BS EN 12976-2:2017

BSI Standards Publication

Thermal solar systems and components — Factory made systems

Part 2: Test methods

National foreword

This British Standard is the UK implementation of EN 12976-2:2017. It supersedes BS EN 12976-2:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/25, Solar Heating.

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

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Thermische Solaranlagen und ihre Bauteile - Vorgefertigte Anlagen - Teil 2: Prüfverfahren

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European foreword

This document (EN 12976-2:2017) has been prepared by Technical Committee CEN/TC 312 “Thermal solar systems and components”, the secretariat of which is held by ELOT.

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of an identical text or by endorsement, at the latest by July 2017, and conflicting national standards shall be withdrawn at the latest by July 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12976-2:2006.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annexes ZA, ZB or ZC, which are an integral part of this document.

Most significant changes in EN 12976-1:2017 and EN 12976-2:2017 since the 2006 editions of both parts:

The first edition of the EN 12976 series was published in 2000. The standard series provided an important basis for the assessment of the performance as well as the reliability and durability of Factory made solar thermal systems. In the past 15 years or so, several important technological developments and changes of the framework conditions, such as e.g. the aspect of requiring “Energy Labelling”, the EN 12976 series underwent several important changes.

The following modifications are the most important ones that have been implemented in this new edition of EN 12976-2:

— main changes related to ErP and the new mechanical load test;

— Annex ZA (new): harmonisation with Regulation (EC) No 811/2013;

— Annex ZB (new): harmonisation with Regulation (EC) No 812/2013:

— Annex ZC (new): harmonisation with Regulation (EC) No 814/2013.

It is worth to notice that, based on these changes and developments, the need for the elaboration of a future strategy of the structure of the EN 12976 series is foreseen.

EN 12976, *Thermal solar systems and components — Factory made systems*, is currently composed with the following parts:

— *Part 1: General requirements*;

— *Part 2: Test methods*.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Drinking water quality:

In respect of potential adverse effects on the quality of water intended for human consumption, caused by the product covered by this standard:

a) this standard provides no information as to whether the product may be used without restriction in any of the Member States of the EU or EFTA;

b) it should be noted that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of this product remain in force.

Factory Made and Custom Built solar heating systems:

The standards EN 12976-1, EN 12976-2, EN 12977-1, EN 12977-2, EN 12977-3, EN 12977-4 and EN 12977-5 distinguish two categories of solar heating systems: **Factory Made** solar heating systems and **Custom Built** solar heating systems. The classification of a system as Factory Made or Custom Built is a choice of the final supplier, in accordance with the following definitions:

Factory Made solar heating systems are batch products with one trade name, sold as complete and ready to install kits, with fixed configurations. Systems of this category are considered as a single product and assessed as a whole.

If a Factory Made Solar Heating System is modified by changing its configuration or by changing one or more of its components, the modified system is considered as a new system for which a new test report is necessary. Requirements and test methods for Factory Made solar heating systems are given in EN 12976-1 and EN 12976-2.

Custom Built solar heating systems are either uniquely built, or assembled by choosing from an assortment of components. Systems of this category are regarded as a set of components. The components are separately tested and test results are integrated to an assessment of the whole system. Requirements for Custom Built solar heating systems are given in EN 12977-1; test methods are specified in EN 12977-2:, EN 12977-3, EN 12977-4 and EN 12977-5. Custom Built solar heating systems are subdivided into two categories:

— **Large Custom Built systems** are uniquely designed for a specific situation. In general HVAC engineers, manufacturers or other experts design them.

— **Small Custom Built systems** offered by a company are described in a so-called assortment file, in which all components and possible system configurations, marketed by the company, are specified. Each possible combination of a system configuration with components from the assortment is considered as **one** Custom Built system.

Table 1 shows the division for different system types:

Table 1 — Division for factory made and custom built solar heating systems

<table>
<tr><th>Factory Made Solar Heating Systems
(EN 12976–1 and EN 12976–2)</th><th>Custom Built Solar Heating Systems
(EN 12977–1, EN 12977–2 and EN 12977–3)</th></tr>
<tr><td>Integrated collector storage systems for domestic hot water preparation</td><td rowspan="2">Forced-circulation systems for hot water preparation and/or space heating, assembled using components and configurations described in an assortment file (mostly small systems)</td></tr>
<tr><td>Thermosiphon systems for domestic hot water preparation</td></tr>
<tr><td>Forced-circulation systems as batch product with fixed configuration for domestic hot water preparation</td><td>Uniquely designed and assembled systems for hot water preparation and/or space heating (mostly large systems)</td></tr>
</table>

NOTE Forced circulation systems can be classified either as Factory Made or as Custom Built, depending on the market approach chosen by the final supplier.

Both Factory Made and Custom Built systems are performance tested under the same set of reference conditions as specified in Annex B of the present standard and EN 12977–2:2012, Annex A. In practice, the installation conditions may differ from these reference conditions.

A Factory Made System for domestic hot water preparation may have an option for space heating, however this option should not be used or considered during testing as a Factory Made system.

1 Scope

This European Standard specifies test methods for validating the requirements for Factory Made Thermal Solar Heating Systems as specified in EN 12976-1. The standard also includes two test methods for thermal performance characterization by means of whole system testing.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1489, *Building valves — Pressure safety valves — Tests and requirements*

EN 1717:2000, *Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow*

EN 12976-1:2017, *Thermal solar systems and components — Factory made systems — Part 1: General requirements*

EN 12977-2:2012, *Thermal solar systems and components — Custom built systems — Part 2: Test methods for solar water heaters and combisystems*

EN 15502-1, *Gas-fired heating boilers — Part 1: General requirements and tests*

EN ISO 9488:1999, *Solar energy — Vocabulary (ISO 9488:1999)*

EN ISO 9806:2013, *Solar energy — Solar thermal collectors — Test methods (ISO 9806:2013)*

ISO 9459-1:1993, *Solar heating — Domestic water heating systems — Part 1: Performance rating procedure using indoor test methods*

ISO 9459-2:1995, *Solar heating — Domestic water heating systems — Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems*

ISO 9459-5, *Solar heating — Domestic water heating systems — Part 5: System performance characterization by means of whole-system tests and computer simulation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 9488:1999 and EN 12976-1:2017 apply.

4 Symbols and abbreviations

$Q_{aux, net}$ net auxiliary energy demand of a solar heating system delivered by the auxiliary heater to the store or directly to the distribution system (see 5.9.3.2)

Q_d heat demand

Q_L energy delivered at the outlet of the solar heating system

Q_{par} parasitic energy (electricity) for the collector loop pump(s) and control unit

H_c hemispherical solar irradiation in the collector plane

Q_l store heat loss

Q_{ohp} heat diverted from the store as active overheating protection, if any

Q_{sol} heat delivered by the collector loop to the store

5 Testing

5.1 Freeze resistance

5.1.1 General

The following checks are given to ensure that the protective anti-freezing provisions are operating properly. There are many possible forms of protective provisions, and the testing authority shall first identify which method has been employed.

