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Heat pump water heaters — Testing and rating for performance —

Part 1: Heat pump water heater for hot water supply

Chauffe-eau à pompe à chaleur — Essais et classification des performances —

Partie 1: Chauffe-eau à pompe à chaleur pour l'alimentation en eau chaude

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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 documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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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*.

A list of all parts in the ISO 19967 series can be found on the ISO website.

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Heat pump water heaters — Testing and rating for performance —

Part 1:
Heat pump water heater for hot water supply

1 Scope

This document specifies test conditions and test procedures for determining the performance characteristics of air source heat pump water heaters for hot water supply with electrically driven compressors with or without supplementary electric heater and connected to or including only one hot water storage tank. Hot water storage tanks that are connected in series or parallel and behave hydronically as one single tank are considered as one hot water storage tank. In the case of heat pump water heaters consisting of several parts with refrigerant or water connections, this document applies only to those designed and supplied as a complete package.

NOTE This document is not applicable to testing procedures for simultaneous operation for hot water supply and space heating. "Simultaneous" means that hot water supply and space heating generation occur at the same time and may interact.

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
heat pump water heater for hot water supply
air source heat pump water heater with electrically driven compressors with or without supplementary electrical heater and connected to or including a hot water storage tank for hot water supply for human use

3.2
hot water supply
water heated for human use or household or similar purposes

3.3
storage volume
V_m
measured volume of hot water that can be contained in the storage tank

3.4
non heated space air
heat source for a heat pump which absorbs heat by an air heat exchanger in direct contact with the air inside a space in a building which is not heated

3.5
coefficient of performance for hot water supply
COP_{HW}
coefficient of performance which is determined by the use of reference load profiles and which includes the heat losses of the storage tank

3.6
reference hot water temperature
θ'_{WH}
temperature determined as the mean temperature value of the average temperatures during one single draw-off which ends when the hot water temperature is below 40 °C

3.7
volume of mixed water at 40 °C
V_{40}
volume of water at 40 °C, which has the same heat content (enthalpy as the hot water which is delivered above 40 °C at the output of the heat pump water heater

3.8
off-peak product
heat pump water heater that is energised for a maximum period of eight consecutive hours between 22:00 and 07:00 of the 24-h tapping pattern

3.9
load profile
given sequence of water draw-offs

Note 1 to entry: See Annex A.

3.10
water draw-off
given combination of useful water flow rate, useful water temperature, useful energy content and target temperature

3.11
useful water flow rate
$f(t)$
minimum flow rate for the draw-off of the load profile

3.12
useful water temperature
T_m
minimum hot water temperature for the draw-off of the load profile

3.13
useful energy content
Q_{tap}
energy content of hot water provided at a temperature equal to, or above, the useful water temperature, and at water flow rates equal to, or above, the useful water flow rate

3.14
target temperature
T_p
minimum water temperature to be achieved during water draw-off calculated as the mean value over the water draw off

3.15
reference energy of the load profile
Q_{ref}
sum of the useful energy content of water draw-offs in a particular load profile

3.16
smart control
device that automatically adapts the water heating process to individual usage conditions with the aim of reducing energy consumption

3.17
smart control factor
SCF
water heating energy efficiency gain due to smart control

3.18
standby power input
P_{es}
total power input of the unit during the standby test, including the power input of the unit to overcome heat losses of the tank and the power input of any auxiliary device

3.19
coefficient of performance of smart control products
COP_{smart}
coefficient of performance of unit that can take benefit from a smart control

3.20
nominal volume
V_n
volume of water that is assigned to the storage tank by the manufacturer and that is marked on the tank

3.21
operating range
working range for the heat pump water heater as specified by the manufacturer

4 Symbols and abbreviated terms

Symbol	Description	Units
SCF	smart control factor	—
COP_{HW}	coefficient of performance for a given reference load profile	—
COP_{smart}	coefficient of performance of smart control products	—
C_p	specific heat capacity of water	kJ/(kg·K)
Δp_e	measured external static pressure difference	Pa
Δp_i	measured internal static pressure difference	Pa
f	minimum flow rate for which hot water is contributing to the reference energy	l/min
f_{max}	maximum flow rate of considered load profile	l/min
$f_{max}(t)$	flow rate of hot water during draw-off	l/min
$f(t)$	useful water flow rate	l/min
i	index for the draw-off	—
m_{act}	difference of the two weights (filled / empty) of the hot water storage tank	kg
η	efficiency of the fan is 0.3	-
n_{tap}	number of draw-offs during the load profile	—
P_{es}	standby power input	kW
P_s	measured average power consumption for off-peak products	kW
$Q_{EL\text{-}LP}$	calculated heat energy produced by electrical resistance heater during the whole load profile	kWh
$Q_{EL\text{-}tap}$	Calculated heat energy produced by electrical resistance heater to reach the required tapping temperature	kWh
$Q_{HP\text{-}tap}$	useful energy during one single draw-off	kWh

Symbol	Description	Units
Q_{LP}	total useful energy content during the whole load profile	kWh
Q_{elec}^{smart}	total useful energy consumption during the smart period of the smart cycle	kWh
Q_{LP}^{smart}	total useful energy content during the smart period of the smart cycle	kWh
Q_{elec}^{ref}	Total electricity consumption during the reference period of the smart cycle	kWh
Q_{LP}^{ref}	total useful energy content during the reference period of the smart cycle	kWh
$Q_{elec}^{WHL,C}$	Total electricity consumption of the WHL control cycle	kWh
Q_{ref}	reference energy of the considered load profile	kWh
Q_{tap}	energy content of hot water provided at a temperature equal to, or above, the useful water temperature, and at water flow rates equal to, or above, the useful water flow rate	kWh
$\rho(T)$	density of water at temperature T	kg/m^3
t_d	test phase duration	s
t_{es}	duration of the last on-off-cycle of the heat pump water heater	s
t_h	heating up time	s
t_{40}	time from starting the draw-off until θ_{WH} is less than 40 °C	s
t_{tap}	duration of a draw-off of useful water	s
t_{TTC}	load profile time / duration	h
T_{DB}	dry bulb temperature	°C
T_m	useful water temperature at which hot water starts contributing to the reference energy	°C
T_p	target water temperature to be achieved during water draw-off	°C
T_{WB}	Wet bulb temperature	°C
θ_{WC}	incoming cold water temperature	°C
$\theta_{WC}(t)$	incoming cold water temperature during draw-off	°C
θ_{WH}	outgoing hot water temperature	°C
$\theta_{WH}(t)$	hot water temperature during draw-off	°C
θ'_{WH}	reference hot water temperature	°C
V_{air}	nominal air volume flow rate	m^3/s
V_{Fluid}	measured liquid volume flow rate	m^3/s
V_m	measured volume of a hot water storage tank	l
V_{40}	mixed volume of mixed water at 40 °C	l
V_n	volume of water that is assigned to the storage tank by the manufacturer and marked on it	l
$W_{eh\text{-}HP}$	total electricity consumption during the test duration t_h	kWh
$W_{eh\text{-}M}$	measured electricity consumption during the test duration t_h	kWh
$W_{EL\text{-}Corr}$	correction due to electricity consumption of fan/liquid pump	kWh
$W_{EL\text{-}LP}$	total electrical energy consumption during the whole load profile	kWh
$W_{EL\text{-}M\text{-}LP}$	total measured electrical energy input	kWh
$W_{EL\text{-}OFF}$	calculated energy consumption for off-peak products	kWh
$W_{es\text{-}HP}$	total energy input during the last on-off-cycle	kWh
$W_{es\text{-}M}$	measured energy consumption during the last on-off cycle	kWh

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 temperatures of the hot water supply are measured in the centre of the flow and as close as possible to the appliance. 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.

For inverter type control units, the setting of the frequency shall be done for each rating condition. The manufacturer shall provide in the documentation information instructions on obtaining the necessary data to set the required frequencies. If skilled personnel with knowledge of control software are required for the start of the system, the manufacturer or the nominated agent should be in attendance when the system is being installed and prepared for tests.

