumption for heating* (3.3).

Note 2 to entry: Expressed in kWh/kWh.

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

3.43
standby mode operating hours
H_{SB}
annual number of hours the unit is considered to be in *standby mode* (3.42), 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.

3.44
standby mode power input
P_{SB}
power input of the unit due to *standby mode* (3.42) operation

Note 1 to entry: Expressed in W.

3.45
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* (3.1) is not considered as thermostat-off.

3.46
thermostat-off mode operating hours
H_{TO}
annual number of hours the unit is considered to be in *thermostat-off mode* (3.45), 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.

3.47
thermostat-off mode power input
P_{TO}
power input of the unit due to *thermostat-off mode* (3.45) operation

Note 1 to entry: Expressed in W.

3.52
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
Cd	Degradation coefficient	—
COP	Coefficient of performance	kW/kW
COP_{bin}	Coefficient of performance at part load	kW/kW
$COP_{bin}(T_j)$	Bin-specific coefficient of performance	kW/kW
COP_d	Coefficient of performance at the declared capacity	kW/kW
CR	Capacity ratio	kW/kW
EEI	Energy efficiency index of liquid pump	—
h_j	Bin hours	h
H_{HE}	Equivalent active mode hours for heating	h
H_{CK}	Crankcase heater mode operating hours	h
H_{OFF}	Off mode operating hours	h
H_{SB}	Standby mode operating hours	h
H_{TO}	Thermostat-off mode operating hours	h
j	Bin number	—
n	Total number of bin	—
P_{CK}	Crankcase heater mode power input	W
Pc_{off}	Effective power input during compressor-off state	kW
Pc_{on}	Effective power input with declared capacity	kW
Pdh	Declared capacity in heating	kW
$P_{designh}$	Design load heating	kW
$P_h(T_j)$	Part load for heating	kW
P_{OFF}	Off mode power input	W
P_{SB}	Standby mode power input	W
P_{TO}	Thermostat-off mode power input	W
$pl(T_j)$	Part load ratio for bin temperature T_j	—
Q_H	Annual heating demand	kWh
Q_{HE}	Annual energy consumption for heating	kWh
$SCOP$	Seasonal coefficient of performance	kW/kW
$SCOP_{net}$	Net seasonal coefficient of performance	kW/kW
$SCOP_{on}$	Active mode seasonal coefficient of performance	kW/kW
T_{biv}	Bivalent temperature	°C
$T_{designh}$	Design temperature conditions for heating	°C
T_j	Bin temperature (outdoor temperature)	°C
T_{ol}	Operation limit temperature	°C

Symbol	Definition	Units
elbu(T_j)	electric supplementary heater capacity	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 inlet and outlet water temperatures of the heat pump shall be measured in the center of the flow and as close as possible to the unit. 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.

When performing measurements, set the highest room temperature on the unit/system control device. 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 meter, 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	m^3/s	±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/s	±5 %

Table 1 *(continued)*

Measured quantity	Unit	Uncertainty
Static pressure difference	Pa	±5 Pa ($\Delta P \leq 100$ Pa) ±5 % ($\Delta P \geq 100$ 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 calculated according to Formula (1) independently of the individual uncertainties of measurements including the uncertainties on the properties of the fluid.

$$maximum\ uncertainty = 2 + \frac{3}{Part\ load\ ratio} \times 100\ \ (\%) \qquad (1)$$

5.2 Test room for the airside and remote condenser

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 back-up 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 is allowed to attend 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 the ESP is lower than 30 Pa, the air flow rate is decreased to reach this minimum value. The apparatus used for setting the ESP shall be maintained in the same position during all the tests.

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.

When the liquid pump has one or several fixed speeds, the speed of the pump shall be set in order to provide the minimum external static pressure.

In case of variable speed liquid pump, the manufacturer shall provide information to set the pump in order to reach a maximal external static pressure of 10 kPa.

Deviations from set values shall not exceed values indicated in Table 2. Variations from specified conditions shall not exceed values indicated in Table 3.

Table 2 — Permissible deviations from set values

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 flow[a]	±1 %	±2,5 %
— static pressure difference	—	±10 %
Air		
— inlet temperature		
— dry bulb	±0,3 K	±1 K
— wet bulb	±0,4 K	±1 K
Voltage	±4 %	±4 %

[a] Frosting period excluded.

