BS EN 13203-3:2010

BSI Standards Publication

Solar supported gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 500 litres water storage capacity

Part 3: Assessment of energy consumption

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National foreword

This British Standard is the UK implementation of EN 13203-3:2010.

The UK participation in its preparation was entrusted to Technical Committee GSE/29, Gas-fired central heating boilers (domestic and non-domestic) and domestic gas-fired water heaters.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Solar supported gas-fired domestic appliances producing hot water - Appliances not exceeding 70 kW heat input and 500 litres water storage capacity - Part 3: Assessment of energy consumption

Appareils domestiques produisant de l'eau chaude sanitaire utilisant les combustibles gazeux couplés à un capteur solaire - Appareils de débit calorifique inférieur ou égal à 70 kW et de capacité de stockage inférieure ou égale à 500 litres - Partie 3 : Évaluation de la consommation énergétique

Solar unterstützte gasbeheizte Geräte für die sanitäre Warmwasserbereitung für den Hausgebrauch - Geräte, die eine Nennwärmebelastung von 70 kW und eine Speicherkapazität von 500 Liter Wasser nicht überschreiten - Teil 3: Bewertung des Energieverbrauchs

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Foreword

This document (EN 13203-3:2010) has been prepared by Technical Committee CEN/TC 109 “Central heating boilers using gaseous fuels”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2011, and conflicting national standards shall be withdrawn at the latest by February 2011.

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1 Scope

This European Standard is applicable to solar supported gas-fired appliances producing domestic hot water. It applies to a system marketed as single unit or a system fully specified by a manufacturer that:

— has a gas heat input not exceeding 70 kW; and

— has a hot water storage capacity not exceeding 500 l; and

— is equipped with at least one solar collector; and

— is, with regard to the solar hydraulic circuit, considered as a forced circulation system (definition according to EN ISO 9488:1999).

The appliances covered by this European Standard are described in Annex C.

This European Standard does not apply to thermo-siphon or integral collector storage systems (definitions according to EN ISO 9488:1999).

NOTE In principle, the energy consumption of thermo-siphon solar preheat systems and integral collector storage preheat systems can also be assessed on the basis of this standard. One appropriate procedure for that purpose is to calculate the temperature level of the domestic hot water withdrawn from the thermal solar system for the reference conditions defined in this standard by using the numerical system model and the thermal solar system performance parameters according to ISO 9459-5. Based on the temperature level of the hot water withdrawn from the store the energy consumption of the gas appliance should be determined. This determination can either be done by means of calculations or by performing a test according to EN 13203-2 and using instead of the cold water inlet temperature the hot water temperature withdrawn from the store.

This standard is not intended to assess the performance:

— of the solar collector(s), which should comply with EN 12975-1 and EN 12975-2; and

— thermal solar systems and components, which should comply with EN 12976-1 and EN 12976-2.

This European Standard, EN 13203-3, sets out a method for assessing the energy performance of a solar supported appliance. It defines a number of daily tapping cycles for each domestic hot water use, kitchen, shower, bath and a combination of these, together with corresponding test procedures including information about the available solar radiation. It enables the energy performances of different gas-fired appliances to be compared and matched to the needs of the user.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12975-1, *Thermal solar systems and components — Solar collectors — Part 1: General requirements*

EN 12975-2, *Thermal solar systems and components — Solar collectors — Part 2: Test methods*

EN 12976-1, *Thermal solar systems and components — Factory made systems — Part 1: General requirements*

EN 12976-2:2006, *Thermal solar systems and components — Factory made systems — Part 2: Test methods*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
aperture area of solar collector
maximum projected area through which solar radiation enters the collector

NOTE See definition and explanation according to EN ISO 9488:1999.

3.2
controls
all hydraulic, thermal and electronic components necessary for the operation of the system

3.3
control cycle
time cycle for keeping components and/or the storage of the domestic hot water circuit at predetermined temperature level, consisting of an "ON" duration time during which the heating of the domestic hot water (by gas energy and auxiliary energy) is operating, and an "OFF" duration time during which no heating occurs

3.4
domestic water mean temperature
average temperature of the water delivered during the time Δt

SYMBOL T_m

NOTE $$T_m = \frac{1}{\Delta t}\int T \cdot dt$$

3.5
domestic water test temperature
temperature of the delivered water at which the tests are conducted

3.6
measurement period
ongoing 24 h period during which the system is continuously operated

NOTE Measurement period starts at 0h00.

3.7
nominal domestic hot water heat input
value of the heat input stated by the manufacturer for the production of domestic hot water[1)]

SYMBOL Q_{nw}

NOTE Q_{nw} is expressed in kilowatts (kW).

3.8
off mode
state of an appliance, selected by the user, in which hot sanitary water cannot be provided

3.9
solar collector field
either one or a combination of more than one solar collectors

1) The manufacturer is the organisation or company that assumes responsibility for the product.

3.10
solar collector simulator
device delivering the thermal power to the system (store) instead of a real solar collector based on the solar collector efficiency parameters according to EN 12975-2

NOTE The solar collector simulator is described in Annex B.

3.11
solar collector simulator circuit
circuit containing the piping, the pump, the controls, the heat-exchanger and the collector solar simulator

3.12
solar cycle
day of a year representative for middle European climate conditions

NOTE The total daily radiation of that day is 3,0 kWh/m² and the mean value of the outdoor ambient temperature is 6,7 °C.

3.13
solar supported system
system marketed as single unit or a system fully specified by a manufacturer, and composed of solar collector, water storage tank, controls, pipework and the gas appliance

3.14
stand by mode
operating state in which the appliance can provide hot sanitary water at any time

NOTE In the case of an appliance with a control cycle for keeping components and/or the storage (if any) of the domestic hot water circuit at predetermined temperature level no tapping is made.

3.15
storage
reservoir for domestic hot water

3.16
summer mode
conditions during which the appliance supplies energy only for the production of domestic hot water

3.17
useful water
quantity of water delivered for which the temperature increase is in accordance with the requirement fixed for each individual delivery of the tapping cycles

3.18
wasted water
quantity of water delivered for which the temperature increase is not in accordance with the requirement fixed for each individual delivery of the tapping cycles

3.19
winter mode
conditions during which the appliance supplies energy for the production of domestic hot water and/or space heating

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4 General test conditions

4.1 General

In order to apply the test procedures specified in this standard, it is required:

— that the collectors of the system fulfil the requirements of EN 12975-1 and are already tested according to EN 12975-2; and

— that factory made thermal solar systems fulfil the requirements of EN 12976-1 are tested according to EN 12976-2.

4.2 Reference conditions

Unless otherwise stated, the general test conditions are as follows:

— cold water temperature: (10 ± 2) °C;

— cold water pressure: (2 ± 0,1) bar;

— ambient air temperature: (20 ± 3) °C;

— electrical supply voltage: (230 ± 2) V.

4.3 Measurement uncertainties

Except where otherwise stated in the clauses describing the tests, the uncertainties of measurements carried out shall be not greater than the maximum uncertainties indicated below.

These uncertainties correspond to two standard deviations.