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

Table 1 — Uncertainties of measurement

Measured quantity	Unit	Uncertainty
Hot water supply		
Temperature	°C	0,15 K
Temperature difference	K	0,15 K
Volume	L	2 %
Volume flow	l/min	2 %
Thermal energy	kWh	5 %
Air (heat source)		
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 % ($\Delta P \geq 100$ Pa)
Electrical quantities		
Electric power	W	For ≥10 W, 1 % For <10 W, 0.1 W
Electrical energy	kWh	1 %
Voltage	V	0,5 %
current	A	0,5 %
Ambient		
Ambient temperature indoors	°C	0,5 K

5.2 Test room for the outdoor heat exchanger of air source heat pump water heaters

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; this also applies to any measuring ducts.

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

5.3 Installation and connection of the heat pump water heaters

The heat pump water heater shall be installed and connected for the test as recommended by the manufacturer's installation and operation manual. The accessories provided by option (for example heating element) are not included in the test. Temperature and pressure measuring points shall be arranged in order to obtain representative mean values.

5.4 Installation of heat pump water heater consisting of several parts

In the case of heat pump water heaters consisting of several refrigeration parts (split heat pump water heater) the following installation conditions shall be complied with 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.

For indirect systems where the heat pump water heater is separated from the tank, water or brine connections to the tank shall be installed in accordance with the manufacturer's instructions to the maximum stated length or 5 m whichever is shorter. Piping shall be well insulated and made as short as possible and with as few bends as possible.

6 Settings and test conditions

6.1 General

Set points for internal control equipment of the unit such as 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.

Thermostat settings and settings for supplementary electrical heaters shall be done according to the installations and operating instructions and shall remain in the same position for the duration of the test. If the heat pump water heater is equipped with a mixing valve for the hot water, this valve shall be set at the manufacturer's recommended setting throughout the test.

6.2 Settings for non-ducted air source units

For non-ducted units, the adjustable settings such as louvers and fan speed shall be set according to the installation and operating instructions. Without information from the manufacturer, louvers and fan speed shall be set for maximum air flow rate.

6.3 Setting the external static pressure difference for ducted air source units

The volume flow and the pressure difference shall be related to standard air and with a 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, then the unit shall be tested with the duct length and the ESP is considered to be 0.

6.4 Test conditions

6.4.1 General test conditions

The tests shall be carried out at the test conditions specified in Table 3 and Table 4 as appropriate. Permissible deviations shall not exceed the values specified in Table 2. In addition, the maximal permissible deviation of thermal energy for the complete load profile shall be less than 5 %.

6.4.2 Additional test conditions

Table 2 — Variations allowed for the test conditions when the heat pump water heater 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 S[c]	Interval H[a]	Interval D[b]	Interval S[c]
Air temperature						
dry-bulb[d]	±0,6 K	±1,5 K		±1,0 K	±5,0 K	±2,5 K
— wet-bulb	±0,3 K	±1,0 K		±0,6 K	—	
— volume flow	±5 %			±10 %		
— static pressure difference	—			±10 %		
— ambient temperature of the tank (if not used as heat source)	±1 K			±2 K		

[a] Interval H applies when the heat pump water heater 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 water heater.

[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 water heater is operating in the heating mode.

[c] Interval S applies when the compressor is stopped and during the first 10 min after the hot water thermostat has started the heat pump water heater again.

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

Table 2 *(continued)*

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 S[c]	Interval H[a]	Interval D[b]	Interval S[c]
hot water supply						
— inlet temperature	±1 K			±1 K		
— volume flow	±5 % (≥10 l/min) ±0,5 l/min (<10 l/min)			±10 % (≥10 l/min) ±1,0 l/min (<10 l/min)		
Electrical						
Voltage	±3 %			±3 %		
Frequency	±2 %			±2 %		

[a] Interval H applies when the heat pump water heater 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 water heater.

[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 water heater is operating in the heating mode.

[c] Interval S applies when the compressor is stopped and during the first 10 min after the hot water thermostat has started the heat pump water heater again.

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

Table 3 — Test conditions applicable to all systems

Measured variable	Set value
Power supply voltage	Rated voltage
Power supply frequency	Rated frequency
Air flow rate	Nominal, as indicated by the manufacturer. When only a range is given, tests are to be carried out at the minimum and maximum value.
Temperature of the incoming cold water (°C)	10
Hot water flow rate (l/min)	(see load profiles in Annex A)

Table 4 — Test conditions for particular types of systems

Type of heat source	Heat source air dry (wet) bulb temperature in °C	Range of ambient temperature of heat pump water heater in °C	Ambient temperature of storage tank in °C
Outdoor air heat pump water heater (placed indoors)	7 (6)	from 15 to 30	20
Outdoor air heat pump water heater (placed outdoors)	7 (6)	heat source temperature	20
Non heated space air	15 (12)	heat source temperature	15
Exhaust air	20 (12)	from 15 to 30	20

7 Performance test and determination of the energy consumption

7.1 General

The test methods specified in this clause are designed to determine the performance of the heat pump water heater when providing heat for hot water supply. The unit shall be installed and adjusted in the initial state conditions and in the initial adjustment conditions as given in Clauses 5 and 6.

7.2 Basic principles

The test consists of the following six principal stages:

— [Stage A] Stabilisation (see 7.5);

— [Stage B] Filling and storage volume (see 7.6);

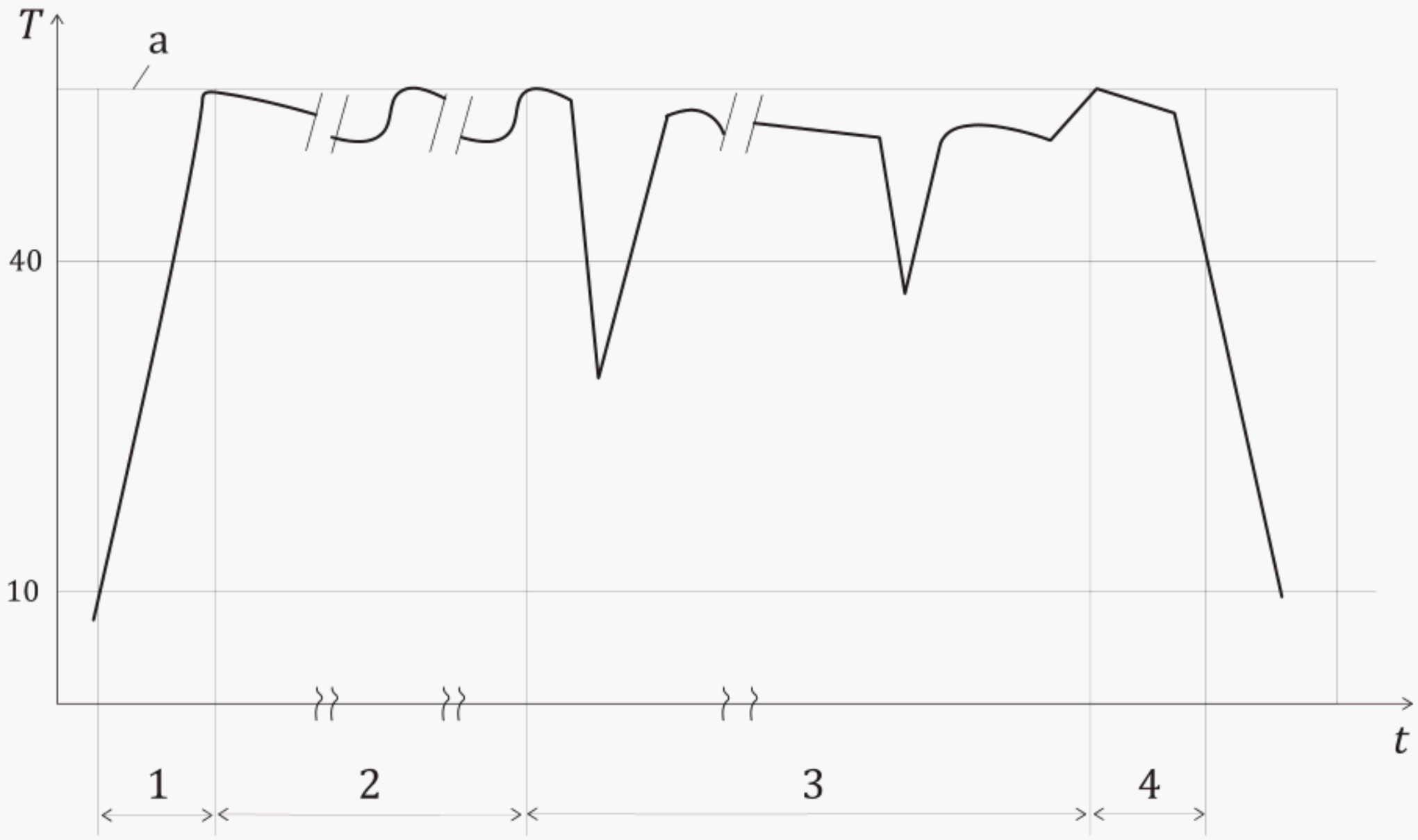
— [Stage C] Filling and heating up period (see 7.7);

— [Stage D] Standby power input (see 7.8);

— [Stage E] Water draw-offs (see 7.9);

— [Stage F] Mixed water at 40 °C and reference hot water temperature (see 7.10).