Table 3 — Variations allowed for the test conditions when the heat pump is running

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				
— dry-bulb temperature[c]	±0,6 K	±1,5 K	±1,0 K	±5,0 K
— wet-bulb temperature	±0,4 K	±1,0 K	±0,6 K	—
Liquid				
— inlet temperature	±0,2 K	—	±0,5 K	−5 K
— outlet temperature	±0,5 K	—	±1 K	+2 K

[a] Interval H applies when the heat pump is in the heating mode, except for the first 10 min after termination of a defrost cycle, and the first 10 min after a restart of the heat pump.

[b] Interval D applies during a defrost cycle and during the first 10 min after the termination of a defrost cycle when the heat pump is operating in the heating mode.

[c] For units with outdoor heat exchanger surfaces greater than 5 m^2, the deviation on the air inlet dry bulb temperature is doubled.

6.5 Part load test conditions

For the part load tests, the appropriate test conditions shall be chosen from Tables 6 to 8 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, low, medium and high, as given in Table 4 and Table 5, respectively.

Table 4 — Design conditions

Design temperature $T_{designh}$	Design conditions		
	Average (A)	Warmer (W)	Colder (C)
— Dry bulb	−10 °C	2 °C	−22 °C
— Wet bulb	−11 °C	1 °C	—

Table 5 — Temperature applications

	Temperature application		
	Low	Medium	High
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 minus 1 K. For dry bulb temperatures below −10 °C, the wet bulb temperature is not defined.

If the declared *TOL* is lower than T_{design}, then the outdoor dry bulb temperature is equal to $T_{designh}$ for the part load condition E in Table 6, Table 7 and Table 8.

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 6 to 8.

Table 6 — Low temperature 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	$(-7-16)/(T_{designh}-16)$	88	n/a	61	−7(−8)	[a]/35	[a]/34	n/a	[a]/30
B	$(+2-16)/(T_{designh}-16)$	54	100	37	2(1)	[a]/35	[a]/30	[a]/35	[a]/27
C	$(+7-16)/(T_{designh}-16)$	35	64	24	7(6)	[a]/35	[a]/27	[a]/31	[a]/25
D	$(+12-16)/(T_{designh}-16)$	15	29	11	12(11)	[a]/35	[a]/24	[a]/26	[a]/24
E	$(T_{ol}-16)/(T_{designh}-16)$				T_{ol}	[a]/35	[a] / [b]	[a] / [b]	[a]/[b]
F	$(T_{biv}-16)/(T_{designh}-16)$				T_{biv}	[a]/35	[a] / [c]	[a] / [c]	[a]/[c]
G	$(-15-16)/(T_{designh}-16)$	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 $T_{designh}$ and the temperature which is closest to the 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 7 — Medium temperature 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)/($T_{designh}$ −16)	88	n/a	61	−7(−8)	[a]/45	[a]/43	n/a	[a]/38
B	(+2 − 16)/($T_{designh}$ −16)	54	100	37	2(1)	[a]/45	[a]/37	[a]/45	[a]/33
C	(+7 − 16)/($T_{designh}$ −16)	35	64	24	7(6)	[a]/45	[a]/33	[a]/39	[a]/30
D	(+12 − 16)/($T_{designh}$ −16)	15	29	11	12(11)	[a]/45	[a]/28	[a]/31	[a]/26
E	(T_{ol} − 16)/($T_{designh}$ −16)				T_{ol}	[a]/45	[a]/[b]	[a]/[b]	[a]/[b]
F	(T_{biv} − 16)/($T_{designh}$ − 16)				T_{biv}	[a]/45	[a]/[c]	[a]/[c]	[a]/[c]
G	(−15 − 16)/($T_{designh}$ −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 $T_{designh}$ and the temperature which is closest to the 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 8 — High temperature 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	$(-7-16)/(T_{designh}-16)$	88	n/a	61	−7(−8)	[a]/55	[a]/52	n/a	[a]/44
B	$(+2-16)/(T_{designh}-16)$	54	100	37	2(1)	[a]/55	[a]/42	[a]/55	[a]/37
C	$(+7-16)/(T_{designh}-16)$	35	64	24	7(6)	[a]/55	[a]/36	[a]/46	[a]/32
D	$(+12-16)/(T_{designh}-16)$	15	29	11	12(11)	[a]/55	[a]/30	[a]/34	[a]/28
E	$(T_{ol}-16)/(T_{designh}-16)$				T_{ol}	[a]/55	[a]/[b]	[a]/[b]	[a]/[b]
F	$(T_{biv}-16)/(T_{designh}-16)$				T_{biv}	[a]/55	[a]/[c]	[a]/[c]	[a]/[c]
H[f]	$(T_{switch}-16)/(T_{designh}-16)$				T_{switch}	[a]/55	[a]/[e]	[a]/[e]	[a]/[e]
G	$(-15-16)/(T_{designh}-16)$	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 $T_{designh}$ and the temperature which is closest to the 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.

