
**Heat pump water heaters — Testing
and rating for performance —**

**Part 1:
Heat pump water heater for hot
water supply**

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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

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/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.

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.

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.

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2 Normative references (standards.iteh.ai)

There are no normative references in this document.

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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](#).

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3.10
water draw-off

given combination of useful water flow rate, useful water temperature, useful energy content and target temperature

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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

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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	$\text{kJ}/(\text{kg}\cdot\text{K})$
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-LP}	calculated heat energy produced by electrical resistance heater during the whole load profile	kWh
Q_{EL-tap}	Calculated heat energy produced by electrical resistance heater to reach the required tapping temperature	kWh
Q_{HP-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-HP}	total electricity consumption during the test duration t_h	kWh
W_{eh-M}	measured electricity consumption during the test duration t_h	kWh
$W_{EL-Corr}$	correction due to electricity consumption of fan/liquid pump	kWh
W_{EL-LP}	total electrical energy consumption during the whole load profile	kWh
$W_{EL-M-LP}$	total measured electrical energy input	kWh
W_{EL-OFF}	calculated energy consumption for off-peak products	kWh
W_{es-HP}	total energy input during the last on-off-cycle	kWh
W_{es-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 Ha	Interval Db	Interval Sc	Interval Ha	Interval Db	Interval Sc
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 m², 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 %		
<p>^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.</p> <p>^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.</p> <p>^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.</p> <p>^d For units with outdoor heat exchanger surfaces greater than 5 m², the deviation on the air inlet dry bulb temperature is doubled.</p>						

Table 3 — Test conditions applicable to all systems
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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