After the preparation of the test (stages A and B) the tests C to F are performed as shown in Figure 1. Each individual stage can be carried out independently if the starting conditions are the ending conditions of the previous stage.



Key

1 [Stage C] Filling and heating up period (see 7.7)
2 [Stage D] Standby power input (see 7.8)
3 [Stage E] Water draw-offs (see 7.9)
4 [Stage F] Mixed water at 40 °C and reference hot water temperature (see 7.10)
T temperature
t time
a Set point temperature.

Figure 1 — Stages and order of the tests

All tests are performed with power supplied at the rated voltage and rated frequency as stated in the installation and operation instructions. After the initial start of the heat pump water heater the power supply is left for the duration of the test.

Any supplementary heat supply which can be switched off by the user shall be switched off during the entire test, unless otherwise stated by the manufacturer.

7.3 Off-peak products

For off-peak products, the product shall be installed and connected as stated in the installation and operation instructions. All appropriate information to set the time period for which the unit is not allowed to be energized whereas the unit is under power supply shall be stated in the installation and operation instructions, for conducting Stage E of the performance test.

For off-peak products, the power supply to the unit is shut down at the beginning of Stage E (load profiles) and is reactivated 16 h later.

After that, the next switch off of the compressor by the thermostat sensing the water temperature in the tank shall be obtained within 8 h, otherwise the product is not considered to be an off-peak product.

For off peak products the power consumption due to auxiliaries shall be included in the total power consumption in Stage E.

If this measurement is not made during Stage E, then the average power consumption (P_s) is determined from the first 20 min of the standby period and shall be added to the measured power consumption during Stage E.

The corresponding energy consumption is to be added to Stage E and shall be calculated according to Formula (1).

$$W_{\text{EL-OFF}} = 16 \cdot P_s \quad (1)$$

where

$W_{\text{EL-OFF}}$ is the calculated energy consumption for off-peak products in kWh;

16 is the compressor off time in h;

P_s is the measured average power consumption when the compressor is off in kW.

7.4 Power input corrections

7.4.1 Power input of fans for heat pump water heater with duct connection

In the case of heat pump water heater, which allows an external static pressure difference, only a fraction of the input to the fan motor shall be included in the effective power absorbed by the heat pump water heater.

If no fan is provided with the heat pump water heater, the proportional power input which is to be included in the effective power absorbed by the heat pump water heater, $W_{\text{EL-Corr}}$ expressed in kWh, shall be calculated using Formula (2):

$$W_{\text{EL-Corr}} = \frac{1}{3\,600 \times 1000} \times \int_0^{t_d} \frac{V_{\text{air}}(t) \cdot \Delta p_i}{\eta} dt \quad (2)$$

where

η is the efficiency of the fan and is equal to 0,3 by convention;

Δp_i is the measured internal static pressure difference in Pa;

V_{air} is the nominal air volume flow rate in m^3/s;

t_d is the test duration in s.

If a fan is an integral part of the heat pump water heater, only a fraction of the input to the fan motor shall be included in the effective power absorbed by the heat pump water heater. The fraction which is to be excluded from the total power absorbed by the heat pump water heater, $W_{\text{EL-Corr}}$ expressed in kWh, shall be calculated using Formula (3):

$$W_{\text{EL-Corr}} = \frac{1}{3600 \times 1000} \times \int_0^{t_d} \frac{V_{\text{air}}(t) \cdot \Delta p_e}{\eta} dt \quad (3)$$

where

H is the efficiency of the fan and is equal to 0,3 by convention;

V_{air} is the nominal air volume flow rate in m^3/s;

Δp_e is the measured external static pressure difference in Pa;

t_d is the test duration in s.

7.5 Stabilization [stage A]

The product is kept at ambient conditions until all parts of the product have reached ambient conditions ±2 K (at least 24 h).

7.6 Filling and storage [stage B]

The empty hot water storage tank is to be weighed; the weight of taps on inlet and/or outlet pipes shall be included. Then the hot water storage tank is filled with water as stated in the installation and operation instructions at cold water pressure. The water supply is then cut off. The filled hot water storage tank r shall be weighed, including the taps. The difference of the two weights (m_{act}) shall be converted into volume in litres in accordance with Formula (4).

$$V_m = 1000 \times \frac{m_{act}}{\rho(T)} \quad (4)$$

where

V_m is the measured volume of a hot water storage tank in l;

m_{act} is the difference of the two weights in kg;

$\rho(T)$ is the density of water in kg/m^3.

This volume shall be reported in litres to the nearest one-tenth litres. Filling and storage are not applicable to heat pump water heater combination heaters.

7.7 Filling and heating up period [stage C]

The product shall be fully filled with cold water. Cold water shall circulate in the tank until the outlet temperature is equal to the inlet temperature within the allowed variation given in Table 2. The test consists of determining the heating up time t_h necessary to heat the storage quantity of water from an initial state until the first time the compressor is switched off by the thermostat sensing the water temperature in the tank.

This initial state is at the temperature of the incoming cold water specified in Table 3. The heat pump water heater is switched on. The heating up time, t_h and the corresponding input of electrical energy, $W_{eh\text{-}HP}$, are measured from the time the heat pump water heater is switched on until it is shut off by the hot water thermostat situated in the tank, with the correction calculated according to 7.4, with test duration $t_d = t_h$.

The energy consumption is calculated according to Formula (5).

$$W_{eh\text{-}HP} = W_{eh\text{-}M} - W_{EL\text{-}Corr} \quad (5)$$

where

$W_{\text{eh-M}}$ is the measured electricity consumption during the test duration t_{h} in kWh;

$W_{\text{EL-Corr}}$ is the correction due to electricity consumption of fan in kWh;

$W_{\text{eh-HP}}$ is the total electricity consumption during the test duration t_{h} in kWh.

7.8 Standby power input [stage D]

The standby power input is determined by measuring the electrical power input over an integral number of on-off cycles of the heat pump water heater, initiated by the thermostat situated in the tank, when no hot water draw-offs are done.

After the thermostat shuts off the heat pump water heater following the heating up period, the system is left to operate with no hot water draw-offs for a number of full cycles or a minimum duration.

The test shall be performed over a period of minimum 48 h or less if 6 on-off-cycles have occurred. Then the duration t_{es}, and the energy input $W_{\text{ES-HP}}$, expressed in kWh, of the last on-off cycle are determined using Formula (6).

$$W_{\text{es-HP}} = W_{\text{es-M}} - W_{\text{EL-Corr}} \tag{6}$$

where

$W_{\text{es-M}}$ is the measured energy consumption during the last on-off cycle, in kWh;

$W_{\text{EL-Corr}}$ is the correction due to electricity consumption of fan, in kWh according to 7.4 with test duration $t_{\text{d}} = t_{\text{es}}$;

$W_{\text{es-HP}}$ is the total energy input during the last on-off-cycle, in kWh. The

standby power input, P_{es} expressed in kWh, is determined by Formula (7):

$$P_{\text{es}} = \frac{W_{\text{es-HP}}}{t_{\text{es}}} \cdot 3\,600 \tag{7}$$

where

P_{es} is the standby power input in kW;

$W_{\text{es-HP}}$ is the total energy input during the last on-off-cycle in kWh;