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 (2):

$$P_H = q \times \rho \times C_p \times \Delta t \quad (2)$$

where

P_H is the heating capacity, expressed in watts;

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

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

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 $\left(C_p \times \Delta t\right)$.

7.2 Heating capacity correction

7.2.1 General

The capacity shall include the correction due to the heat output of indoor and/or outdoor fans and/or pumps, integrated into the unit or not as follows.

7.2.2 Capacity 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 difference, and which are equipped with an integral fan, no capacity correction due to heat provide by the fan shall apply.

7.2.3 Capacity correction due to indoor fan for ducted units

7.2.3.1 Units with integrated indoor fan

If the fan at the indoor heat exchanger is an integral part of the unit, the power input correction of the fan, as calculated with Formula (7) (see 7.2.5.3.1) shall be subtracted from the measured heating capacity.

7.2.3.2 Units with non-integrated indoor fan

If the fan at the indoor heat exchanger is not an integral part of the unit, the power input correction as calculated with Formula (8) (see 7.2.5.3.2) shall be added to the measured heating capacity.

7.2.4 Capacity correction due to indoor liquid pump

7.2.4.1 Units with integrated liquid pump

If the liquid pump is an integrated part of the unit, the capacity correction as defined in 7.2.4.3 or 7.2.4.4 shall be subtracted from the measured heating capacity.

7.2.4.2 Units with non-integrated liquid pump

If the liquid pump is not an integrated part of the unit, the capacity correction as defined in 7.2.4.5 shall be added to the measured heating capacity.

7.2.4.3 Capacity correction for integrated glandless circulators

If the unit is equipped with a glandless circulator, the capacity correction is calculated using Formula (3):

$$(q \times \Delta p_e) \times \left[\frac{(1-\eta)}{\eta} \right] \tag{3}$$

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 meters per second.

7.2.4.4 Capacity correction for integrated dry motor pumps

If the unit is equipped with a dry-motor pump, the capacity correction is calculated using Formula (4):

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

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 meters per second;

IE is the motor efficiency level.

7.2.4.5 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 (5):

$$\lfloor q \times (-\Delta p_e) \rfloor \times \left[\frac{(1-\eta)}{\eta} \right] \tag{5}$$

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 meters 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 (6):

$$\lfloor q \times (-\Delta p_e) \rfloor \times \left[\frac{(IE-\eta)}{\eta} \right] \tag{6}$$

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 meters per second;

IE is the motor efficiency level.

7.2.5 Effective power input

7.2.5.1 General

The effective power input shall include the correction due to power input of indoor and/or outdoor fans and/or pumps, integrated or no to the unit as follows.

7.2.5.2 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.

7.2.5.3 Power input correction of fans for units with duct connection

7.2.5.3.1 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 (7):

$$\frac{(q \times \Delta p_e)}{\eta} \tag{7}$$

where

η is 0,3 by convention;

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

q is the nominal air flow rate, in cubic meters per second.

7.2.5.3.2 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 (8):

$$\frac{[q \times (-\Delta p_i)]}{\eta} \tag{8}$$

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 meters per second.

7.2.5.4 Power input correction of liquid pumps

7.2.5.4.1 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 (9):

$$\frac{\left(q \times \Delta p_e\right)}{\eta} \quad (9)$$

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 meters 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 7.2.5.3.2.

7.2.5.4.2 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 (10):

$$\frac{\left[q \times \left(-\Delta p_i\right)\right]}{\eta} \quad (10)$$

where

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

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

q is the measured liquid flow rate, in cubic meters 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 detail of heating capacity test procedure is specified in Annex A.

7.3.2 Preconditioning period

The test room reconditioning apparatus and the heat pump under test shall be operated until the test tolerances specified in Table 2 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 6, Table 7 and Table 8.

7.3.3 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 test tolerances in Table 2.

7.3.4 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 sec.

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 *Cd*

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

The only effect that will impact the *COP* 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 *Cd* 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 (*Cd*) is determined for each part load ratio by Formula (11):

$$Cd = 1 - \frac{P_{Coff}}{P_{Con}} \quad (11)$$

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 6. 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 6, 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 *Cd* 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 or the fan 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 or fan to provide this available static pressure, as described in Clause 6. 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 or fan is not an integral part of the unit, the thermostat-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 6. 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.