The provision shall then be checked in accordance with the appropriate section of the following list (see 5.1.2 to 5.1.6) in accordance with the manufacturer's recommendations.

5.1.2 Systems using antifreeze fluid

The system components which are exposed to low ambient temperature are filled with an antifreeze fluid usually a glycol/water mixture, having a low enough freezing point. For thermosiphon systems declared as freeze resistant down to a specific temperature, one possible test procedure described in AS/NZS 2712 is recommended. This procedure could also be adapted to other systems containing pure water. So far, electrical heater for freeze protection will not be tested for suitability.

For these systems, no freezing test is performed. However, if no sufficient data are available on the freezing point of the antifreeze fluid, the freezing point shall be measured and checked against the minimum system temperature as given by the manufacturer.

NOTE In general, the minimum allowed temperature of the system is equal to the freezing point of the antifreeze fluid. If the concentration of some antifreeze fluids like glycols - exceeds a certain limit, they can freeze without damaging the system. In this case the minimum allowed temperature can be lower than the freezing point of the antifreeze fluid.

Check the freezing point by measuring the glycol concentration (e.g. using a portable refractometer) before and after the over temperature protection test (5.2). The freezing point shall not differ more than 2 K from the value recommended by the manufacturer in agreement with the local climate (minimum expected air temperature, radiative cooling of the collectors).

The composition of the fluid shall be checked to see whether it is in accordance with the manufacturer's specifications.

5.1.3 Drain-back systems

When freezing danger occurs, the fluid in the system components that is exposed to low ambient temperature, is drained into a storage vessel for subsequent reuse.

The collector loop piping should be in accordance with the manufacturer's recommendations in the installer manual and if there is no instruction, according to reference conditions given in Annex B.

Filling may be observed from the pressure gauge or from water level indicator. Switch the pump on, and observe the pressure gauge or water level indicator. If the system does not include a pressure gauge or level indicator, other means for checking filling provided by the manufacturer shall be used in accordance with the instruction manual.

Drain-back may be observed from the decreasing reading of the pressure gauge or water level indicator. Switch the pump OFF, and observe the pressure gauge or water level indicator. If the system does not include a pressure gauge or level indicator, other means for checking drain-back provided by the manufacturer shall be used in accordance with the instruction manual.

A system in which components and/or piping are subject to damage by freezing shall have the proper fittings, pipe slope and collector design to allow for manual gravity draining and air filling of the affected components and piping. Pipe slope for gravity draining shall be as the manufacturer recommendation or shall have a minimum 2 cm vertical drop for each meter of horizontal length. This also applies to any header pipes or absorber plate riser tubes internal to the collector.

5.1.4 Drain-down systems

The fluid in the system components, which are exposed to low ambient temperature, is drained and run to waste when freezing danger occurs.

To perform checks of the drain-down function the collector loop piping should be in accordance with the manufacturer's recommendations in the installer manual and if there is no instruction, according to reference conditions given in Annex B.

In most cases the systems are equipped with a drain-down valve at the bottom and a vacuum relief valve at the top of the fluid circuit.

The proper opening and closing of the vacuum relief valve shall be checked during drain-down operation and after refilling the system.

If there is a solenoid drain valve independent of the control unit, simulate the opening temperature.

If there is a non-electrically operated freeze protection valve, a check can be made using a freezing spray. The temperature-sensing element shall be sprayed. The measured temperature of the valve opening shall be compared with the nominal value given by the manufacturer. It is important that the sensing part of the freeze protection valve be properly placed.

If the system uses an electrically operated freeze-protection valve, drain down shall be checked while interrupting the power.

The drain-down rate shall be measured (e.g. by using a vessel and a stop-watch) and documented during drain-down operation.

5.1.5 Freeze protection and combined control functions

For systems where the freeze protection and control functions are combined, the control unit shall be checked as follows:

Set the simulated temperature of the freeze-protection sensor to a value deactivating the freeze protection. Decrease the simulated temperature slowly. Measure the temperature T_{FP} (freeze protection) of the related actuator. Compare it with the nominal value given by the manufacturer.

5.1.6 Other systems

For all other systems, the pump control system, drain-down valve or any other freeze protection device or system shall be checked to the manufacturer's specification and the minimum allowed temperature specified by the manufacturer.

For Integrated Collector-Storage Systems (ICS), or other Solar Domestic Hot Water (SDHW) systems with the tank placed outside, special frost resistance tests should be carried out, as described in C.1.

5.2 Over temperature protection

5.2.1 Purpose

The purpose of this test is to determine whether the solar water heating system is protected against damage and the user is protected from scalding hot water delivery after a period of no hot water draw and failure of electrical power.

5.2.2 Apparatus

The following apparatus is required:

a) a pyranometer having the minimum characteristics specified in EN ISO 9806:2013, 22.1.1.1, to measure the total short wave radiation from both the sun and the sky or the short wave radiation from a solar simulator lamp if the test is to be conducted inside a solar simulation chamber;

b) equipment to measure the temperature, flow rate and volume of hot water drawn from the system;

c) an outdoor or an indoor test stand for installing the solar hot water system with the collector array at the manufacturer's specified tilt angle;

d) a temperature and pressure controlled water supply within the range of 5°C to 25 °C and 200 kPa to 600 kPa or the manufacturer's maximum working pressure whichever is less.

This test may be conducted using a solar simulator or outdoors.

5.2.3 Procedure

The system, both as described in the installation manual and as installed on the test facility, shall be first checked on overheating safety, e.g. if safety valves and other overheating protection devices are present and installed at the right place, if there are no valves between components and relief valves, etc. For systems containing antifreeze fluids, it shall be checked whether sufficient precautions have been taken to prevent the antifreeze fluid from deterioration as a result of high temperature conditions (see also 5.7).

Furthermore, if non-metallic materials are used in any circuit, the highest temperature in the circuit during the over temperature protection test shall be measured at the main water inlet, for use in the pressure resistance test.

The procedure of testing shall be as follows:

a) assemble the solar water heating system according to the installation instructions with the collector array oriented towards solar noon for the outdoor test, or the simulator lamp may be adjusted to normal incidence for the indoor test;

b) charge the system from the water supply and, for pressurized storage tanks, maintain the water supply pressure;

c) energize the system as per installation instructions;

d)

   1) for the outdoor test, operate the system for three consecutive days without any hot water withdrawal with a minimal solar irradiation of 20 MJ/m^2 per day and with ambient temperature higher than 20 °C during solar noon;

i) electric power (if any) in the installation shall be disconnected on the third day;

2) for the indoor test:

i) operate the system without any hot water withdrawal at an ambient temperature of (25 ± 2) °C and a minimum solar lamp irradiance of 1 000 W/m2 at the plane of the collector array, measured and with a uniformity as specified in ISO 9459-1:1993, 6.3.1.2 for a 5 h period or until the collector array drains;

ii) disconnect all electrical power to the system and subject the system to a solar lamp irradiance of 1 000 W/m^2 at the plane of the collector array for an additional 4 h or until the collector array drains;

e) at the end of sequence d) or immediately after the collector drains, withdraw a volume of water greater than the total volume of water in the system at a rate of $(2 \times 10^{-4} \pm 3 \times 10^{-5})$ m^3/s (10 ± 1) l/min.