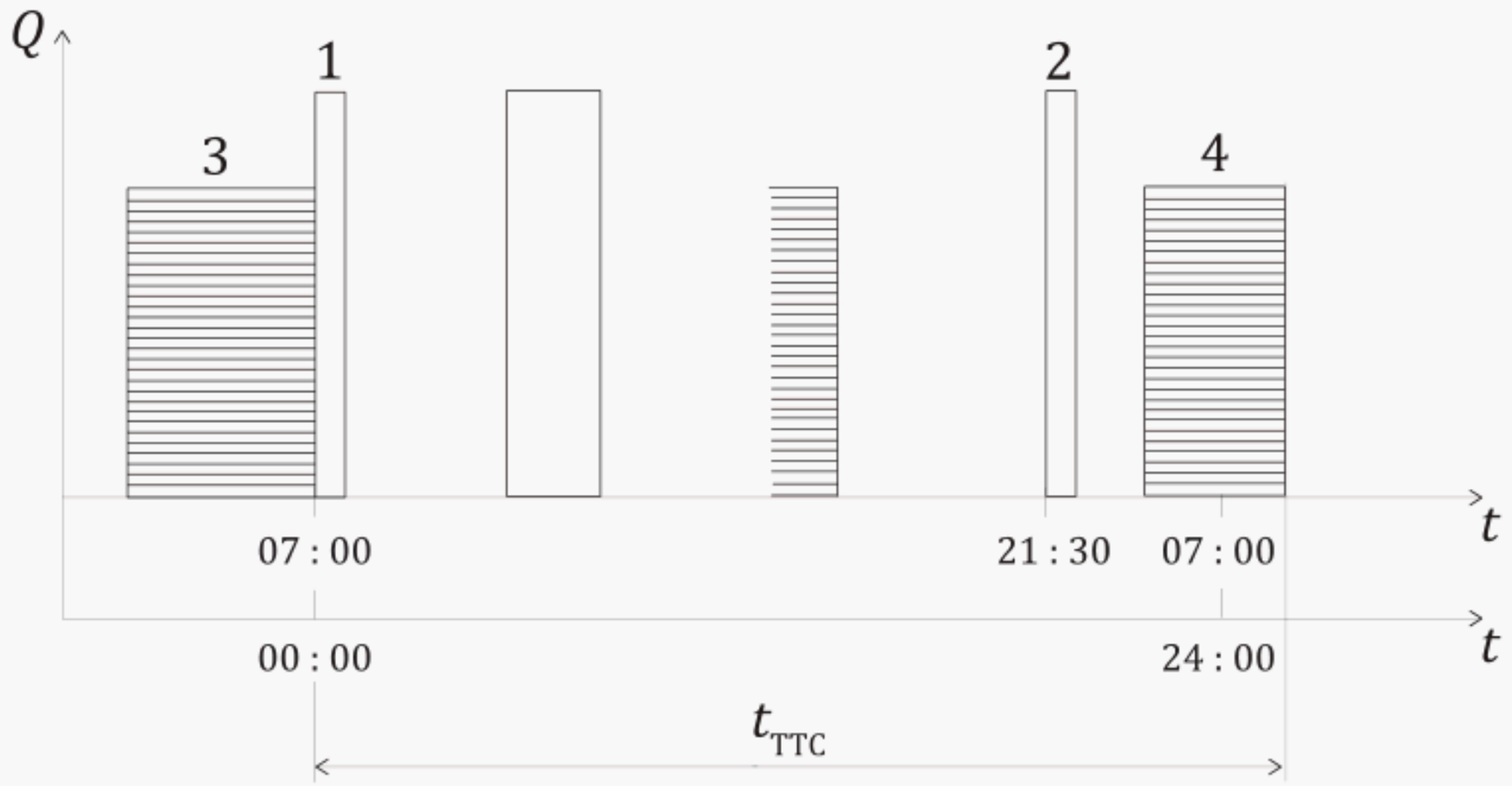
t_{es} is the duration of the last on-off-cycle of the heat pump water heater in s.

7.9 Water draw-offs and COP calculation [stage E]

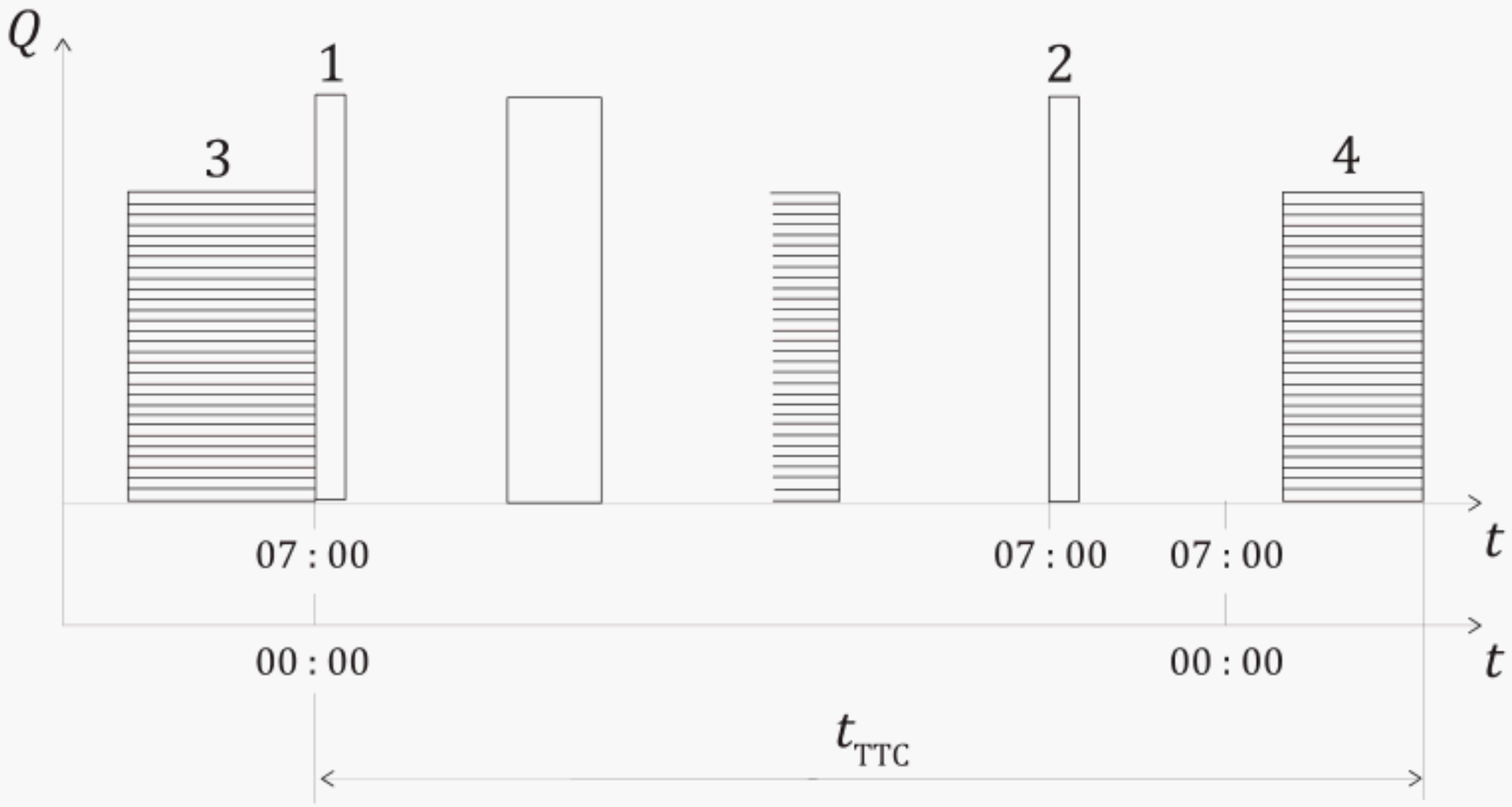
7.9.1 Determination of the useful energy content

There are different load profiles for different energy contents according to Annex A. For the test a specific load profile shall be selected from Table A.1 to Table A.2. Each individual draw-off of the load profile shall be completed; this means the valve shall be closed, and a delay of at least one minute is required, before starting the following draw-off.