7.7.3 Measurement of electric power input during standby mode

After the unit has been running for 30 min in "D" test condition, the unit is stopped with the control device. After 10 min, the residual energy consumption is measured during the next 10 minutes and assumed to be 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, the standby mode power input is set 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 the unit is stopped with the control device, and 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.

The standby power input is deducted 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, the residual power input is measured during the next 10 min and the average value during this period is assumed 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, the off mode power input is assumed to be equal to the thermostat-off mode power input.

8 Calculation methods for seasonal coefficient of performance (*SCOP*)

8.1 General formula for calculation of *SCOP*

The SCOP is defined as the reference annual heating demand Q_H divided by the annual energy consumption for heating Q_{HE} according to Formula (12):

$$\mathrm{SCOP} = \frac{Q_H}{Q_{HE}} \tag{12}$$

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 SCOP calculations. Any other set of bin hours where available may be used.

Annexes D and E are informative annexes providing examples of SCOP 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 (13):

$$Q_H = P_{designh} \times H_{HE} \tag{13}$$

where

$P_{designh}$ 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 electricity 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 (14).

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

$$Q_{HE} = \frac{Q_H}{SCOP_{\mathrm{on}}} + H_{TO} \times P_{TO} + H_{SB} \times P_{SB} + H_{CK} \times P_{CK} + H_{OFF} \times P_{OFF} \tag{14}$$

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;

$SCOP_{on}$ 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 $SCOP_{on}$ and $SCOP_{net}$

The $SCOP_{on}$ and $SCOP_{net}$ are determined according to Formula (15) and Formula (16), respectively.

For units with real or assumed electrical supplementary heater:

$$SCOP_{on} = \frac{\sum_{j=1}^{n} h_j \left[P_h(T_j) \right]}{\sum_{j=1}^{n} h_j \left[\frac{P_h(T_j) - elbu(T_j)}{COP_{bin}(T_j)} + elbu(T_j) \right]} \quad (15)$$

$$SCOP_{net} = \frac{\sum_{j=1}^{n} h_j \left[P_h(T_j) - elbu(T_j) \right]}{\sum_{j=1}^{n} h_j \left[\frac{P_h(T_j) - elbu(T_j)}{COP_{bin}(T_j)} \right]} \quad (16)$$

where

T_j is the bin temperature;

j is the bin number;

n is the total number of bins;

$P_h(T_j)$ 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;

$COP_{bin}(T_j)$ is the *COP* value of the unit for the corresponding temperature T_j;

$elbu(T_j)$ 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 $P_h(T_j)$ can be determined by multiplying the design heating load value ($P_{designh}$) with the part load ratio for each corresponding bin. This part load ratio $pl(T_j)$ is calculated according to Formula (17):

$$pl(T_j) = (T_j - 16)/(T_{designh} - 16) \quad (17)$$

where

j is the bin number;

T_j is the bin temperature;

$T_{designh}$ is the design temperature for heating.

The COP_{bin} values and capacity values at each bin are determined via interpolation of the COP_{bin} and capacity values at part load conditions A, B, C, D, E , F and G where applicable. Interpolation of COP_{bin} and capacities are done between with the two closest part load conditions (as mentioned in the tables of 6, 7 and 8).

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

If the capacity of the unit is lower than the value of $P_h\left(T_j\right)$, correction needs to be made for the missing capacity with an electric supplementary heater with a COP of 1.

Below TOL (operation limit) the unit is not running. The capacity of the unit at outside air temperatures below TOL is 0 kW and correction needs to be made for the missing capacity with an electric supplementary heater with a COP of 1.

8.5 Calculation procedure for determination of COP_{bin} 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 COP_d 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(Cd) has to be used to calculate the corresponding COP_{bin} value. The calculation has to be done according to Formula (19).

CR is the ratio of the heating load over the declared capacity (Pdh) of the unit at the same temperature conditions, calculated according to Formula (18):

$$CR = pl\left(T_j\right) \times \frac{P_{designh}}{Pdh} \tag{18}$$

where

$P_{designh}$ is the design heating load of the building the unit is suitable for as declared by the manufacturer, expressed in kW;

$pl(T_j)$ is the part load ratio as given in Formula (17);

Pdh 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 CR is greater than 1, CR is equal to 1.

8.5.2 Calculation procedure for fixed capacity units

In part load conditions A to G, where applicable, the COP_{bin} is calculated according to Formula (19):

$$COP_{bin} = COP_d \times \frac{CR}{Cd \times CR + (1 - Cd)} \quad (19)$$

where

COP_d is the COP corresponding to the declared capacity (Pdh) of the unit at the same temperature conditions as for part load conditions A to G, where applicable;

Cd is the degradation coefficient;

CR is the capacity ratio.