5.2.4 Reporting requirements

The following results shall be reported:

a) the make and model identification of the system including ancillary scald and over temperature protection devices fitted as well as a physical description of how over temperature protection should work according to the manufacture's documentation;

b) the inclination of the collector array;

c) a record of temperature of the hot water withdrawn from the system versus time and the total volume of water withdrawn: note the presence of steam if observed;

d) details of the condition of the system and individual components following the test or any failure modes during the test with particular regard to any defects which may affect the serviceability of the system such as the swelling of pipes and components or fluid leakages.

5.3 Pressure resistance

5.3.1 Purpose

The purpose of this test is to evaluate hydraulic pressure rating of all components and interconnections of a solar water heating system when installed according to the manufacturer's instructions.

5.3.2 Apparatus

The apparatus shall consist of the following:

a) suitable platform and support structure for installation of the system;

b) pressure regulated hydraulic pressure source;

c) pressure gauge suitable to determine the test pressure to within 5 %;

d) bleed valve;

e) isolation valve.

5.3.3 Safety precaution

An explosion safe enclosure is recommended when testing systems that have an integrated expansion space or tank that contains entrapped air.

5.3.4 Procedure

The system, both as described in the installation manual and as installed on the test facility, shall be first checked on pressure safety, e.g. if safety valves and other overheating protection devices are present and installed at the right place, if there are no valves between components and relief valves, etc.

The vessels and tanks already subjected to pressure tests (at least the pressure level required in 5.3.4) may be disconnected from the system (only the vessel may be disconnected, the connecting piping shall not be removed).

The duration of the test is 15 min. If a non-metallic material is used in any circuit, this procedure shall be applied after performing the “Over temperature protection” test (see 5.2).

a) Install the solar water heating system on the test platform in accordance with the manufacturer's instructions.

b) Disable the pressure relief valves, if applicable, to prevent their opening during testing.

c) Connect the isolation valves to the (lower) fill ports of each circuit of the system.

d) Fill all circuits in the order described in the manufacturer’s installer manual using the required fluid for each circuit. If no information about the fill procedure is provided in the manual, the inner circuits should be filled first. After filling the upper port of each circuit should remain open to provide pressure balance with the ambient pressure.

e) Perform the pressure tests of the circuits of the system in the same order as they shall be pressurized (or installed) according to the manufacturer’s installer manual. If no installation order is given by the manufacturer, perform the pressure tests of the internal heat transfer loops (and other internal vessels) first.

f) For testing of each independent loop follow the steps listed below:

   1) connect the bleed valve and pressure gauge to the (upper) drain port of the heat transfer loop;

   2) connect the hydraulic pressure source to the fill port of the tested heat transfer circuit;

   3) bleed all air, as far as possible, out of the loop through the bleed valve at the drain port;

   4) apply a hydraulic pressure equal to 1,5 times the manufacturer's stated maximum individual working pressures;

   5) isolate the pressure source by closing the isolation valve and record the readings of the pressure gauge at the beginning and end of the next 15 min interval;

   6) release the pressure through the bleed valve and record any visible permanent deformation and heat transfer fluid leakage from system components and interconnections;

   7) disconnect the hydraulic pressure source from the fill port, the bleed valve and pressure gauge from the drain port and leave the circuit filled and opened at the ambient pressure;

   8) repeat the steps 1) - 7) until all circuits have been tested.

g) Empty all circuits in the reversed fill order or according to emptying instructions contained in the manufacturer's installer manual, if present.

h) Disconnect all isolation valves from the system.

5.3.5 Reporting requirements

Report the maximum test pressures applied, the pressure readings at the beginning and end of the 15 min test intervals and any visible permanent deformation or leakage from system components and interconnections. If the applied test pressures are lower than 1,5 times, note the manufacturer's stated maximum working pressure.

The test may be considered as passed if the pressure drop during the test period does not exceed more than 5 % of the test pressure.

5.4 Water contamination

Check if the documentation for the installer includes instructions for the installation of the adequate means for preventing backflow from all circuits to drinking main supplies.

A method for analysing the risks in the use point and election of the suitable protection is described in EN 1717.

According to EN 1717:2000, Table B.1, antifreeze protection is fluid category 3.

Secondary circuit or consumer loop: The working domestic hot water (DHW). According to EN 1717:2000, Table B.1, DHW is fluid category 2.

Category 1 Water to be used for human consumption coming directly from a potable water distribution system.

Category 2 Fluid presenting no human health hazard. Fluid recognized as being fit for human consumption including water taken from a potable water distribution system, which can have undergone a change in taste, odour, colour or a temperature change (heating or cooling).

Category 3 Fluid representing some human health hazard due to the presence of one or more harmful substances.

Category 4 Fluid representing a human health hazard due to the presence of one or more toxic or very toxic substances or one or more radioactive, mutagenic or carcinogenic substances.

Category 5 Fluid presenting a human health hazard due to the presence of microbiological or viral elements. The final outcome is the list containing the fluid category of each loop.

Step1 Determination of the fluid categories that could be in contact with potable water. First of all determine the number of hydraulic circuits to protect in the factory made system. Primary circuit or collector loop: The working fluid can be water with antifreeze protection.

Step 2 Check the separation between collector loop and consumer loop. Check that the separation between collector and consumer loop of the solar thermal system according to the fluid category is at least a wall. Category 2 and 3 fluids may be separated from potable water by a single wall, while a single wall is not sufficient for category 4 and 5 fluids. A double wall with a safety medium in between (liquid or gas) and an acoustical or visual alarm system is required when the fluid from which the potable water shall be protected against is of category 4 or 5.

Step 3 Air opening for drain. Check that the factory made system have open air outlets before draining to the building drain system. Outcome: TRUE/FALSE.

Step 4 Installation features. Check the pressure on the connection point between the system and the mains water network.

P = 1 013,25 hPa

P > 1 013,25 hPa

Step 5 Determination of the protection units for the mains water network connection point suitable for the fluid category.

Conclusion

According to EN 1717:2000, Table 2, usually for factory made systems with DHW in the consumer loop it is enough to check that there is at least a reverse flow protection valve.