The test cycle starts directly after the last shut off of the heat pump water heater by the hot water thermostat situated in the tank. The test cycle ends with the last shut off of the heat pump water heater, if load profile time (duration) t_{TTC} is at least 24 h or more [see Figure 2 a)]. If the heat pump water heater is not running when 24 h have passed from the start of the test cycle, the test cycle has to be extended until the heat pump water heater restarts and stops again [see Figure 2 b)].



a) Heat pump water heater is still running at the end of the 24-h period



b) Heat pump water heater is not running at the end of the 24-h period

Key

1 first draw-off of the load profile
2 last draw-off of the load profile
3 running period of the heat pump water heater directly before the start of the test cycle
4 running period of heat pump water heater after last draw-off (2)
Q energy in kwh
t time in h:min
t_{TTC} load profile time/duration in h:min

Figure 2 — Illustration of a test for one possible load profile

The useful energy $Q_{HP\text{-}tap}$ (kWh) during one single draw-off is given by Formula (8):

$$Q_{HP-tap} = \frac{1}{60 \cdot 1\,000 \cdot 3\,600} \int_0^{tap} Cp \cdot \rho(T) \cdot f_{(t)} \cdot \left[\theta_{WH}(t) - \theta_{WC}(t)\right] dt \quad (8)$$

where

$\theta_{WH}(t) - \theta_{WC}(t)$ is the temperature difference between hot water temperature at outlet and cold water at inlet of hot water supply storage in K;

$f_{(t)}$ is the useful water flow rate, expressed in l/min;

t_{tap} is the time duration of a draw-off of useful water in s;

C_p is the specific heat capacity of water in kJ/(kgK);

$\rho(T)$ is the density of the hot water at the flow meter in kg/m^3.

For draw-offs with a target temperature T_p of 55 °C, this temperature cannot always be achieved by the heat pump water heater alone. During the draw-off it is then assumed that the missing temperature difference to the required T_p is produced by an additional electrical resistance heater.

For that case, the following formulae are used:

$$Q_{EL-tap} = \frac{1}{60 \cdot 1\,000 \cdot 3\,600} \int_0^{tap} Cp \cdot \rho(T) \cdot f_{(t)} \cdot \left[\theta_{WH}(t) + \left(T_p - 10\right) - \theta_{WC}(t)\right] dt \quad (9)$$

The overall tapping energy Q_{LP} of the load profile is:

$$Q_{EL-LP} = \sum_{i=1}^{n_{tap}} \left(Q_{EL-tap}\right) \quad (10)$$

$$Q_{LP} = \sum_{i=1}^{n_{tap}} \left(Q_{HP-tap} + Q_{EL-LP}\right) \quad (11)$$

where

n_{tap} is the number of draw-offs during the load profile;

i is the index for the draw-off.

7.9.2 Determination of the energy consumption

The total measured electrical energy input $W_{EL\text{-}M\text{-}LP}$ (kWh) of the unit during the measurement period of the load profile t_{TTC} is corrected by the following energy consumptions to obtain the total energy consumption $W_{EL\text{-}LP}$, using Formula (12):

— correction for fans, $W_{EL\text{-}Corr}$ (kWh);

— heat loss of the tank for a duration of 24 h;

— additional electrical input, $Q_{EL\text{-}LP}$ (kWh);

— energy consumption for off-peak product where applicable, $W_{EL\text{-}OFF}$ (kWh).

$$W_{EL\text{-}LP} = W_{EL\text{-}M\text{-}LP} - W_{EL\text{-}Corr} + (24 - t_{TTC}) \cdot P_{es} + Q_{EL\text{-}LP} + W_{EL\text{-}OFF} \quad (12)$$

where

$W_{EL\text{-}LP}$ is the total electrical energy consumption during the whole load profile in kWh;

t_{TTC} is the load profile time/duration in h;

P_{es} is the standby power input in kW.

7.9.3 Coefficient of performance (COP_{HW})

The coefficient of performance COP_{HW} for the whole load profile is calculated by:

$$COP_{HW} = \frac{Q_{LP}}{W_{EL-LP}} \quad (13)$$

where

Q_{LP} is the total useful energy content during the whole load profile in kWh;

W_{EL-LP} is the total electrical energy consumption during the whole load profile in kWh.

7.10 Reference hot water temperature and volume of mixed water at 40 °C [stage F]

This test is started when the compressor switches off at the end of the last measurement period for the load profile. A continuous hot water draw-off is started and continues until the hot water temperature $\theta_{WH}(t)$ falls below 40 °C. The hot water flow rate, f_{max}, shall be set to maximum flow rate of the considered load profile.

A reference value for the hot water temperature inside the tank is determined by measuring the outlet water temperature. The average temperature during this draw-off is the reference hot water temperature θ'_{WH} according to Formula (15):

$$\theta'_{WH} = \frac{1}{t_{40}} \int_0^{t40} \theta WH(t) \cdot dt \quad (14)$$

where

θ'_{WH} is the reference hot water temperature in °C;

$\theta_{WH}(t)$ is the outgoing hot water temperature in °C;

t_{40} is the time from starting the draw-off until θ_{WH} is less than 40 °C in s.

The maximum amount of mixed water at 40 °C in one single draw-off shall be determined. This is done by calculating the hot water energy during the draw-off.

The hot water flow rate f_{max} together with the temperatures of the incoming cold water θ_{WC} and the outgoing hot water θ_{WH} are measured during the draw-off at least each 10 s. The maximum hot water volume V_{40} is calculated as:

$$V_{40} = \frac{1}{(40-10)\cdot 60} \int_0^{t_{40}} f_{max}(t) \cdot \left[\theta_{WH}(t) - \theta_{WC}(t)\right] dt \quad (15)$$

where

V_{40} is the maximum volume of mixed water at 40 °C in l;

$\theta_{WH}(t) - \theta_{WC}(t)$ is the temperature difference between hot water temperature at outlet and cold water at inlet of hot water supply storage in K;

t_{40} is the time from starting the draw-off until $\theta_{WH}(t)$ is less than 40 °C in s;

$f_{max}(t)$ is the flow rate of hot water during draw-off in l/min.

7.11 Units with smart control

In case a unit is equipped with a smart control, the benefit of the smart control can be taken into account in the coefficient of performance of the unit. The COP_{smart} can then be determined according to Annex B.

7.12 Temperature operating range

The unit shall be capable of operating within the limit of use indicated by the manufacturer. Refer to Annex C for additional information.

8 Test results and test report

8.1 Data to be recorded

The data to be recorded during the tests of stage C to F are given in Table 5. The table identifies the general information required but is not intended to limit the data to be obtained.

For units with smart control, the additional data to be recorded from the smart cycle test are given in B.2. For each day of the smart cycle, data of stage E shall also be recorded.

Table 5 — Data to be recorded

Measured or calculated quantity	Unit	All tests	Heating up period (stage C)	Standby power input (stage D)	Water draw-offs and COP_{HW} (stage E)	Mixed water and reference temperature (stage F)
Heat source						
Air dry bulb temperature	°C	x				
Air wet bulb temperature	°C	x				
Air flow rate	m^3/h	x (only for ducted product)				
Internal/external static pressure	Pa	x (only for ducted product)				
Hot water supply						
Temperature of incoming cold water	°C	θ_{wc}				
Hot water temperature(s)	°C				T_m	θ_{WH}
Target temperature	°C				T_p	
Hot water flow rate(s)	l/min				f	$_x f_{max}$
Time duration	s		t_h	t_{es}	t_{TTC}	t_{40}
Number of on/off cycles	—			x		
Load profile	—				x	
Reference energy	kWh				Q_{ref}	
Useful heat energy of each draw-off	kWh				$Q_{HP\text{-}tap}$	
Total useful energy content of the load profile	—				Q_{LP}	
Coefficient of performance	—				COP_{HW}	
Volume of tapped water	l					V_{40} V_{40}
Reference temperature	°C					θ'_{WH}
Defrost cycles						

Table 5 *(continued)*

Measured or calculated quantity	Unit	All tests	Heating up period (stage C)	Standby power input (stage D)	Water draw-offs and COP_{HW} (stage E)	Mixed water and reference temperature (stage F)
Defrost period	s	x				
Operating cycle with defrost period	s	x				
Others						
Atmospheric pressure	Pa	x				
Ambient temperature	°C	x				
Electrical						
Voltage	V	x				
Frequency	Hz	x				
Power input	kW			P_{es}		
Measured Electrical energy	kWh		$W_{eh\text{-}M}$	$W_{es\text{-}M}$	$Q_{EL\text{-}tap}$, $Q_{EL\text{-}LP}$, $W_{EL\text{-}M\text{-}LP}$	
Correction for fans	kWh		$W_{EL\text{-}corr}$	$W_{EL\text{-}corr}$	$W_{EL\text{-}corr}$	
Off-peak product energy consumption, where applicable	kWh				$W_{EL\text{-}OFF}$	
Electrical energy	kWh		$W_{eh\text{-}HP}$	$W_{es\text{-}HP}$	$W_{EL\text{-}LP}$	

8.2 Test report

8.2.1 General information

The test report shall at least contain:

a) the date;

b) the testing institute;

c) the test place;

d) the test supervisor;

e) the test object denomination;

f) the manufacturer's serial numbers of the heat pump water heater and the storage tank, as applicable;

g) descriptions of the heat pump water heater and the storage tank including thermostat setting, fan speed;

h) off-peak product (yes/no);

i) type and mass of refrigerant;

j) reference to this document, i.e. ISO 19967-1:2019;

k) any deviations from the test method;

l) data recorded (see 8.1);

m) data recorded (Annex B, where applicable)

n) the main results (see 8.2.2);

o) the date and signature of the test supervisor.