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

8.5.3 Calculation procedure for staged and variable capacity units

Determine the declared capacity and COP_d at the closest step or increment of the capacity control of the unit to reach the required heating load.

If this step allows to reach the required heating load within ±10 % (e.g. between 9,9 kW and 8,1 kW for a required heating load of 9 kW), it is assumed that:

— For temperatures above or equal to T_{biv}, the target capacity is achieved and the measured COP can be used as COP_{bin}.

— For temperatures below T_{biv}, the target capacity is not achieved. The measured capacity and corresponding COP shall be considered as declared capacity and COP_d.

If this step does not allow to reach the required heating part load within ±10 %, determine the capacity and the effective power input at the defined part load temperatures for the steps on either side of the required heating load. The part load power input at the required heating part load is then determined by linear interpolation between the results obtained from these two steps. The COP_d is then determined by the required heating part load divided by the part load power input.

If the smallest control step of the unit is more than 10 % higher than the required heating load, the COP_d at the required part load ratio is calculated using Formula (19) as for fixed capacity units.

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. The table identifies the general information required but is not intended to limit the data to be obtained. 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
outlet temperature	°C	x	x
volume flow	m^3/s	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	min^{-1}	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

Each heat pump shall have a durable, permanently fixed marking that is easily readable when the unit is in position for use, bearing at least the information required by safety standards. If the heat pump consists of several parts, the information shall be marked on each of these parts together with the model designation of the complementary parts.

Annex A
(normative)

Heating capacity test procedures given in 7.3

A.1 General

The test procedure shall identify whether the unit will operate in steady state conditions or in transient regime due to defrost cycles that can occur depending on the operating conditions.

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

The test procedure is described by the flowchart in Figure A.1. The different steps of the procedure are explained in the following subclauses. The steps of the flowchart shall immediately follow each other.