Outcome: reverse flow protection valve present? TRUE/FALSE

5.5 Testing the resistance against mechanical load

5.5.1 Purpose

This test is used to evaluate the carrying capacity of a (thermosiphon) system due to snow and wind loads. The following procedure is for systems comprising a rack with a tilt angle where either the collector is separable or not separable from the tank. In both cases, the whole system shall undergo a mechanical load test, not only for systems with not separable collectors as described in EN 12976-1:2017, 4.3.1. The mechanical load test with positive pressure (intended to assess the extent to which the transparent cover of the collector, the collector box and the fixings are able to resist the positive pressure load due to the effect of wind and snow) and with negative pressure (intended to assess the deformation and the extent to which the collector box and the fixings between the collector cover, collector box and collector mounting are able to resist uplift forces caused by the wind) needs to be performed adopting the procedure according to EN ISO 9806:2013, Clause 16.

5.5.2 Apparatus

5.5.2.1 Plane surface to put the system on.

5.5.2.2 Sand sacks (stone plates…).

5.5.2.3 Measuring tape.

5.5.2.4 Stop watch.

5.5.2.5 Camera.

5.5.2.6 Straps for keeping single weights in position.

5.5.3 Safety precaution

— Safety glasses;

— safety shoes;

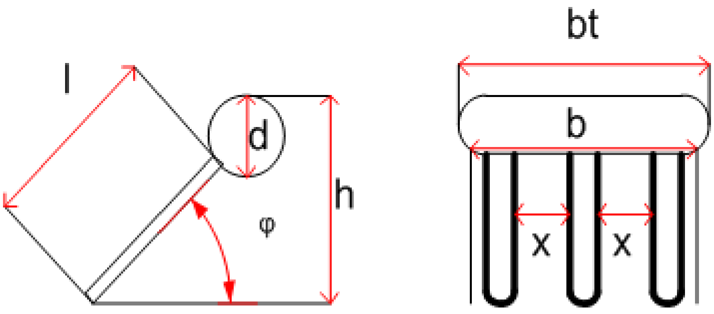
— gloves;

— long sleeved clothing and cap.

5.5.4 Calculation procedure for the mechanical load

The requested pressure on the system is charged with sand sacks (or stone plates) and should be raised in 250 Pa steps until 1 000 Pa.

To determine these four weights classes, to charge the system with, first of all the system area A_{sys} needs to be calculated.



a) Side view **b) Front view**

Figure 1 — Dimensions of the system to be measured

$A_{sys} = AT + A_{brutt} - A_x$

where

$A_T = bt * d$

where

A_T = area tank

bt = width tank

d = diameter

$A_{brutt} = l * b$

where

A_{brutt} = gross collector area

l = length of collector/ length mounting device

b = width collector/ width mounting device

For vacuum tube collectors*:

$A_x = l * x * a$

where

A_x = tube spacing area

x = distance between tubes

a = number of gaps between tubes

NOTE In case there is a reflector located behind the tubes, then the tube spacing area A_x is set to zero ($A_x = 0$).

Now the mass, *m*, with which the system shall be charged, can be determined with pressure:

$P = F/A$

$F = m * g$

where

P = pressure in Pa or N/m²;

F = force in N or kg * m /s²;

A = area in m²;

g = acceleration due to gravitation with g = 9,81 m/s².

To calculate the force orthogonal to the surface of the system, the tilt angle φ of the system shall be taken into account (see Figure 2).

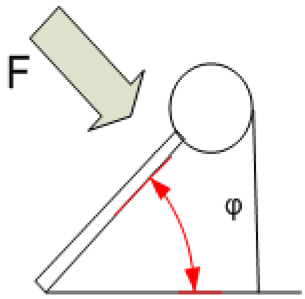


Figure 2 — Force orthogonal to surface of system — Side view

$\boldsymbol{m = p * A_{sys} / (g * \cos(\varphi))}$

This results in following formulae for the different weight classes:

m_1 = 250 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (φ))

m_2 = 500 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (φ))

m_3 = 750 [Pa] * A_{sys} [m²]/ (9,81 [m /s²] * cos (φ))

m_4 = 1 000 [Pa] * A_{sys} [m²]/ (9,81 [m /s²] * cos (φ))

Out of these masses, the number of sand sacks per weight class can be calculated.

The weight of each sand sack shall be checked.

$\boldsymbol{i = m_{1234}/m_s}$

i = number of sand sacks

m_{1234} = load to charge the system with:

m_s = mass of sand sack

5.5.5 Procedure

a) The system shall be mounted according to the manufacturer.

b) Tank should be filled with water during the test.

c) Before testing, the whole system shall be checked for damages on the rack, tank or collector.

d) Following steps should be conducted:

1) Calculate the weight load -number of sand sacks- for the 4 steps according to 5.5.4.

2) The sand sacks for the first weight class (250 Pa) shall be distributed, starting with tank, **equally over the system** (Figure 2).

3) After charging the load, wait 5 min and check the mounting device/system for damage or deformation after. **Take picture** for protocol.

4) Put the missing sand sacks for the second weight class (500 Pa) on the system and repeat Step 3). The same for the third (750 Pa) and fourth (1 000 Pa) weight class.

5.5.6 Reporting requirements

After every weight class minimum, one picture from front and side of the system shall be taken to notice and document possible damage on the system.

Weight-class	Area and weight determination	Charged load number of sand sacks	Pictures	Notes/Evacuation
1	m_1 = 250 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (φ)) A_{sys} = cos (φ) = m_1 =			
2	m_2 = 500 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (φ)) A_{sys} = cos (φ) = m_2 =			
3	m_3 = 750 [Pa] * A_{sys} [m²]/ (9,81 [m /s²] * cos (φ)) A_{sys} = cos (φ) = m_3 =			
4	m_4 = 1000 [Pa] * A_{sys} [m²]/ (9,81 [m /s²] * cos (φ)) A_{sys} = cos (φ) = m_4 =			

5.6 Lightning protection

This test is only applicable to the components of the factory-made solar system which are exposed to outdoor weather. This test assesses if the system is manufactured to withstand and reduce significantly the risk of lightning damage by redirecting it to the building Lightning Protection System (LPS). The systems with few or no metallic parts are excluded from this test.

The system should conform to EN 62305-3.

A manufacturer declaration of conformity will be checked by the test lab.

NOTE Annexes E and F give information to assist manufacturers in meeting the requirements given in EN 62305-3.

5.7 Safety equipment

5.7.1 Safety valves

The safety valves shall conform to EN 1489.

The manufacturers shall deliver these documents. The test laboratory shall check, if the safety valves delivered with the test sample fit to the documents.

Check the system documentation to verify that each collector circuit or group of collector circuits is fitted with at least one safety valve.

Check the specification of the safety valves, whether the materials conform to:

— resist the temperature conditions which they are exposed to, especially the highest temperature that can occur.