8.2.2 Main results

Main results shall be reported according to Table 6.

Table 6 — Presentation of main results

No.	Result	Symbol	Unit
1)	Loa profile	—	—
2)	Settings of the control, e.g. thermostat set point temperature, mode	—	—
3)	Heating up time	t_h	h:min
4)	Heating up energy input	$W_{eh\text{-}HP}$	kWh
5)	Stand-by power input	P_{es}	W
6)	Total useful energy content during the load profile	Q_{LP}	kWh
7)	Total electrical energy consumption during load profile	$W_{EL\text{-}LP}$	kWh
8)	Coefficient of Performance	COP_{HW}	—
9)	Reference hot water temperature	θ'_{WH}	°C
10)	Maximum volume of mixed water at 40°C	V_{40}	l
11)	Smart control settings, e.g. thermostat set point temperature, mode	—	—
12)	For products with smart control, Smart Control Factor	SCF	—
13)	For products with smart control, order of the load profiles of Day 1 to Day 5	—	—
14)	Coefficient of Performance with smart control	$COP_{s\text{-}mart}$	—
15)	measured volume of the tank, where applicable	V_m	l

9 Marking

Each heat pump water heater 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 water heater consists of several parts, the information shall be marked on each of these parts together with the model designation of the complementary parts.

Further information can be provided; if performance details are provided, the test conditions of Table 3, Table 4 and Annex A are required.

Annex A
(normative)

Load profiles

Table A.1 to A.2 provide the reference load profiles for the determination according to 7.2 stage E. "Water draw-offs". The reference load profile in Table A.1 is for different energy contents according to Table A.1 and the reference load profile in Table A.2 is for different water volume to use. For the test, a specific load profile shall be selected from Table A.1 to Table A.2.

Table A.1 — Load profiles S to XL (energy content)

hh:mm		S (40 l)				M (100 l)				L (200 l)				XL (320 l)			
		Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p
		kWh	l/min	°C	°C	**kWh**	l/min	°C	°C	**kWh**	l/min	°C	°C	**kWh**	l/min	°C	°C
1	07:00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
2	07:05					**1,4**	6	40		**1,4**	6	40					
3	07:15													**1,82**	6	40	
4	07:26													**0,105**	3	25	
5	07:30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25					
6	07:45									**0,105**	3	25		**4,42**	10	10	40
7	08:01					**0,105**	3	25						**0,105**	3	25	
8	08:05									**3,605**	10	10	40				
9	08:15					**0,105**	3	25						**0,105**	3	25	
10	08:25									**0,105**	3	25					
11	08:30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
12	08:45					**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
13	09:00					**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
14	09:30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
15	10:00													**0,105**	3	25	
16	10:30					**0,105**	3	10	40	**0,105**	3	10	40	**0,105**	3	25	40
17	11:00													**0,105**	3	25	
18	11:30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
19	11:45	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
20	12:00																
21	12:30																
22	12:45	**0,315**	4	10	55	**0,315**	4	10	55	**0,315**	4	10	55	0,735	4	10	55
23	14:30					**0,105**	3	25		**0,105**	3	25		0,105	3	25	
24	15:00													**0,105**	3	25	
25	15:30					**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
26	16:00													**0,105**	3	25	
27	16:30					**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
28	17:00													**0,105**	3	25	
29	18:00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
30	18:15	**0,105**	3	40		**0,105**	3	40		**0,105**	3	40		**0,105**	3	40	
31	18:30					**0,105**	3	40		**0,105**	3	40		**0,105**	3	40	
32	19:00					**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
33	19:30																
34	20:00																

Table A.1 *(continued)*

hh:mm		S (40 l)				M (100 l)				L (200 l)				XL (320 l)			
		Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p
		kWh	l/min	°C	°C	**kWh**	l/min	°C	°C	**kWh**	l/min	°C	°C	**kWh**	l/min	°C	°C
35	20:30	**0,42**	4	10	55	**0,735**	4	10	55	**0,735**	4	10	55	**0,735**	4	10	55
36	20:45																
37	20:46													**4,42**	10	10	40
38	21:00									**3,605**	10	10	40				
39	21:15					**0,105**	3	25						**0,105**	3	25	
40	21:30	**0,525**	5	45		**1,4**	6	40		**0,105**	3	25		**4,42**	10	10	40
41	21:35																
42	21:45																
43	Q_{ref}	**2,100**				**5,845**				**11,655**				**19,07**			

Table A.2 — Load profiles S to XL (water volume)

hh:mm		S (40 l)				M (100 l)				L (200 l)				XL (320 l)			
		Volume	f	T_m	T_p	*Volume*	f	T_m	T_p	*Volume*	f	T_m	T_p	*Volume*	f	T_m	T_p
		l	l/min	°C	°C	l	l/min	°C	°C	l	l/min	°C	°C	l	l/min	°C	°C
1	0:00	**7,6**	3,8			**56,8**	6,4			**56,8**	6,4			**102**	11,4		
2	0:30					**7,6**	3,8			**7,6**	3,8			**7,6**	3,8		
3	0:40													**3,8**	3,8		
4	1:00	**3,8**	3,8			**3,8**	3,8										
5	1:05	**1,9**	3,8														
6	1:10	**1,9**	3,8														
7	1:15	**1,9**	3,8														
8	1:40									**34,1**	6,4			**34,1**	6,4		
9	8:00	**3,8**	3,8														
10	8:15	**7,6**	3,8														
11	9:00	**5,7**	3,8														
12	9:15	**3,8**	3,8														
13	10:30					**22,7**	6,4			**34,1**	6,4			**56,8**	11,4		
14	11:30					**15,1**	6,4			**18,9**	6,4			**18,9**	6,4		
15	12:00					**3,8**	3,8			**3,8**	3,8			**3,8**	3,8		
16	12:45					**3,8**	3,8			**3,8**	3,8			**3,8**	3,8		
17	12:50					**3,8**	3,8			**3,8**	3,8			**3,8**	3,8		
18	16:00									**3,8**	3,8			**7,6**	3,8		
19	16:15					**7,6**	3,8			**7,6**	3,8			**7,6**	3,8		
20	16:30													**7,6**	6,4		
21	16:45					**7,6**	6,4			**7,6**	6,4			**7,6**	6,4		
22	17:00					**11,4**	6,4			**26,5**	6,4			**53,0**	11,4		
23	Q_{ref}	**38**				**114**				**208**				**318**			

Annex B
(informative)

Determination of the smart control factor SCF

B.1 General

In case a smart control is declared, the smart control should be tested according to 7.1 and B.2.

B.2 Smart control test procedure

B.2.1 Measurement procedure

The smart control test procedure is based on two periods of test: “reference period” and “smart period”. During the first period, “reference period”, the smart control does not influence the heating procedure and the appliance uses the settings for the temperature according to 7.1; in the second period, “smart period”, which will be reached automatically, the appliance works to reduce any electricity consumption to achieve a minimum performance goal (i.e. smart control factor: SCF) compared with the first period of test.