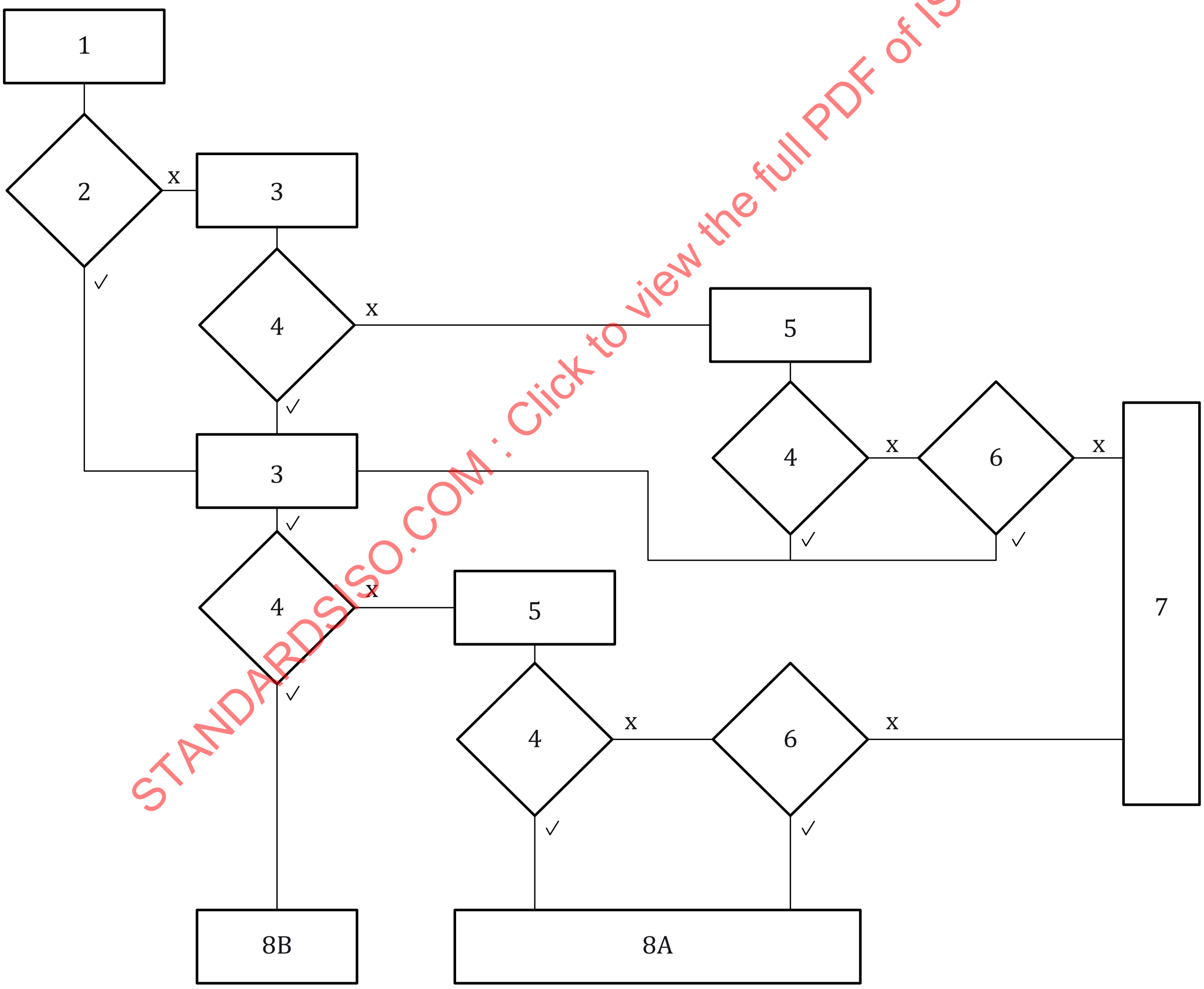


Figure A.1 — Flowchart of steps procedure

A.2 Step 1: Preconditioning

The test room reconditioning apparatus and the heat pump water heater under test shall start and operate until the test tolerances specified in Table 2 are attained for at least 10 min.

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 6, Table 7 and Table 8.

For heat pump water heater units having defrost cycles at part load condition, the water flow rate shall be set at the corresponding time averaged inlet/outlet water temperatures measured on a 5 min period starting 20 min after the end of a defrost cycle, manually or automatically induced.

A.3 Step 2: Forced defrost cycle

It is recommended to terminate Step 1 with a manually or automatically induced defrost cycle, so that the procedure can continue with no or very small influence on the unit of the way the operating conditions were achieved.

Step 2 checks whether the recommendation has been followed or not to decide the next step of the flowchart.

A.4 Step 3: Equilibrium period

During an equilibrium period of 1 h, the heat pump water heater shall operate, while meeting the test tolerances specified in Table 2, except if a defrost occurs during this period in which case the test tolerances specified in Table 3 apply.

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 4: Defrost cycle

It is checked whether the unit operated a defrost cycle during the previous step (Step 3 or Step 5).

A.6 Step 5: Data collection

Data shall be sampled at equal intervals that span every 30 s or less, except during defrost cycles as specified below, for a duration of 70 min.

During defrost cycles, plus the first 10 min following defrost termination, data used in evaluating the integrated heating capacity and the integrated power input of the heat pump water heater shall be sampled more frequently, at equal intervals that span every 10 s or less.

When using the indoor air enthalpy method, these more frequently sampled data include the change in indoor-side dry bulb temperature. When using the calorimeter method, these more frequently sampled data include all measurements required to determine the indoor-side capacity.

For heat pump water heaters that automatically switch 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, if using the indoor air enthalpy method. If using the calorimeter test method, the integration of capacity shall continue while the indoor fan is off.

The difference between the leaving and entering temperatures of the heat transfer medium at the indoor heat exchanger shall be measured during the data collection period (Step 5). For each interval of 5 min during the data collection period, an average temperature difference shall be calculated, $\Delta T_i(t)$.

The average temperature difference for the first 5 min of the data collection period, $\Delta T_i\,(t=0)$, shall be saved for the purpose of calculating Formula (A.1):

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

Figure A.2 illustrates the temperature decrease during Step 5 and the calculation of $\%\Delta T$.