Check whether the size of the safety valve is correct in order that it can release highest flow of hot water or steam that can occur. The testing authority shall verify whether the safety valve(s), if part(s) of the system, and the belonging exhaust line(s), are appropriate for the respective application and withstand all operating condition which might occur.

Check whether the temperature of the heat transfer medium at the release pressure of the safety valve exceeds the maximum allowed temperature of the heat transfer medium.

To check the applicability of the specified maintenance frequency of a thermostatic valve, the ageing test for thermostatic valves should be carried out as described in Annex D.

5.7.2 Safety lines and expansion lines

Check the system documentation to verify that safety and expansion lines, if any, cannot be shut-off.

Check the internal diameter of the expansion line, if any, to verify if, for the highest flow of hot water or steam that can occur, at no place in the collector loop the maximum allowed pressure is exceeded due to the pressure drop in these lines. The testing authority shall verify, whether the run of the piping, the inside diameter of the pipes, the piping material and its pressure resistance are appropriate for the respective application and withstand all operating condition which might occur.

Check the system documentation to verify that the expansion line and the safety line, if any, are connected and laid in such a way that any accumulation of dirt, scale or similar impurities are avoided.

5.7.3 Blow-off lines

Check the hydraulic scheme and system documentation to verify that the blow-off lines, if any, cannot freeze up and that no water can accumulate within these lines. The orifices of the blow-off lines shall be arranged in such a way that any steam or heat transfer medium issuing from the safety valves does not cause any risk for people, materials or environment.

5.8 Labelling

The testing laboratory should check that the manufacturer provides all information required by EN 12976-1 on the marking plate or label. The label should be included in the documentation of the system.

Even though the collector or the storage tank can have separate labels for their technical characteristics, the information required for the complete system should be placed on one template. The manufacturer can combine those templates, ensuring though that the information for the specific type of the system is available on the marking. It is recommended to refer to the consultation of checklists for evaluation of system documentation available as Solar Keymark Document SKN N0157R0.

5.9 Thermal performance characterization

5.9.1 Introduction

In this clause the methods for performance testing are described. The thermal performance of the system shall be characterized as described in 5.9.2 and presented as specified in 5.9.3.

The performance of a solar heating system depends on the individual installation and actual boundary conditions. With regard to the heat losses of the store besides deficits in the thermal insulation, badly designed connections can increase the heat loss capacity rate of the store due to natural convection that occurs internally in the pipe in the absence of forced flow created by a pump or a water draw-off. In order to avoid this effect the connections of the pipes should be designed in such a way that no natural convection inside the pipe occurs. This can be achieved, for example, if the pipe is directly going downwards after leaving the store or by using a siphon.

5.9.2 Test procedure

One of the following test methods shall be used, as described in Table 2:

a) Test method in accordance with ISO 9459-2:

This test method may be applied on “solar only” or “preheat systems”.

b) Test method in accordance with ISO 9459-5:

This test method may be applied on all types of systems.

Table 2 — Selection of the performance test method

Test method	Solar-plus-supplementary systems	Solar-only and preheat systems
ISO 9459-2 (CSTG)	No	Yes
ISO 9459-5 (DST)	Yes	Yes

Some systems have allowances for variations in the installation instructions that may affect the performance of the system. In cases where the circumstances are not uniquely defined by the Reference Conditions given in Annex B, the most unfavourable conditions should be chosen for testing and reporting of the system performance. For example, systems without forced circulation should be tested with the lowest position of the storage above the collector and the longest pipe length between collector and storage specified by the manufacturer.

NOTE In October 1999, the EU –SMT project team “Bridging the Gap” reported on the comparability between CSTG (ISO 9459-2) and DST (ISO 9459-5) and conversion factors were successfully established. The relation between the performance predictions of both test methods is given by:

$$Q_{DST} = (a \pm \sigma_a) Q_{CSTG}$$

The ‘a-values’ are represented in Table 3:

Table 3 — Parameter a values for different load volumes

Type of system	Condition	a	σ_a
Forced circulation	$V_{load} \geq V_{store}$ [a]	1,004	0,004
Thermosyphon system	All V_{load}	1,056	0,004
ICS system	All V_{load}	1,037	0,003

[a] In the case $V_{load} < V_{store}$ (forced circulation systems), the determined 'a-values' are higher. This indicates a stronger tendency for overestimation of the DST test method.

5.9.3 Prediction of yearly performance indicators

5.9.3.1 General

NOTE In the following, performance indicators for solar heating systems for hot water preparation only are specified. The text of these paragraphs is identical for this standard and for Custom Built Systems (EN 12977–2). Performance indicators for space heating systems are presently excluded, since there is not yet enough experience available. This is a preliminary step for the standardization of this procedure. After enough experience has been gained, also the performance indicators for space heating systems will be elaborated.

Uniform reference conditions for the calculation of the performance are specified in the identical Annex B of this standard or EN 12977-2:2012, Annex A. For these conditions, the following performance indicators shall be derived from the performance test results:

a) for “solar-plus-supplementary systems”:

   1) the net auxiliary energy demand $Q_{aux, net}$;

   2) the parasitic energy Q_{par} ;

b) for “solar-only” and “preheat systems”:

   1) the heat delivered by the solar heating system Q_L;

   2) the solar fraction f_{sol} ;

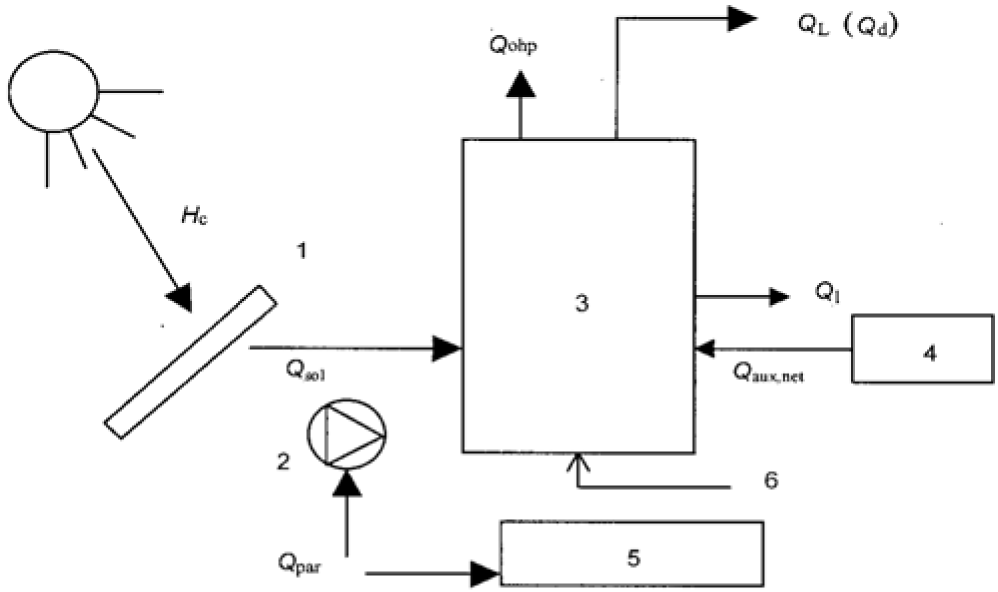
   3) the parasitic energy, Q_{par}, if any.