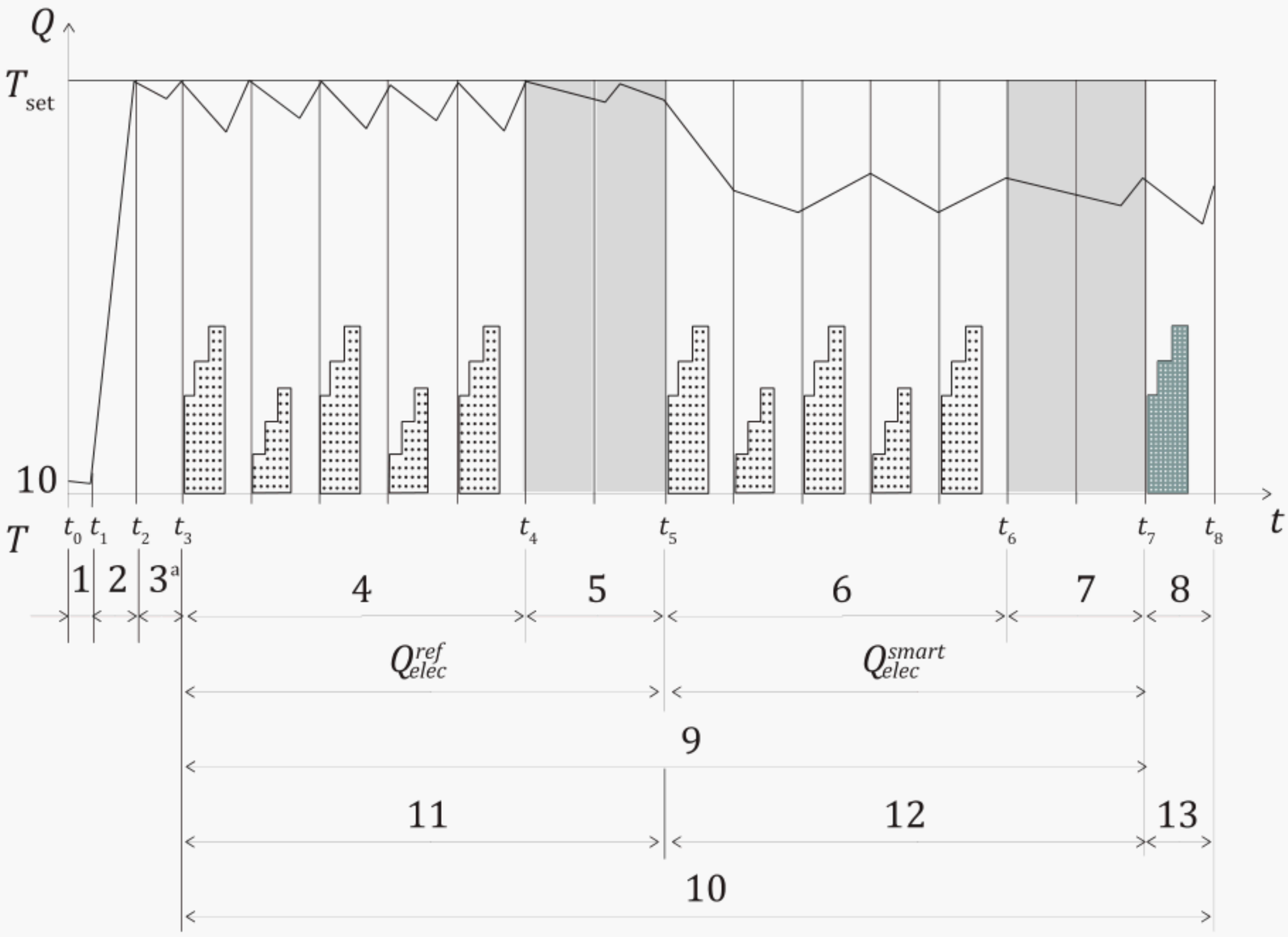
During the reference period the smart control is activated for learning but disabled for operation.

During the smart period the smart control is activated and enabled for optimized operations, i.e. energy savings.

During both periods the chosen load profiles have to be fulfilled.

The total test period is called SMART CYCLE.

The whole test is made using the product thermostat.



Key

1	step 0/1	8	step 8
2	step 2	9	measured energy
3	step 3	10	smart cycle
4	step 4	11	reference period
5	step 5	12	SMART period
6	step 6	13	WHL Control Cycle
7	step 7		
T	temperature	T_{set}	set temperature
t	time		
Q_{elec}^{ref}	total electricity consumption during the reference period of the smart cycle	Q_{elec}^{smart}	total useful energy consumption during the smart period of the smart cycle
a	$t \geq 12$ h		
	hot water temperature		tapping day
	no tapping day		

Figure B.1 — Test procedure for "SMART CYCLE"

B.2.2 Installation

STEP 0 of Figure B.1: The appliance is installed following the same methodology showed in Clause 5.

B.2.3 Stabilisation

STEP 1 of Figure B.1: The appliance is stabilised following the same methodology showed in 7.5.

B.2.4 Filling and heat-up

STEP 2 of Figure B.1: The product shall be fully filled with cold water. The step consists of heating up the storage quantity of water from this initial state until the first time the compressor is switched off by the thermostat sensing the water temperature in the tank.

B.2.5 Stabilisation before reference period

STEP 3 of Figure B.1: keep the product operating without draw-offs during at least 12 h. This stage ends - and next stage starts - at the first thermostat cut-out after 12 h. After the thermostat shuts off the heat pump water heater following the former step, the system is left to operate without draw-offs. This step ends at the first thermostat cut-out after 12 h.

B.2.6 Reference period

STEP 4/5 of Figure B.1: This test period allows consumer behaviour learning and measuring energy consumption with smart control activation.

STEP 4/5 can last 7 or 14 days (1 or 2 weeks); the manufacturer will decide to use one or two weeks procedure and the product will be tested following this one.

The first 5 days of test, in terms of load profiles, will be chosen randomly by the lab between the Load Profile, declared by the manufacturer for the product (WHL, ater Heater Load), and the immediately lower Load Profile (WHL-1). Five water heater loads shall be defined (e.g. three “WHL” and two “WHL-1”) and the lab can decide to use them randomly (e.g. WHL=M → MMMSS, SSMMM, MSMSM,..). In the (unlikely) case that WHL is the smallest Load Profile XXS, the product shall be tested using only the Load Profile WHL (i.e. XXS) for all five days. There is no tapping on the sixth and seventh days. An example is given in Table B.1.

Table B.1 — Example of a series of load profiles

Reference period	Smart period
Day 1: WHL	Repetition in the same order
Day 2: WHL-1	
Day 3: WHL	
Day 4: WHL-1	
Day 5: WHL	
Day 6: no tapping	
Day 7: no tapping	
Day 6: no tapping	
Day 7: no tapping	

If a second week in the reference period is used, it shall have the same load profiles sequence and order compared with the first week

Smart Control is manually/automatically activated, according to the manufacturer’s instructions, at time t_3 (Figure B.1), and it stays on from t_3 to t_8. For the selected Load Profiles, draw-offs are made in accordance with the specifications of the appropriate 24 h tapping pattern from tables of Annex A. Tapping patterns start at t_3 (7:00h) according to tables of Annex A. The tapping period ends 24 h later for each day.

During the tapping step, technical parameters (power, temperature, etc.) are established in accordance with specifications in Tables 3 and 4. During draw-offs, the recommended sample rate is 3 s or less. Recorded values shall be part of the technical test report.

Electricity consumption over each 24 h test, $Q_{\text{elec}}^{\text{ref}}[i]$ [kWh], shall be measured and a total electrical consumption, $Q_{\text{elec}}^{\text{ref}}$ is calculated for the "Reference period" according to Formula (B.1).

$$Q_{\text{elec}}^{\text{ref}} = \sum_{i=l}^{7n} Q_{\text{elec}}^{\text{ref}}[i] \tag{B.1}$$

where

n = 1 is the "reference period" based on one week;

n = 2 is the "reference period" based on two weeks.

The useful energy content of each load profile of the reference period $Q_{\text{elec}}^{\text{ref}}[i]$ [kWh] shall be determined as specified in 7.9.1. The total useful energy content of the reference period $Q_{\text{LP}}^{\text{ref}}$ shall be calculated using Formula (B.2):

$$Q_{\text{LP}}^{\text{ref}} = \sum_{i=l}^{7n} Q_{\text{LP}}^{\text{ref}}[i] \tag{B.2}$$

where

n = 1 is the "reference period" based on one week;

n = 2 is the "reference period" based on two weeks.