The laboratory evaluates these standard deviations taking account of the various sources of uncertainty: contribution from the instrument, repeatability, calibration, ambient conditions, etc.

a) Water rate: ± 1 %;

b) gas rate: ± 1 %;

c) time: ± 0,2 s;

d) temperatures :

   1) ambient: ± 1 °C;

   2) water: ± 0,5 °C;

   3) gas: ± 0,5 °C;

e) mass: ± 0,5 %;

f) gas pressure: ± 2 %;

g) gas calorific value: ± 1 %;

h) gas density: ± 0,5 %;

i) electrical energy: ± 2 %.

The stated measurement uncertainties relate to individual measurements. For measurements that combine a number of individual measurements, smaller uncertainties on the individual measurements may be necessary to ensure a total uncertainty within ± 2 %.

4.4 Test conditions

4.4.1 General

Except where otherwise stated, the appliance is tested under the following conditions.

For combination gas appliances, the tests are carried out only in summer mode as defined in 3.16, and the appliance is set in summer mode.

4.4.2 Installation for test procedure

The installation for testing, including thermal insulation of the components, shall be in accordance with the manufacturer specifications.

The maximum length of the piping between the gas appliance and the storage tank(s) shall not exceed 3 m in total (inlet plus outlet).

The minimum length of the piping between the solar collector simulator and the storage tank(s) shall be 6 m in total (inlet plus outlet) and shall not exceed 10 m.

If not specified by the manufacturer of the appliance, the piping shall be in accordance with EN 12976-2:2006, Annex B and Table B.2 (pipe diameter and insulation thickness).

For drain back solar thermal systems only the mass flow rate according to the collector circuit specifications ($\dot{m}$) supplied by the manufacturer shall be used.

4.4.3 Test room

The appliance is installed in a well-ventilated, draught-free room (air speed less than 0,5 m/s).

The appliance is protected from direct solar radiation.

4.4.4 Water supply

For the tests:

— the domestic water pressure is the static inlet pressure under dynamic conditions measured as close as possible to the system;

— the inlet and outlet temperatures of the domestic water are measured in the centre of the flow and as close as possible to the system.

The inlet temperatures are measured immediately upstream of the water inlet connection. Except where otherwise stated, the outlet temperatures are measured immediately downstream of the outlet connection or, in the case of a system with spout delivery, by means of an immersed temperature measuring device, e.g. a U-tube fitted at the outlet of a tube of the same length as the minimum length of the spout normally supplied by the manufacturer.

The hot water temperature is measured with a rapid response thermometer.

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"Rapid response thermometer" means a measuring instrument with a response time such that 90 % of the final temperature rise, from 15 °C to 100 °C, is obtained within about 1 s, when the sensor is plunged into still water.

4.4.5 Solar circuit

For the tests, the fluid used in the solar collector simulator circuit is water at the pressure specified by the manufacturer.

4.4.6 Initial adjustment of the appliance

The system is installed in accordance with the manufacturer's instructions.

The heat input of the gas appliance shall be adjusted to within ± 2 % of the nominal domestic hot water heat input under the conditions prevailing at the time of the test with solar collector simulator off.

The delivered water temperature at the system outlet is defined as follows:

a) System with an adjustable temperature: the tests are carried out at a temperature not greater than 65 °C, with a minimum temperature increase equal to or greater than 45 K above cold water inlet temperature.

b) System with a fixed temperature: the tests are carried out at the temperature specified by the manufacturer, with a minimum temperature increase equal to or greater than 45 K above cold water inlet temperature.

The same conditions of initial adjustment stated by the manufacturer are used for all the tests. These conditions are included in the test report.

4.4.7 Electrical supply

The appliance is supplied with the nominal voltage or a voltage included within the range of nominal voltages.

4.4.8 Solar thermal input

The solar thermal input is supplied to the solar heat exchanger of the solar tank as follows.

Instead of installing the solar collector field, a solar collector simulator is connected to the hydraulic connections of the storage tank originally foreseen for the connection to the solar collector field as described in Annex D. The flow rate in the solar hydraulic circuit shall be according to the specifications of the appliance manufacturer. If not specified by the appliance manufacturer, a flow rate of 50 l/h for each square metre of aperture area of the solar collector field shall be used.

5 Determination of the energy consumption of the solar supported gas-fired appliance

5.1 General

This clause defines the test methods to be employed in determining the energy consumption of the appliance.

5.2 Tapping cycles

All patterns define a 24 h measurement cycle and within that cycle the starting times and the total energy content (in kilowatt hours equivalent of hot water tapped) of each draw-off are defined.

Furthermore, the draw-off can be characterised in two ways, either:

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a) "basin" type draw-off (bath, dish wash) versus "continuous flow" draw-offs (shower, hand wash, etc.).

The aim of the former is to arrive at an average temperature of the tub, so all supplied energy can be considered useful from the very beginning of the draw-off (minimum useful temperature increase is 0 K).

The latter start to be useful only from a certain temperature (minimum useful temperature increase is 15 K lower than the desired temperature); or

b) "kitchen" type draw-off which are carried out with a water temperature of 45 K rather than the 30 K increase in a).

The tapping flow rates used to perform the different types of tapping of each of the five tapping cycles defined by Tables 2 to 6 should be taken as given by Table 1.

When these tapping rates result in a tapping period of less than 15 s, the flow rate should be decreased such that the tapping period is (15 ± 1) s.

If, by design of the appliance, the test cannot be carried out with these low flow rates, the minimum flow rate for the ignition of the appliance is taken.

If, by design, the appliance is fitted with an excess flow valve, the tests are carried out with this excess flow rate.

Table 1 — Tapping flow rates

Type of tapping	**Energy** kWh	**Hot water flow rates corresponding to a temperature rise of 45 K** l/min
household cleaning	0,105	3 ± 0,5
small	0,105	3 ± 0,5
floor cleaning	0,105	3 ± 0,5
dish washing	0,315	4 ± 0,5
dish washing	0,420	4 ± 0,5
dish washing	0,735	4 ± 0,5
large (cycle n° 1)	0,525	4 ± 0,5
shower	1,400	6 ± 0,5
shower (cycles n° 4 et n° 5)	1,800	6 ± 0,5
bath	3,605	10 ± 0,5
bath (cycles n° 4 et n° 5)	4,420	10 ± 0,5
shower + bath (cycle n° 5)	6,240	16 ± 0,5

NOTE For all other temperature rises a proportional correction is applied to the hot water flow rate, as follows: K = (55 – 10) / (delivered water temperature defined by 4.4.6 – 10).