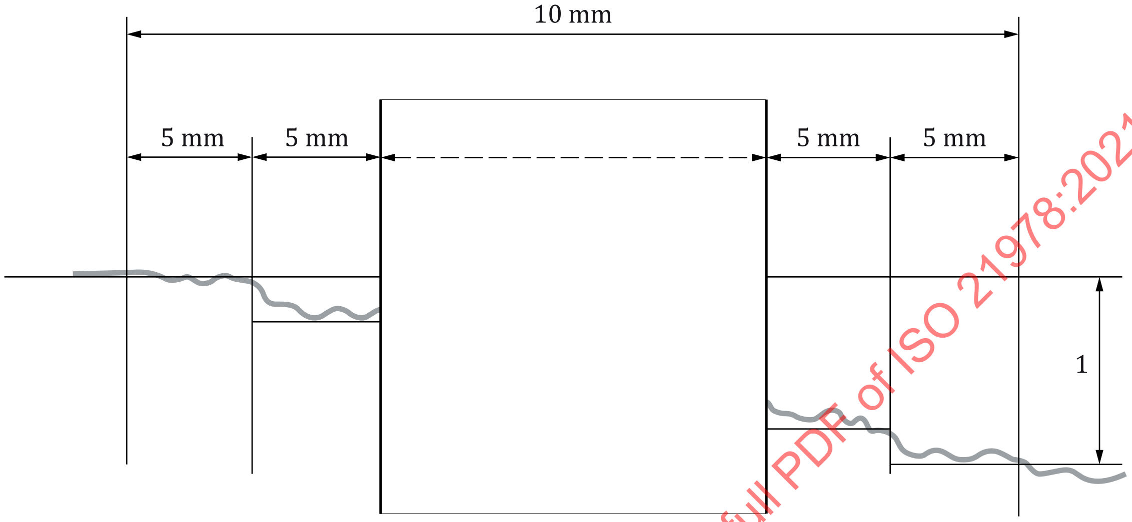


Figure A.2 — Data collection

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.

A.7 Step 6: Variation of $\%\Delta T$

If the quantity $\%\Delta T$ does not exceed 2,5 % and the test tolerances specified in Table 2 are satisfied during the data collection period (Step 5), the heating capacity test shall be designated a steady-state test (Step 7).

If at any time during Step 5, the quantity $\%\Delta T$ exceeds 2,5 %, the test shall directly continue with the next step of the flowchart.

A.8 Step 7: Steady state operation

The test is considered to be steady state and shall be terminated after the data collection (Step 5) during which the test tolerances specified in Table 2 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 2.

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

A.9 Step 8: Transient operation

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

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

NOTE 1 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 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 initial state.

NOTE 2 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 is larger than 0,2 K;

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

As noted in Table 3, the test tolerances are specified for two sub-intervals. 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.

All data collected during each interval, H or D, shall be used to evaluate compliance with the Table 3 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 3 compliance. Compliance is based on evaluating data from each interval separately.

A.10 Step 8b

In Step 8b, the data shall be recorded until 3 h have elapsed or until the heat pump water heater 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 8a, the test tolerances specified in Table 3 shall be achieved during the total duration.

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

If at an elapsed time of 3 h, the heat pump water heater 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 multiple refrigerant circuit units, the data is recorded and calculated over a 3-hour 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 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):

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

where

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

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

B.2.2 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):

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

where

q is the measured liquid volume flow rate, in cubic meters 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 (Figure B.1), the calculation of the global efficiency η is based on the energy efficiency index (EEI) and using Formula (B.3):

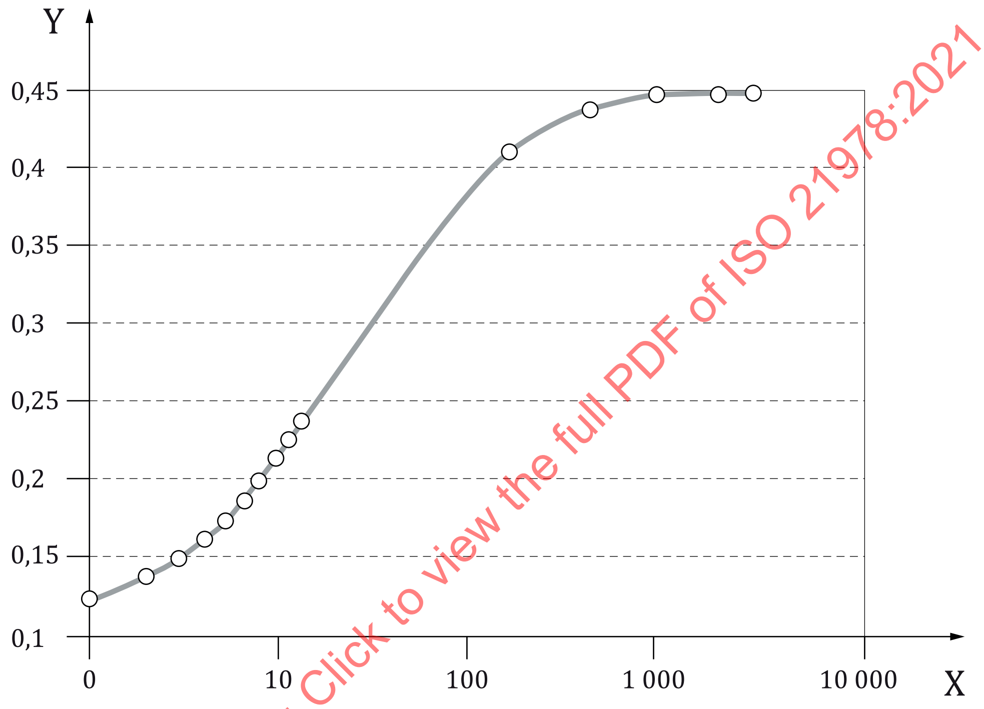
$$\eta = \frac{0{,}358\,44 \times P_{hyd}}{1{,}7 \times P_{hyd} + 17 \times \left(1 - e^{-0{,}3 \times P_{hyd}}\right)} \times \frac{C_{20}}{EEI} \qquad \text{(B.3)}$$