Products classified as "Off-peak" appliances shall be energized for a maximum period of eight consecutive hours during 22:00h and 7:00h of the 24 h tapping pattern as specified in the tables of Annex A.

The load profile period of 24 h shall be respected, i.e. each 24 h period, at 07:00 the draw-offs specified in the tables of Annex A begin without waiting for a shut off of the heat pump water heater by the thermostat.

B.2.7 Smart period

STEP 6/7 of Figure B.1: Immediately after the "Reference period", the test of "Smart period" is performed for one week, using the same repetition of load profile sequence defined during the "reference period"; smart control function is enabled. The energy consumption is measured during this step as well and it will be compared to the energy consumption of the "reference period". This percentage of saving is named "Smart control factor: SCF".

The main results of the test are the electricity consumption over each 24 h test, $Q_{\text{elec}}^{\text{smart}}[i]$ [kWh and the total electricity consumption for the "Smart period", $Q_{\text{elec}}^{\text{smart}}$, calculated according to Formula (B.3)

$$Q_{\text{elec}}^{\text{smart}} = \sum_{i=l}^{7n} Q_{\text{elec}}^{\text{smart}}[i]\,\text{s} \tag{B.3}$$

where

n = 1 is the "reference period" based on one week;

n = 2 is the "reference period" based on two weeks.

The useful energy content of each load profile of the reference period $Q_{\mathrm{LP}}^{\mathrm{smart}}[i]$ [kWh] shall be determined as specified in 7.9.1. The total useful energy content of the reference period $Q_{\mathrm{LP}}^{\mathrm{smart}}$ shall be calculated using Formula (B.4):

$$Q_{\mathrm{LP}}^{\mathrm{smart}} = \sum_{i=l}^{7n} Q_{\mathrm{LP}}^{\mathrm{smart}}[i] \tag{B.4}$$

where

n = 1 is the "reference period" based on one week;

n = 2 is the "reference period" based on two weeks.

Products to be classified as "Off-peak" appliances shall be energized for a maximum period of eight consecutive hours during 22:00h and 7:00h of the 24 h tapping pattern as specified in the tables of Annex A.

The load profile period of 24 h shall be respected, i.e. each 24 h period, at 07:00 the draw-offs specified in the tables of Annex A begin without waiting for a shut-off of the heat pump water heater by the thermostat.

B.2.8 Reporting of "Smart Control Factor" (SCF)

The difference between $Q_{\mathrm{LP}}^{\mathrm{ref}}$ and $Q_{\mathrm{LP}}^{\mathrm{smart}}$ measurement results shall be lower than 2 %. The SCF shall be calculated by the following Formula (B.5):

$$SCF = \left(1 - \frac{Q_{\mathrm{elec}}^{\mathrm{smart}}}{Q_{\mathrm{elec}}^{\mathrm{ref}}}\right) \tag{B.5}$$

If the value of SCF is greater or equal to 0,07 and the requirements under B.2.9 are fulfilled, then the value of *smart* shall be 1. In all other cases, the value of *smart* shall be 0.

B.2.9 Check cycle

STEP 8 of Figure B.1: Immediately after the "Smart period" an additional 24 h load profile (named "WHL check cycle") is performed and requirements shall be fulfilled. If the requirement is not fulfilled, the smart control benefit cannot be taken into account and the value of smart is equal to 0 in Formula (B.6). In this step the product is tested in accordance to the water heater load profile of the first day (Day 1) of the "reference period". The unit shall be able to fulfil the requirements of this load profile.

B.3 Calculation of COP_{smart}

The coefficient of performance COP_{HW} determined according to 7.9.3 for the load profile can be corrected for the smart control benefit if any, to determine COP_{smart} by using Formula (B.6)

$$\mathrm{COP}_{\mathrm{smart}} = \left(\frac{\mathrm{COP}_{\mathrm{HW}}}{1 - SCF \times \mathrm{smart}}\right) \tag{B.6}$$

where

COP_{HW} is the coefficient of performance for the load profile according to 7.9.3

SCF is the smart control factor as determined according to B.2.8;

smart is the value of the indicator of smart control compliance of the product determined according to B.2.8 and B.2.9;

B.4 Test results and test report

B.4.1 Additional data to be recorded

For units with smart control, the additional data to be recorded from the smart control test are given in Table B.2. For each day of the smart cycle, data of stage E shall also be recorded.

Table B.2 — Additional data to be recorded for smart control test

Measured or calculated quantity	Unit	Smart cycle	Reference period	Smart period	WHL control
Hot water supply					
Order of load profiles for Day 1 to Day 5			x	x	
Total useful energy content	kWh		$Q_{\mathrm{LP}}^{\mathrm{ref}}$	$Q_{\mathrm{LP}}^{\mathrm{smart}}$	
Electrical					
Total electricity consumption	kWh		$Q_{\mathrm{elec}}^{\mathrm{ref}}$	$Q_{\mathrm{elec}}^{\mathrm{smart}}$	$Q_{\mathrm{elec}}^{\mathrm{WHL,C}}$
Smart control factor	—	SCF			

B.4.2 Additional test results

For units with smart control, the additional results shall be reported according to Table B.3.

Table B.3 — Presentation of additional results

No.	Result	Symbol	Unit
1)	Smart control settings, e.g. thermostat set point temperature, mode	—	—
2)	For products with smart control, Smart Control Factor	*SCF*	—
3)	For products with smart control, order of the load profiles of Day 1 to Day 5	—	—
4)	Coefficient of Performance with smart control	$\mathrm{COP}_{\mathrm{smart}}$	—

Annex C
(informative)

Temperature operating range

C.1 Temperature operating range

The unit shall be capable of operating within the limit of use indicated by the manufacturer. The procedure includes two heating up periods, the first one proceeded at the minimal heat source temperature, the second one at maximal heat source temperature.

Table C.1 — Operating conditions

Test No.	Heat source temperature at the evaporator °C	Temperature hot water supply or intermediate fluid in the tank °C
Test 1	minimal heat source temperature	start temperature according to Table 3 maximal hot water temperature (thermostat setting) hot water mean temperature (draw-off)
Test 2	maximal heat source temperature	minimal start temperature maximal hot water temperature (thermostat setting) hot water mean temperature (draw-off)

The minimal heat source temperature (lower limit of use) at the outdoor heat exchanger is set at the beginning of the test and maintained constant during the test. The maximal hot water temperature (higher limit of use) is set at the thermostat during the beginning of the test and maintained constant during the test. Permissible deviations from set values are specified in Table 2. The tank is filled with water at the temperature of the incoming cold water specified in Table 3. Then the unit shall start up and heat up the tank to the maximum possible hot water temperature defined by the manufacturer, without being stopped by the safety devices.

The maximum set point of the hot water temperature values is stated in the operation and installation instructions. The deviation between individual values and set values shall be between:

— zero and minus twice the permissible deviation according to Table 2, for maximal temperatures;

— zero and plus twice the permissible deviation according to Table 2, for minimal temperatures.

Uncertainty of measurement shall be as specified in Table 1. The test is performed with the same source volume flow as used for the measurement of the load profile.

Table C.2 — Determination of wet bulb temperature related to dry bulb temperature

Dry bulb temperature T_{DB} in °C	Wet bulb temperature T_{WB} in °C
$T_{DB} < -10$	Not defined
$-10 \leq T_{DB} \leq 12$	$T_{WB} = T_{DB} - 1$
$12 < T_{DB} \leq 20$	$T_{WB} = 0{,}34 * T_{DB} + 6{,}95$
$T_{DB} > 20$	$T_{WB} = 0{,}86 * T_{DB} - 3{,}50$

Immediately after the heat pump water heater stops the first time, 50 % of the nominal tank volume is tapped and the hot water temperature is measured. The hot water flow rate has to be set to the

maximum flow rate of the declared load profile. The mean value of the hot water temperature during the draw-off is the upper limit for the hot water supply production.

Then the procedure is repeated with the maximal heat source temperature (upper limit of use). The environmental conditions during the test shall be as specified in Table 4. The test is fulfilled when under the specified conditions during the whole test procedure the heat pump water heater is not shut off by a security device.

Bibliography

[1] ISO 5801, *Fans — Performance testing using standardized airways*

[2] ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

[3] ISO 12759, *Fans — Efficiency classification for fans*

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