5.9.3.2 Calculation of the net auxiliary energy demand for solar-plus-supplementary systems

Calculate the yearly net auxiliary energy demand $Q_{aux, net}$ directly by computer simulation (long term performance prediction) as specified in 5.9.2 of this standard (for Factory Made systems) or EN 12977-2:2012, 7.5.1 (for Custom Built Systems). Additional indication on the quantities entering the energy balance of a one-store solar-plus-supplementary heating system may be found in Figure 3.

If a solar-plus-supplementary system cannot meet the heat demand to such a degree that the energy delivered to the user is less than 90 % of the yearly heat demand, this shall be stated in the test report.

NOTE The energy delivered to the user can be less than the heat demand for example when the power of the auxiliary heater is not sufficient or when strong mixing occurs in the store during draw-offs.



Key

1 collector
2 pump
3 storage tank
4 auxiliary heater
5 control unit
6 cold water

Figure 3 — Energy balance for one-store solar-plus-supplementary systems (example)

5.9.3.3 Calculation of the solar fraction for solar-only and preheat systems

Compute the system energy balance on a yearly basis. This includes the following energy quantities (see Figure 4 and Figure 5), calculated using the reference data and conditions given in Annex B of this standard or EN 12977-2:2012, Annex A.

— Q_d : heat demand;

— Q_L : heat delivered by the solar heating system (load);

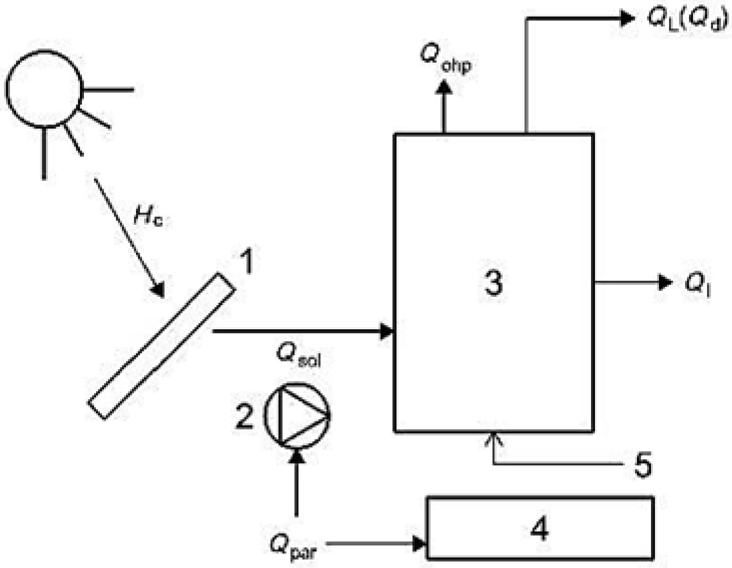
— Q_{par} : parasitic energy (electricity) for pump and controls.

The parasitic energy Q_{par} shall be calculated according to 5.9.3.4.

The reference locations for calculating the load QL are the store ports or the load-side heat exchanger ports, if provided. The reference temperature for calculating the loads is the cold water temperature. Heat losses of the circulation line, if any, are not included in the loads.

NOTE According to EN ISO 9488, a solar preheat system is a solar system to preheat water or air prior to its entry into any other type of water or air heater. This water or air heater is not part of the solar preheat system itself. Hence, for this type of system the energy delivered by the solar heating system QL is calculated at the outlet of the solar heating system and the store heat loss Q_l is the heat loss of the solar store itself (see Figure 5).

The yearly heat demand is calculated using the load volume, cold water temperature and the desired temperature for hot water as specified in Annex B.



Key

1 collector

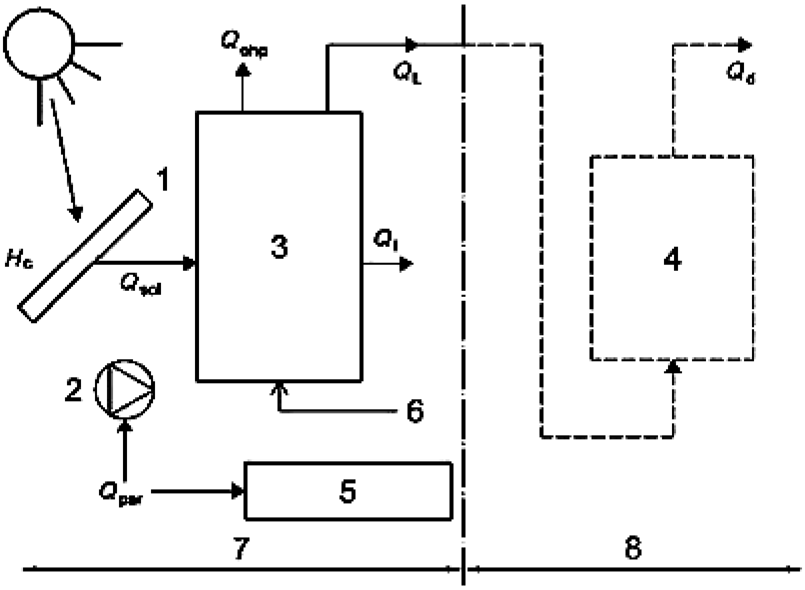
2 pump

3 storage tank

4 control unit

5 cold water

Figure 4 — Energy balance for solar-only systems



Key

1 collector
2 pump
3 solar storage tank
4 auxiliary heater
5 control unit
6 cold water
7 solar preheat system
8 series connected auxiliary heating system

Figure 5 — Energy balance for solar preheat systems

Calculate the solar fraction, f_{sol} by using the definition of EN ISO 9488.

$$f_{sol} = Q_L / Q_d$$

where

Solar fraction f_{sol} : the energy supplied by the solar part of a system divided by the total system load (Q_d = heat demand).

5.9.3.4 Calculation of the parasitic energy

The parasitic energy Q_{par} shall be calculated as follows:

$$Q_{par} = \sum_i y_{oti} * P_{par\_mean_i}$$

The electrical parasitic power P_{par_i} of the pump(s), control systems, electrical valves, etc. shall be measured during the “S-sol” test sequences according to ISO 9459-5 (DST) or during the days used for the determination of the daily system performance according to ISO 9459-2 (CSTG). $P_{par:mean\_i}$ shall be determined as mean values during the operating time of each measured device.

The standard measurement uncertainty of the electrical power shall be ± 2 W or 1 % of the measured value, whichever is higher. The operating time during the test sequences shall be determined with a standard measurement uncertainty of ± 10 s.