Table 2 — Tapping cycle n° 1

	H min. start	Energy kWh	Type of delivery	ΔT desired (K), to be achieved during tapping	Min. ΔT (K) = start of counting useful energy
1	07.00	0,105	small		15
2	07.30	0,105	small		15
3	08.30	0,105	small		15
4	09.30	0,105	small		15
5	11.30	0,105	small		15
6	11.45	0,105	small		15
7	12.45	0,315	dish washing	45	0
8	18.00	0,105	small		15
9	18.15	0,105	household cleaning		30
10	20.30	0,420	dish washing	45	0
11	21.30	0,525	large		30
Total		2,1			

Equivalent hot water litres at 60 °C | 36 |

Table 3 — Tapping cycle n° 2

	H min. start	Energy kWh	Type of delivery	ΔT desired (K), to be achieved during tapping	Min. ΔT (K) = start of counting useful energy
1	07.00	0,105	small		15
2	07.15	1,400	shower		30
3	07.30	0,105	small		15
4	08.01	0,105	small		15
5	08.15	0,105	small		15
6	08.30	0,105	small		15
7	08.45	0,105	small		15
8	09.00	0,105	small		15
9	09.30	0,105	small		15
10	10.30	0,105	floor cleaning	30	0
11	11.30	0,105	small		15
12	11.45	0,105	small		15
13	12.45	0,315	dish washing	45	0
14	14.30	0,105	small		15
15	15.30	0,105	small		15
16	16.30	0,105	small		15
17	18.00	0,105	small		15
18	18.15	0,105	household cleaning		30
19	18.30	0,105	household cleaning		30
20	19.00	0,105	small		15
21	20.30	0,735	dish washing	45	0
22	21.15	0,105	small		15
23	21.30	1,400	shower		30
Total		5,845			

Equivalent hot water litres at 60 °C | 100,2 |

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Table 4 — Tapping cycle n° 3

	H min. start	Energy kWh	Type of delivery	ΔT desired (K), to be achieved during tapping	Min. ΔT (K) = start of counting useful energy
1	07.00	0,105	small		15
2	07.05	1,400	shower		30
3	07.30	0,105	small		15
4	07.45	0,105	small		15
5	08.05	3,605	bath	30	0
6	08.25	0,105	small		15
7	08.30	0,105	small		15
8	08.45	0,105	small		15
9	09.00	0,105	small		15
10	09.30	0,105	small		15
11	10.30	0,105	floor cleaning	30	0
12	11.30	0,105	small		15
13	11.45	0,105	small		15
14	12.45	0,315	dish washing	45	0
15	14.30	0,105	small		15
16	15.30	0,105	small		15
17	16.30	0,105	small		15
18	18.00	0,105	small		15
19	18.15	0,105	household cleaning		30
20	18.30	0,105	household cleaning		30
21	19.00	0,105	small		15
22	20.30	0,735	dish washing	45	0
23	21.00	3,605	bath	30	0
24	21.30	0,105	small		15
Total		11,655			

Equivalent hot water litres at 60 °C | 199,8 |

Table 5 — Tapping cycle n° 4

	H min. start	Energy kWh	Type of delivery	ΔT desired (K), to be achieved during tapping	Min. ΔT (K) = start of counting useful energy
1	07.00	0,105	small		15
2	07.15	1,82	shower		30
3	07.26	0,105	small		15
4	07.45	4,42	bath	30	0
5	08.01	0,105	small		15
6	08.15	0,105	small		15
7	08.30	0,105	small		15
8	08.45	0,105	small		15
9	09.00	0,105	small		15
10	09.30	0,105	small		15
11	10.00	0,105	small		15
12	10.30	0,105	floor cleaning	30	0
13	11.00	0,105	small		15
14	11.30	0,105	small		15
15	11.45	0,105	small		15
16	12.45	0,735	dish washing	45	0
17	14.30	0,105	small		15
18	15.00	0,105	small		15
19	15.30	0,105	small		15
20	16.00	0,105	small		15
21	16.30	0,105	small		15
22	17.00	0,105	small		15
23	18.00	0,105	small		15
24	18.15	0,105	household cleaning		30
25	18.30	0,105	household cleaning		30
26	19.00	0,105	small		15
27	20.30	0,735	dish washing	45	0
28	20.46	4,42	bath	30	0
29	21.15	0,105	small		15
30	21.30	4,42	bath	30	0
Total		19,07			

Equivalent hot water litres at 60 °C | 325 |

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Table 6 — Tapping cycle n° 5

	H min. start	Energy kWh	Type of delivery	ΔT desired (K), to be achieved during tapping	Min. ΔT (K) = start of counting useful energy
1	07.00	0,105	small		15
2	07.15	1,82	shower		30
3	07.26	0,105	small		15
4	07.45	6,24	shower + bath	30	0
5	08.01	0,105	small		15
6	08.15	0,105	small		15
7	08.30	0,105	small		15
8	08.45	0,105	small		15
9	09.00	0,105	small		15
10	09.30	0,105	small		15
11	10.00	0,105	small		15
12	10.30	0,105	floor cleaning	30	0
13	11.00	0,105	small		15
14	11.30	0,105	small		15
15	11.45	0,105	small		15
16	12.45	0,735	dish washing	45	0
17	14.30	0,105	small		15
18	15.00	0,105	small		15
19	15.30	0,105	small		15
20	16.00	0,105	small		15
21	16.30	0,105	small		15
22	17.00	0,105	small		15
23	18.00	0,105	small		15
24	18.15	0,105	household cleaning		30
25	18.30	0,105	household cleaning		30
26	19.00	0,105	small		15
27	20.30	0,735	dish washing	45	0
28	20.46	6,24	shower + bath	30	0
29	21.15	0,105	small		15
30	21.30	6,24	shower + bath	30	0
Total		24,53			

Equivalent hot water litres at 60 °C | 420 |

5.3 Solar cycle

5.3.1 General

The solar cycle given in Table 7 defines a 24 h cycle for the total solar radiation available at the surface of the aperture area of the solar collector field and the outdoor ambient temperature.

The data from Table 7 is required for the generation of the solar thermal input by the solar collector simulator.

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Table 7 — Solar cycle

Hour	Total radiation on collector aperture area kWh/m^2	Outdoor ambient temperature °C
1	0	5
2	0	4,7
3	0	4,4
4	0	4,3
5	0	4,3
6	0	4,3
7	0	4,6
8	0,10	5,1
9	0,16	5,8
10	0,38	6,7
11	0,32	7,7
12	0,28	8,6
13	0,42	9,5
14	0,47	10,1
15	0,55	10,4
16	0,36	10,4
17	0	9,9
18	0	9,2
19	0	8,3
20	0	7,4
21	0	6,5
22	0	5,6
23	0	4,8
24	0	4,1

5.3.2 Test for determination of the daily energy consumption

5.3.2.1 Tapping cycles

There are five different tapping cycles depending on the use.

For each use, the tapping cycle(s) is (are) based respectively on Tables 2, 3, 4, 5 and 6. Each individual tapping of the tapping cycles shall be completed, that means the valve shall be closed, and a delay of at least 1 min is required, before starting the following delivery.

5.3.2.2 Solar cycle

The solar cycle described in 3.12 shall be used in combination with all tapping cycles.

5.3.2.3 Performing the test

For appliances with and without energy consumption between deliveries (gas or electricity), the test is performed in the following way.

The time used for the description of the tapping cycle is synchronous with the time used for the description of the solar cycle.

During the operation of the system on the test facility one specific tapping cycle and the solar cycle are repeated.

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The measurement period starts at 0h00 and stops at 24h00. The test is continued on the test facility until the gas energy consumption of the system during two consecutive measurement periods not differ by more than 5 %.

If this criterion is not fulfilled after six measurement periods, the gas energy consumption for the final measurement period can be determined by using the average value of the gas energy consumption measured during the last three measurement periods.

The gas energy consumption measured during the final measurement period shall be used for the determination of the system performance.

NOTE The measurement period can be shortened by pre-heating the solar part of the storage tank.

5.3.2.4 Measurement of the energy recovered by the useful water

The appliance is installed and adjusted in the initial state conditions and in the initial adjustment conditions defined in 4.4.6.