where

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

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

EEI is the energy efficiency index equal to 0,23.



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 (B.1), is lower than or equal to 500 W, the efficiency of the pump is determined using Formula (B.4):

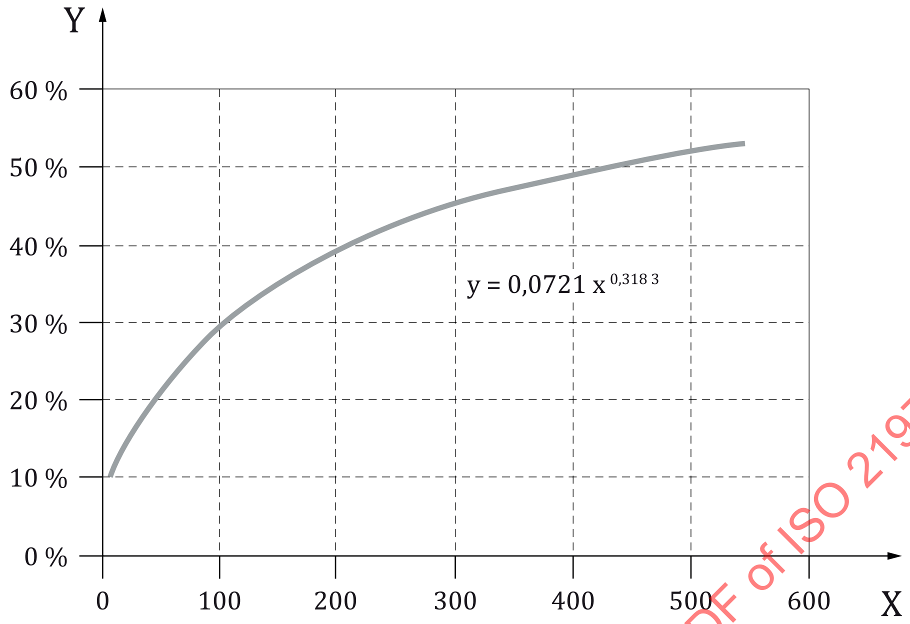
$$\eta = 0{,}0721 P_{hyd}^{0{,}318\,3} \quad \text{(B.4)}$$

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

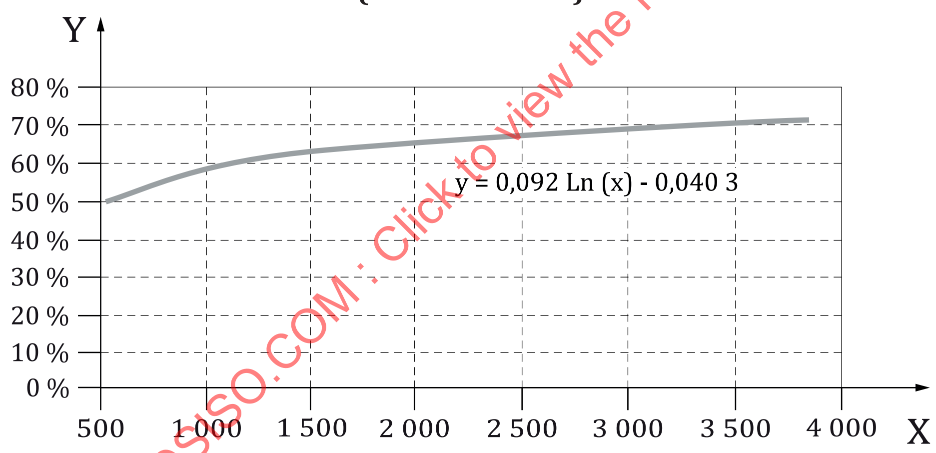
$$\eta = 0{,}092 Ln\left(P_{hyd}\right) - 0{,}0403 \quad \text{(B.5)}$$

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 B.2 is lower than or equal to 300 W, the efficiency of the pump is determined using Formula (B.3).

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

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