The yearly operating times y_{oti} of each electrical device shall be determined by numerical simulation (ISO 9459-5 (DST method)) for the daily loads and reference locations according to Annex B, Table B.1. Taking into account the manufacturer information and system behaviour during the test sequences, laboratories shall calculate operation times with standard values. However, if a reasonable estimation of the operation times of the electrical devices is not possible, a pump operation time of 2 000 h is the best estimation for Solar Domestic Hot Water (SDHW).

5.9.3.5 Calculation of the water heating efficiency of the auxiliary heater

5.9.3.5.1 General

To evaluate the performance of the combination of the solar system and the auxiliary heater the following methods apply. The results shall be reported according to Annex G.

5.9.3.5.2 Solar-plus-supplementary system, with integrated fuel fired heater

The water heating efficiency of the auxiliary heater, integrated in the storage tank, shall be tested according to an appropriate test method.

It is assumed that the effect of the storage tank heat losses of the backup heating part of the storage tank is included in the determination of the water heating efficiency. The heat losses of the backup part of the storage tank are included in the ISO 9459-5 test result. To avoid double counting of these heat losses, the following correction of the measured water heating efficiency of the water heater is required.

The water heater efficiency, excluding the heat losses of the auxiliary part of the tank, shall be calculated by:

$$\eta_{\mathrm{wh,nonsol}} = \frac{\eta_{\mathrm{wh,tot}} \cdot (Q_{\mathrm{ref}} + US \cdot f_{\mathrm{aux}} \cdot \Delta T \cdot 0{,}024)}{Q_{\mathrm{ref}}}$$

where

$\eta_{\mathrm{wh,,tot}}$ measured water heater efficiency for a load profile LP,

Q_{ref} daily heat demand in kWh for the load profile LP according to Table 4,

US overall heat loss coefficient of the storage tank as identified according to ISO 9459-5 (W/K),

f_{aux} auxiliary fraction of the tank as identified according to ISO 9459-5,

ΔT temperature difference between the tank and the surrounding air in K as was applicable during the test of the water heater.

The $\eta_{\mathrm{wh,nonsol}}$, shall maximized at a value of 1.

Table 4 — Daily heat demand for load profiles

Load profile	M	L	XL	XXL	
Q_{nonsol} =	5,845	11,655	19,070	24,530	kWh/d

The daily electricity consumption (= Q_{elec}) in kWh, without solar contribution, is set according to the test method for the water heater.

The daily fuel consumption, without solar contribution, in kWh shall be calculated according to:

$$Q_{\text{fuel}} = \frac{Q_{nonsol}}{\eta_{\text{wh,nonsol}}}$$

5.9.3.5.3 Solar-plus-supplementary system, with integrated electrical resistance heater

The water heating efficiency of the auxiliary (backup) heater is set at a fixed value according to:

$$\eta_{\text{wh,nonsol}} = 40\%$$

NOTE The value of 40 % reflects the average European generation efficiency referred to in Directive 2012/27/EU of the European Parliament and of the Council. If Directive 2012/27/EU is revised in the future, the new value will be used.

The daily fuel consumption (= Q_{fuel}) is set to zero.

The daily electricity consumption without solar contribution in kWh is calculated according to:

$$Q_{\text{elec}} = Q_{\text{nonsol}}$$

where

Q_{nonsol} daily heat demand in kWh according to Table 4.

5.9.3.5.4 Solar-plus-supplementary systems, with external boiler-type auxiliary (backup) heater

The boiler is tested according to EN 15502-1.

Based on the test result of the boiler the following calculations are performed.

$$\eta_{\text{wh,nonsol}} = 0{,}95 \cdot \frac{Q_{\text{nonsol}}}{Q_{\text{fuel}} + CC \cdot Q_{\text{elec}} \cdot + Q_{\text{cor}}}$$

$$Q_{\text{fuel}} = (Q_{\text{nonsol}} + (24 - \frac{Q_{\text{nonsol}}}{P_4} \cdot P_{\text{stby}}) \cdot \frac{100}{\eta_4}$$

$$Q_{\text{elec}} = Q_{\text{elec,on}} + Q_{\text{elec,stby}} = (24 - t_{\text{on}}) \cdot PSB + t_{\text{on}} * el_{\text{max}}$$

$$t_{\text{on}} = (Q_{\text{nonsol}} + (24 - \frac{Q_{\text{nonsol}}}{P_4} \cdot P_{\text{stby}}) \cdot \frac{1}{P_4}$$

where

P_4	[kW]	: maximum power of the boiler
η_4	[%]	: efficiency of the boiler at P_4
P_{stby}	[kW]	: standby heat losses of the boiler
$Q_{\text{elec,stby}}$	[kWh]	: standby electrical consumption
Q_{nonsol}	[kWh]	: daily heat demand for hot water according to the load profiles

NOTE The method makes a series of simplifications:

— the smart control factor is not used as it does not apply in this context,

— the tank losses are set to 0 as they are already considered in the SOLICS method.

5.9.3.5.5 Solar-plus-supplementary systems, with external heat pump type auxiliary heater

The heat pump is tested according to an appropriate test method.

Based on the test result of the heat pump the following calculations are performed.

$$\eta_{\text{wh,nonsol}} = 0{,}95 \cdot f \cdot \frac{COP_{\text{N}}}{CC} \cdot \frac{Q_{\text{nonsol}}}{Q_{\text{nonsol}} + S \cdot 24h}$$

The adjustment factor *f* shall be chosen according to Table 5:

Table 5 — Adjustment factors

Type	Outdoor air			Exhaust air	Brine	Water
Climate:	Average	Colder	Warmer	All	All	All
f	0,919	0,840	1,059	0,888	0,931	0,914

This method makes a series of simplifications:

— the total energy demand is provided by charging the tank at 60°C, in consequence, this method does not apply to low-temperature heat pumps;

— at least 0,25 m^2 of heat exchanger surface are used per kW of thermal capacity;

— the storage losses are pre-determined by standard measurement at a storage temperature of 65 °C;

— the smart factor is not taken into consideration;

— the approach is suitable for heat pumps with electrically driven compressors.

The load profile to be selected shall be done according to Table 6 according to the storage capacity. The load profile to be selected is the next smaller one.

Table 6 — Load profile selection

Profile	**Capacity at 40°C**	**Minimum volume [55°C]**
L	130	87
XL	210	140
XXL	300	200

5.9.3.5.6 Pre-heater systems with external heaters

The water heater efficiency, daily fuel and electricity consumption is determined according to the appropriate test method.

5.9.3.6 Contribution of the auxiliary heater

The method is limited to test results according to ISO 9459-5.

The yearly performance shall be calculated according to the procedure given in 5.9.3, using the reference conditions given in B.4, the average, colder and warmer climate and the load profiles M, L, XL and XXL.