The useful energy recovered by the water Q_{H2O} (kWh) is given by the equation:

$$Q_{H_20} = 1{,}163 \times 10^{-3} \sum_{i=1}^{n} \int_{0}^{t_1} d_i \cdot \Delta T_i(t_i) dt \quad (1)$$

where

n is the number of tapings;

d_i is the water rate delivered in litres per minute;

ΔT_i (t) is the instantaneous temperature rise during the tapping, in kelvins;

t_i is the tapping duration of the useful water, in minutes.

The useful energy recovered at each individual tapping is set against the values given in Tables 2, 3, 4, 5 and 6.

For each individual delivery, the accuracy of the value is ± 10 Wh or ± 2 % with an overall energy recovery of ± 2 %.

5.3.2.5 Calculation of gas energy

The daily consumption of gas is calculated according to the following equation:

$$Q_{gas} = \frac{V_g \cdot K \cdot NCV \cdot Q_{tot}}{Q_{H_2O}} \quad (2)$$

where

Q_{gas} is the daily energy contributed in kilowatt hours calculated using NCV;

V_g is the gas consumption, in cubic metres;

NCV is the net calorific value in kilowatt hours per cubic metre (at 15 °C and 1 013,25 mbar)

and

$$K = \frac{p_a + p_g}{1013{,}25} \times \frac{288{,}15}{T_g + 273{,}15} \quad (3)$$

where

p_a is the atmospheric pressure, in millibars;

p_g is the gas pressure, in millibars;

T_g is the gas temperature, in degrees Celsius;

Q_{H_2O} is the measured energy recovered by the water according to 5.3.2.4 in kilowatt hours;

Q_{tot} is the total delivered energy of used tapping cycle, value from Tables 2, 3, 4, 5 and 6, in kilowatt hours.

For the appliances concerned, the daily consumption of gas is then weighted, to take into account both summer and winter modes, by the following equation:

$$Q_{gas,W} = \frac{Q_{gas}}{1 + 0{,}5 \times \left[\frac{\eta_{CH-nom} \times Q_{gas}}{Q_{tot}} - 1 \right]} \quad (4)$$

where

$Q_{gas,W}$ is the daily energy calculated in winter mode in kilowatt hours calculated using *NCV*;

Q_{gas} is the daily energy consumed in summer mode in kilowatt hours calculated using *NCV*;

η_{CH-nom} is the useful efficiency at nominal heat input and at an average temperature of 70 °C for the space heating function;

Q_{tot} is the total energy delivered of the tapping cycle used, value from Tables 2, 3, 4, 5 and 6, in kilowatt hours.

$$Q_{gas,p} = Q_{gas,W} \times \frac{D_W}{D_W + D_S} + Q_{gas} \times \frac{D_S}{D_W + D_S} \quad (5)$$

where

$Q_{gas,p}$ is the weighted daily energy in kilowatt hours calculated using *NCV*;

$Q_{gas,W}$ is the daily energy calculated in winter mode in kilowatt hours calculated using *NCV*;

Q_{gas} is the daily energy consumed in summer mode in kilowatt hours calculated using *NCV*;

D_W is the number of days of winter mode, this number is equal to 200;

D_S is the number of days of summer mode, this number is equal to 165.

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5.3.2.6 Calculation of electrical energy

The electrical energy of all the electrical auxiliaries necessary to achieve the tapping programme(s) at nominal use selected by the manufacturer is measured.

If these auxiliaries are not integrated in the appliance (e.g. collector loop pump, solar controls, etc.), the theoretical operation time of these electrical auxiliaries shall be recorded. In this case, the electrical consumption of the auxiliaries is calculated based on the theoretical operation time and the nominal electrical power consumption of these auxiliaries.

Where an electrical auxiliary (e.g. a pump) necessary for the delivery of hot water is not included as an integral part of the appliance, then the essential characteristics of the component shall be specified in the appliance installation instructions. An appropriate component shall be used for test procedures.

The measurement of the electrical consumption starts at the same time and finishes at the same time as the measurement of the gas consumption.

The measurement is taken for the nominal use and if necessary for the reduced use.

The electrical energy consumed by the solar collector simulator shall not be considered as electrical energy in this context.

This measurement is corrected, as the gas consumption, according to the following equation:

$$E_{\text{elecco}} = E_{\text{elecmes}} \times \frac{Q_{\text{tot}}}{Q_{H_2O}} \tag{6}$$

where

E_{elecco} is the corrected total electrical energy, in kilowatt hours;

E_{elecmes} is the measured total electrical energy, in kilowatt hours;

Q_{H_2O} is the measured energy recovered by the water according to 5.3.2.4, in kilowatt hours;

Q_{tot} is the total delivered energy of used tapping cycle, value from Tables 2, 3, 4, 5 and 6 in kilowatt hours.

5.3.2.7 Determination of the wasted water (tapping cycle n° 2)

For each individual delivery the quantity of wasted water is determined and given in litre by the equation:

$$V_w = d_i \times t_w \tag{7}$$

where

V_w is the quantity of wasted water, in litres;

d_i is the water rate delivered in litres per minute;

t_w is the tapping duration of the wasted water, in minutes.

The total quantity of the wasted water is equal to the sum of the wasted water quantities of each individual delivery.

This value is expressed in percentage of the overall quantity of the useful water delivered during the measurement of 5.3.2.4.

$$R = (V_w/V_u) \times 100 \quad (8)$$

$$V_u = \sum_{i=1}^{n} \int_0^{t_1} d_i \cdot (t_i) dt \text{ , and } V_w = \sum_{i=1}^{n} \int_0^{t_1} d_i \cdot (t_w)\, dt \quad (9)$$

where

V_w is the quantity of wasted water, in litres;

V_u is the quantity of useful water, in litres;

R is the percentage of the wasted water.

5.3.2.8 Measurement of energy consumption with stand by mode

The consumed energy in stand by mode is measured for a 24 h period without tapping with solar collector simulator operating.

The gas and auxiliary energy consumption in stand by mode is measured after the storage tank is pre-heated until the water temperature in the return of the solar hydraulic circuit is 60 °C and the temperature of the gas heated store is established by cycling the gas boiler. Then the test starts, at 0h00, for a 24 h period.

The daily consumption of gas is calculated according to the following equation:

$$Q_{gas} = V_g \times K \times NCV \times \frac{24}{T_a} \quad (10)$$

where

Q_{gas} is the daily energy consumed in kilowatt hours calculated using *NCV*;

V_g is the gas consumption in cubic metres during the test;

NCV is the net calorific value in kilowatt hours per cubic metre (at 15 °C and 1 013,25 mbar);

T_a is the duration of the test in hours (T_a = 1 h for the appliances without control cycle)

and

$$K = \frac{p_a + p_g}{1\,013{,}25} \times \frac{288{,}15}{T_g + 273{,}15} \quad (11)$$

where

P_a is the atmospheric pressure, in millibars;

P_g is the gas pressure, in millibars;

T_g is the gas temperature, in degrees Celsius.

The daily consumption of auxiliary energy is calculated according to the equation:

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$$E_{elecco} = E_{elecmes} \times \frac{24}{T_a} \quad (12)$$

where

E_{elecco} is the daily consumption of auxiliary energy, in kilowatt hours;

$E_{elecmes}$ is the auxiliary energy measured during the test, in kilowatt hours;

T_a is the duration of the test in hours (T_a = 1 h for the appliances without control cycle).

5.3.2.9 Measurement of auxiliary energy consumption with the off mode

The auxiliary energy consumption is measured for a duration time equal to 1 h.

The daily consumption of auxiliary energy is calculated according to the following equation:

$$E_{elecco} = E_{elecmes} \times 24 \quad (13)$$

where

E_{elecco} is the daily consumption of auxiliary energy, in kilowatt hours;

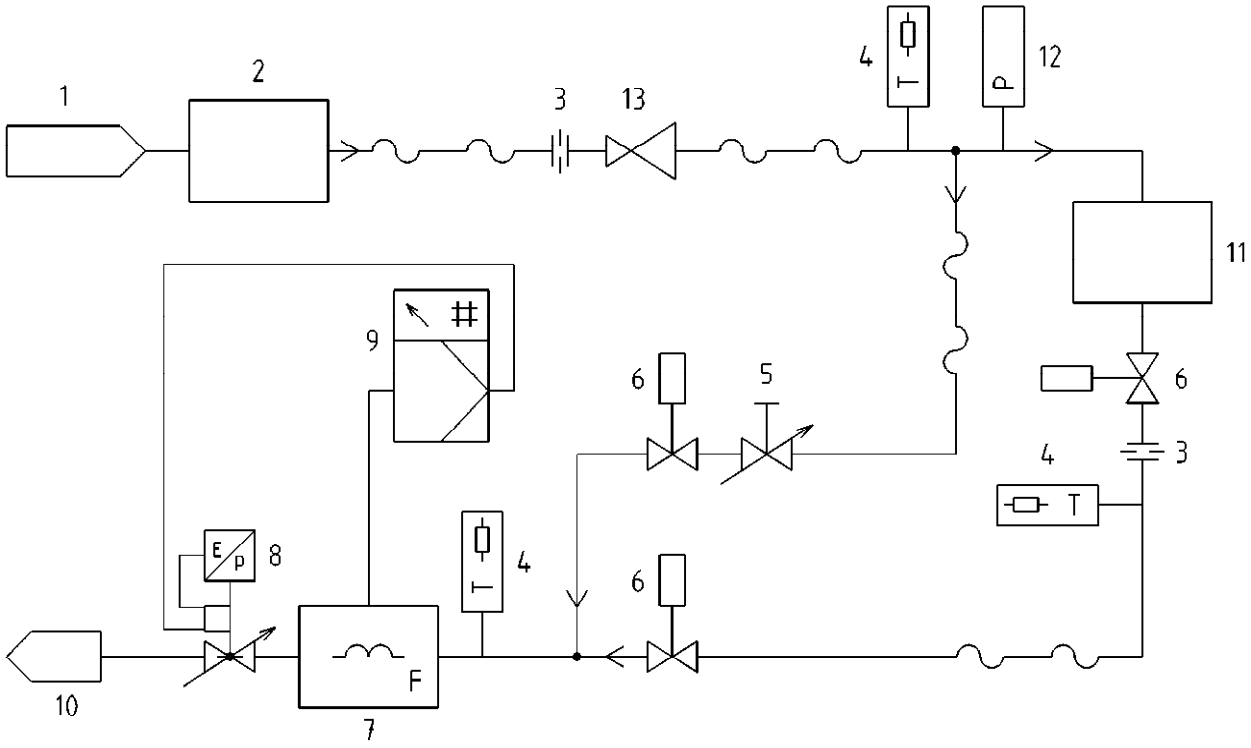
$E_{elecmes}$ is the auxiliary energy measured during the test, in kilowatt hours.

Annex A
(informative)

Test rig and measurement devices

A.1 General

A general diagram of a possible test rig is shown in Figure A.1.



Key

1 Water
2 Preparator of water at 10 °C
3 Diaphragm to homogenise the temperature and pressure profile across the tube diameter
4 Temperature measurement device
5 Equilibrium valve
6 Electro valve
7 Flow meter
8 Control valve
9 Rate control
10 Drain
11 Appliance in test
12 Pressure measurement device
13 Pressure control

Figure A.1 — Example of test rig

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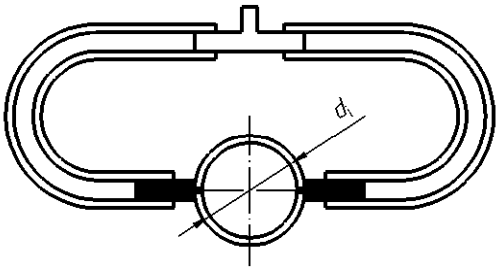
A.2 Pressure measurement

An example of the pressure measurement device is shown Figure A.2. The lengths of the pipe upstream and downstream of the pressure measurement device are 15 d_i and 5 d_i, where d_i is the diameter of the pipe.



Key

d_i Diameter of the pipe

Figure A.2 — Example of pressure measurement device

A.3 Temperature measurement

Temperature sensors used in the test rig could be:

— thermocouples of type T, class 1, diameter of 0,5 mm;

— low inertia Pt 100 probe, diameter of 2 mm.

The temperature measurement device could be equipped with:

— 3 thermocouples + 1 Pt 100 probe, diameter 2 mm;

— 4 thermocouples + 1 Pt 100 probe, diameter 2 mm.

An example of a temperature measurement device is shown Figure A.3.

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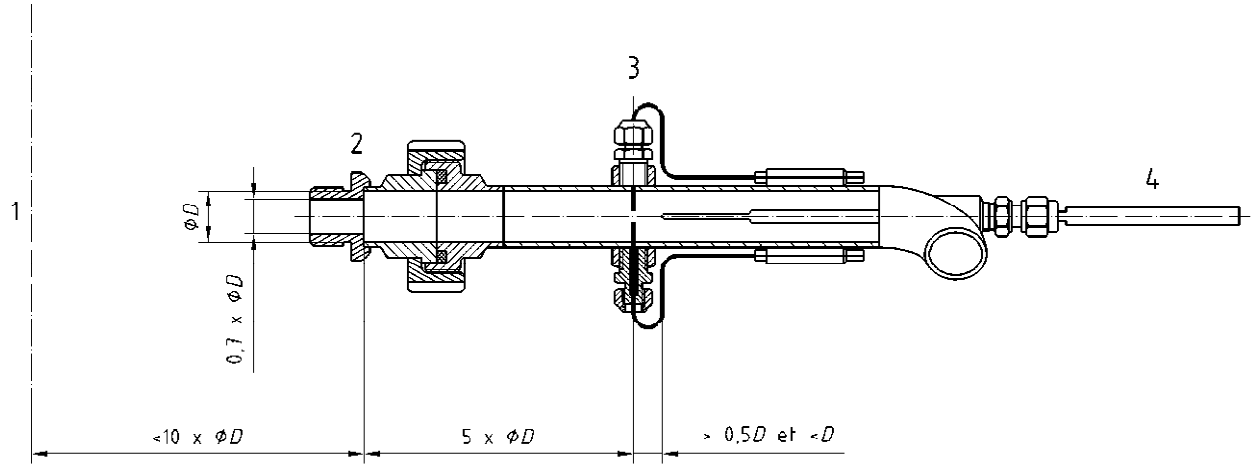
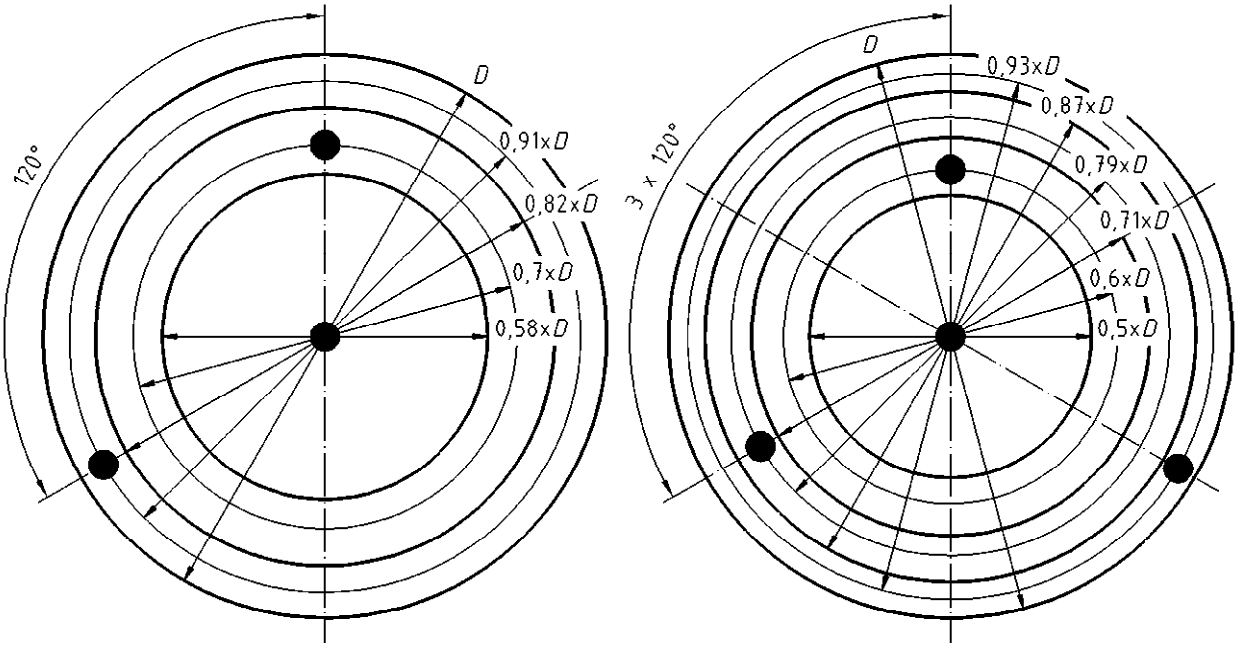


Key

1 Outlet of the appliance in test (hole with ØD)
2 Diaphragm to homogenise the temperature and pressure profile across the tube diameter
3 Thermocouple
4 Platine probe
D Diameter of the outlet of the appliance

Figure A.3 — Example of temperature measurement device

The position of the thermocouples (three or four with one thermocouple at the centre of the flow) could be as shown in Figure A.4.



Key

D Diameter of the outlet of the appliance

Figure A.4 — Example of position of thermocouples − Method of surfaces

Other measuring instruments may be used provided the results required in the standard are obtainable.

Annex B
(informative)

Solar collector simulator

B.1 General

The solar collector simulator (example see Figure B.1) is a device delivering the thermal power to the system (store) instead of a real solar collector. It controls the flow temperature to the system based on the parameters of the solar collector to be emulated, meteorological data and the signal from the collector loop controller indicating the status of the collector loop pump. The solar collector simulator shall be able to emulate the temperature of the collector, when the collector loop pump is not in operation, and the collector flow temperature when the collector loop pump is running.

The collector temperature sensor of the system has to be mounted at a position where it measures the same temperature as the collector outlet temperatures sensor indicated in Figure B.1.

For every time step of the test, the collector outlet temperature or system inlet temperature respectively, has to be controlled. The set value of the collector outlet temperature $T_{\mathrm{Co\ out}}$ is calculated according to Equation (B.1).

NOTE The way how Equation (B.1) is derived from the equation used for the calculation of the collector efficiency in EN 12975-2 is shown in B.2.

$$T_{c,out}(t) = 2T^* + \left[T_{c,out}(t-\Delta t) + T_{c,in} - 2T^* \right] e^{\frac{-\Delta t}{t^*}} - T_{c,in} \tag{B.1}$$

with

$$T^* = \frac{A_a a_1 T_a + A_a \left[\eta_0 G_{tot} - a_2 \left(\frac{T_{c,out}(t-\Delta t) + T_{c,in}}{2} - T_a \right)^2 \right] + 2\dot{m} c_f T_{c,in}}{A_a a_1 + 2\dot{m} c_f} \tag{B.2}$$

and

$$t^* = \frac{A_a C}{A_a a_1 + 2\dot{m} c_f} \tag{B.3}$$

where

$T_{c,out}(t)$ is the collector outlet temperature (at time t), in degrees Celsius;

A_a is the collector aperture area (collector specific parameter, according to EN 12975-2), in square metres;

η_0 is the conversion factor (collector specific parameter, according to EN 12975-2);

a_1 is the first order coefficient of collector efficiency (collector specific parameter, according to EN 12975-2), in watts per square metre per kelvin;

a_2 is the second order coefficient of collector efficiency (collector specific parameter, according to EN 12975-2), in watts per square metre per square kelvin;

C is the specific heat capacity of collector (collector specific parameter, according to EN 12975-2), in joules per square metre per kelvin;

c_f is the specific heat capacity of collector fluid (for water 4,18 kJ/kg·K);

$\dot{m}$ is the mass flow rate in collector circuit (measurement value), in kilograms per second;

G_{tot} is the total radiation on collector (solar cycle data), in watts per square metre;

T_a is the ambient temperature (solar cycle data), in degrees Celsius;

$T_{C,in}$ is the collector inlet temperature (measurement value of store outlet temperature), in degrees Celsius;

Δt is the measurement time step, in seconds;

$T_{C,out}(t-\Delta t)$ is the collector outlet temperature measured as previous time step (measurement value), in degrees Celsius.

B.2 Derivation of the equation used for the calculation of $T_{C,out}$

In the following it is described how the equation used for the calculation of $T_{C,out}$ is derived from the equation used for the calculation of the collector efficiency in EN 12975-2.

In EN 12975-2, the collector efficiency is calculated by the following Equation (B.4):

$$\eta = \eta_0 - a_1 \cdot \frac{\frac{T_{c,out} + T_{c,in}}{2} - T_a}{G_{tot}} - a_2 \cdot \frac{\left(\frac{T_{c,out} + T_{c,in}}{2} - T_a\right)^2}{G_{tot}} \quad \text{(B.4)}$$

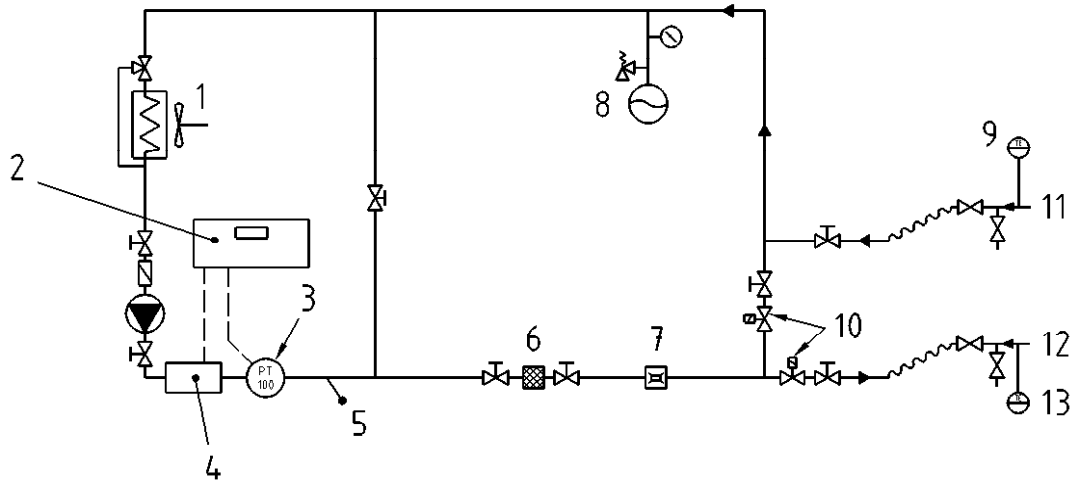
where

$$T_m = \left(\frac{T_{c,in} + T_{c,out}}{2}\right) \quad \text{(B.5)}$$

The transient energy balance at the collector with consideration its thermal capacity is calculated in Equation (B.6):

$$A_a \cdot C \cdot \frac{\Delta T_m}{\Delta t} = A_a \cdot \eta \cdot G_{tot} - \dot{m} \cdot c_f \cdot (T_{C.out} - T_{C,in}) \quad \text{(B.6)}$$

If you put Equation (B.3) into Equation (B.4) and solve this equation for $T_{C,out}$ you will get Equation (B.1).



Key

1 Cooler (optional)
2 Controller
3 Collector outlet temperature
4 Electrical heating element
5 Collector sensor of regular controller
6 Filter
7 Volume flow sensor
8 3 bar
9 Temperature sensor ($T_{C,in}$)
10 Solenoid valves
11 Solar outlet (from system)
12 Solar inlet (to system)
13 Temperature sensor (optional)

Figure B.1 — Example of a solar collector simulator

B.3 Alternative solar collector simulator

The solar collector simulator (example see Figure B.2) is a device delivering the thermal power to the system (store) instead of a real solar collector field. It controls the heat output based on the parameters of a solar collector to be simulated.

For every time step of the test, the heat output of the electrical heating element has to be controlled depending on of the global radiation, the ambient temperature (see solar cycle Table 7) and the signal of the collector inlet and outlet temperature sensor. The set value of the heating performance of the solar collector simulator is calculated according to Equation (B.7):

$$\dot{Q}_{sim,HE} = A_a \cdot \left(\eta_0 - a_1 \cdot \frac{\frac{T_{c,out}+T_{c,in}}{2} - T_a}{G_{tot}} - a_2 \cdot \frac{\left(\frac{T_{c,out}+T_{c,in}}{2} - T_a\right)^2}{G_{tot}} \right) \cdot G_{tot} + \dot{Q}_{loss,HE} \cdot \left(\frac{\frac{T_{c,out}+T_{c,in}}{2} - 20°C}{T_{loss,HE} - 20°C} \right) \qquad \text{(B.7)}$$

where

$Q_{sim, HE}$ is the necessary heating performance of the heating element to simulate the real solar collector field;

A_a is the collector aperture area (collector specific parameter, according to EN 12975-2), in square metres;

η_0 is the conversion factor (collector specific parameter, according to EN 12975-2);

a_1 is the first order coefficient of collector efficiency (collector specific parameter, according to EN 12975-2), in watts per square metre per kelvin;

a_2 is the second order coefficient of collector efficiency (collector specific parameter, according to EN 12975-2), in watts per square metre per square kelvin;

$T_{C,out}$ is the collector outlet temperature at time t, in degrees Celsius;

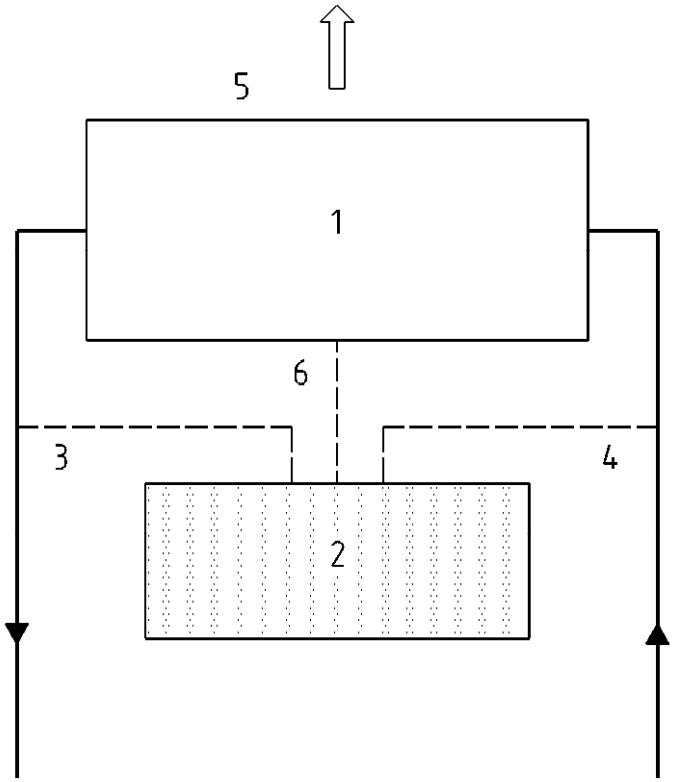
$T_{C,in}$ is the collector inlet temperature (measurement value of store outlet temperature), in degrees Celsius;

G_{tot} is the global radiation on collector (solar cycle data), in watts per square metre;

T_a is the ambient temperature (solar cycle data), in degrees Celsius;

$Q_{loss,HE}$ is the energy loss of the heating element. It has to be determined during a previous measurement, in kilowatts;

$T_{loss,HE}$ is average temperature of the heating element during the determining of the energy loss, in degrees Celsius, e.g. at 70 °C.



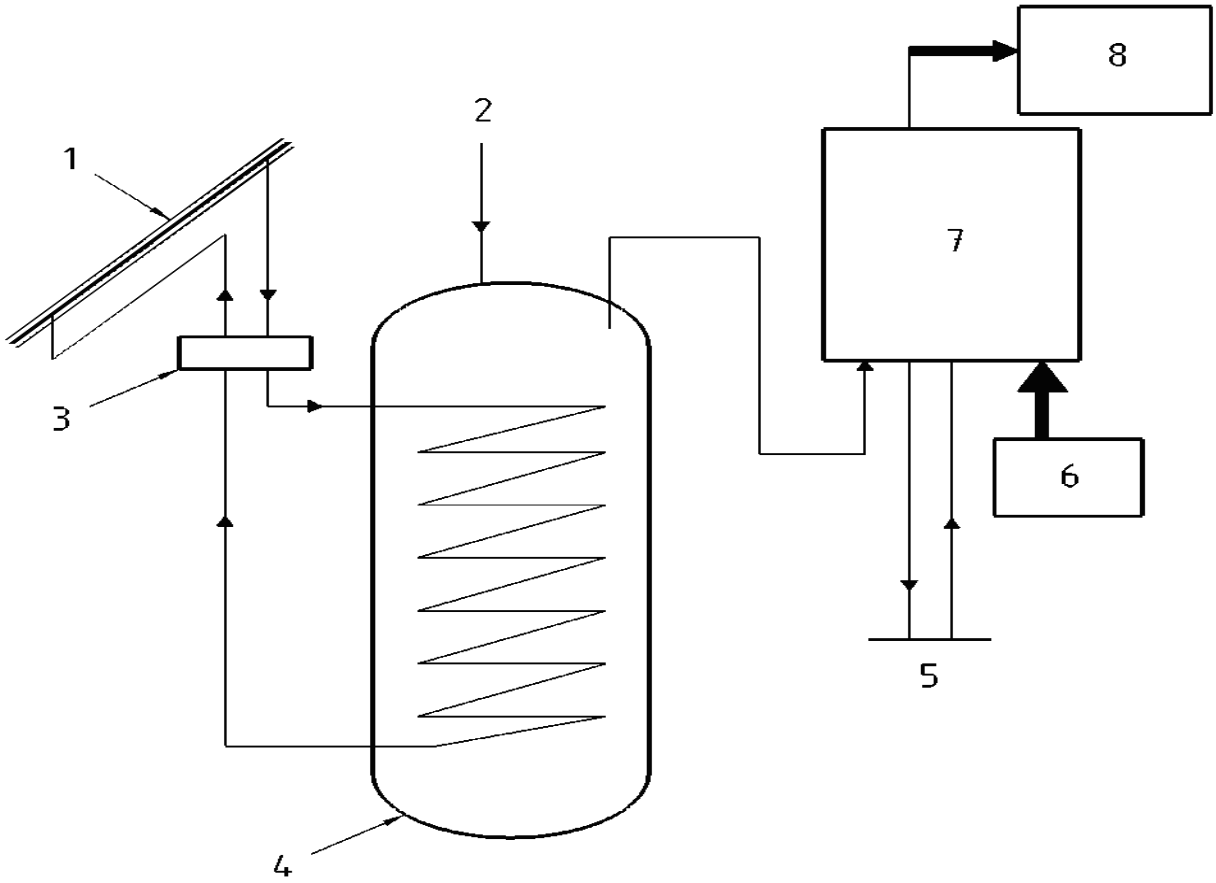
Key

1 Heating element
2 Controller
3 Sensor collector (outlet temperature TC,out)
4 Sensor collector (inlet temperature TC,in)
5 Optional element
6 Additional collector sensor

Figure B.2 — Example of an alternative solar collector simulator

Annex C
(normative)

Appliances covered by this European Standard



Key

1 Solar panel
2 Solar control box with pump
3 Hot water tank
4 Cold water in
5 Q_{gas}
6 Gas boiler
7 Hot water out
8 Heating circuit

Figure C.1 — Solar supported gas fired hot water storage boiler with all components specified by the manufacturer according to EN 13203-3

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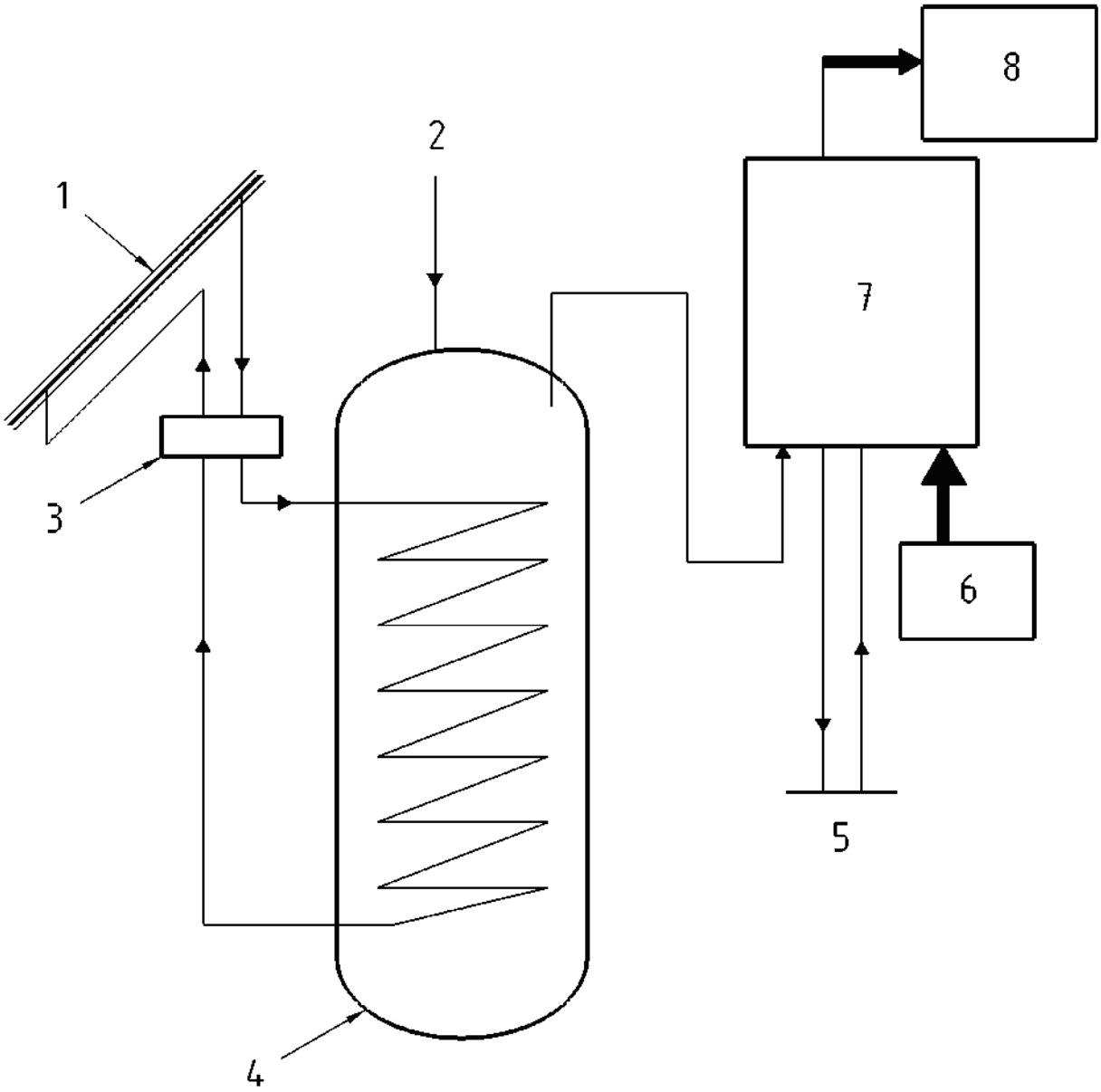

Key

1 Solar panel
2 Cold water in
3 Solar control box with pump
4 Solar hot water storage
5 Heating circuit
6 Q_{gas}
7 Gas boiler
8 Hot water out

Figure C.2 — Solar hot water preheating storage tank with all components specified by the manufacturer according to EN 13203-3

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[6] EN 13203-2, *Gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 300 l water storage capacity — Part 2: Assessment of energy consumption*

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