The contribution of the auxiliary heater shall be calculated, according to:

— for solar-plus-supplementary systems:

$$Q_{nonsol} = Q_{aux,net}$$

where

$Q_{aux,net}$ annual auxiliary energy demand in kWh;

— for pre-heater systems:

$$Q_{nonsol} = 0{,}6 \cdot 366 \cdot (Q_{ref} + 1{,}09) - QL$$

where

$Q_{ref:}$ daily heat demand for the appropriate load profile according to Table 4 in kWh,

QL annual heat delivered by the solar heating system in kWh.

The results shall be reported according to Annex G.

5.9.3.7 Presentation of performance indicators

The results from 5.9.3.2 to 5.9.3.4 shall be presented for the load volume(s) as specified in Annex B or EN 12977-2:2012, Annex A. For Factory Made Systems, the reporting form given in Annex A shall be used, for Custom Built systems the table given in EN 12977-2:2012, 7.6 shall be used.

5.10 Ability of solar-plus-supplementary systems to cover the load

5.10.1 General

The test described in this clause shall be carried out in order to ensure that the solar-plus-supplementary system is able to cover the maximum daily load without solar contribution. If recommended by the manufacturer, this test can be performed for a daily load higher than the maximum daily load related to the reported performance prediction (5.9.3). If the system fails to cover the maximum daily load, this shall be stated in the test report together with the results of the performance prediction related to this maximum daily load. The test shall be repeated for a lower maximum daily load.

The ability of the system to cover the maximum daily load shall be determined for the boundary conditions given in 5.10.2 and 5.10.3.

For systems with auxiliary heater, which are tested in accordance with the test method given in ISO 9459-5 (see 5.10.2), the ability of the system to cover the maximum daily load without solar contribution shall be determined either by the test described in 5.10.4 or by means of numerical simulations as described in 5.10.5.

5.10.2 Boundary conditions for auxiliary heating

The auxiliary heater shall be mounted and operated during the test in accordance with the settings in Annex B for the yearly performance prediction.

In the case of an emergency heater the apparatus shall be made fully operational in accordance with the manufacturers specifications.

When several types of heating devices can be installed, the heating device with a heating power fitted for the maximum "daily load volume" shall be used. The manufacturer shall in this case select the appropriate type of heating device.

For systems with auxiliary heating by means of heated water (e.g. directly or with an immersed heat exchanger inside the store) the "flowrate through auxiliary heat exchanger" shall be as stated in Table B.1.

The following specifications shall be reported:

— control setting for the temperature of the integrated auxiliary heater;

— type of control, if available the serial number of the device and if applicable the setting of the hysteresis;

— power of the electrical auxiliary heating element or the thermal power delivered to the store as applicable;

— if applicable, flow rate through the heating device.

5.10.3 Boundary conditions for daily load

The "maximum daily load conditions" are characterized by:

— volume, as being the highest daily load volume for which the yearly performance is reported

— (Table B.1);

— flowrate, in accordance with Table B.1;

— cold water temperature is 2,1 °C;

— ambient temperature around the storage tank, comprised between 15 °C and 20 °C;

— air velocity around the storage tank, lower than 0,5 m/s.

If the cold water inlet temperature during the test in accordance with 5.10.4 differs from the minimum cold water inlet temperature in accordance with Table B.4, auxiliary set temperature, ambient air temperature and temperature for drawing limit (45 °C) shall be modified from the existing differential between the experimental cold water temperature and the minimal required temperature in Table B.4 (this method is not achievable in the event of a system equipped with a mixing valve on which temperature cannot be adjusted.

The draw-off flow rate shall be adjusted in order to perform a discharge with the same power as calculated with the defined settings.

One "daily load cycle" consists of the following draw-offs based on the cold water temperature (the cycle starts at t_0):

— at $t = (t_0 + 12)$ h withdraw of 40 % the daily load volume;

— at $t = (t_0 + 17)$ h withdraw of 20 % the daily load volume;

— at $t = (t_0 + 22)$ h withdraw of 40 % the daily load volume.

If repeated tests are necessary the cycle starts again at 24 h after the last t_0.

Some kinds of stores with an integrated domestic hot water heat exchanger where the flow inside the store depends on certain thermosiphonic effects, sometimes require a certain temperature in the lower part of the store in order to reach their full performance with respect to hot water preparation. In this case it is recommended to repeat the daily load cycle several times.

5.10.4 Determination of the ability to cover the maximum daily load by means of testing the system

The system shall be mounted, fully operational, but with:

— collector loop disabled or the collector covered in such a way that there is no contribution from the solar collector to the store;

— mixing valve installed, and set as described in the product specifications, only if it is an integral part of the system.

At the beginning of the test at least three store volumes shall be withdrawn while the auxiliary is disabled.

After this initial conditioning ($t = t_0$) the auxiliary heating is set into operation. Discharges in accordance with the daily load cycle as described in 5.10.3 shall be performed.

During each draw-off the temperature of the hot water drawn from the store and the thermal power discharged from the store shall be measured and recorded.

The test with a duration of one daily load cycle is considered as valid, if during 95 % of the draw-off time the hot water temperature does not drop below 45 °C.

5.10.5 Determination of the ability to cover the maximum daily load by means of numerical simulations

For the determination of the ability to cover the maximum daily load by means of numerical simulations the model given in ISO 9459-5, with the boundary conditions described in 5.10.2 and 5.10.3 shall be used.

The calculation procedure for the determination of the ability to cover the maximum daily load (without solar contribution) by means of numerical simulations is in principle similar to the test procedure described in 5.10.4.

During the calculation process the solar irradiation shall be set to zero.

The power for the heating element used in the DST-model shall be determined as the mean value of the measured power delivered to the store during the first heating up of the auxiliary part within the test sequence $S_{aux.}$ The test with a duration of one daily load cycle is considered as valid, if during 95 % of the draw-off time the hot water temperature does not drop below 45 °C.

5.10.6 Determination of the ability to cover the daily load defined by the European load profiles by means of numerical simulations

The method is limited to solar-plus-supplementary systems for which the performance is determined according to ISO 9459-5.

When several types of heating devices can be installed, the heating device with a heating power fitted for the maximum “daily load volume” shall be used. The manufacturer shall in this case select the appropriate type of heating device.

For systems with auxiliary heating by means of heated water (e.g. directly or with an immersed heat exchanger inside the store) the “flowrate through auxiliary heat exchanger“ shall be as stated in Table B.1.

The conditions and calculation results shall be reported according to Annex G.

The calculations are performed with the long-term performance calculation using the appropriate set of system parameters describing the system in terms of the LTP-model. The settings shall be in accordance with B.5. The calculation period is 6 d.

The system is able to comply to the daily load if the minimum output temperature is higher than the desired temperature (55 °C) with a tolerance of 0,1 K.

5.10.7 Requirements for mixed water at 40 °C

This section is only relevant for solar-plus-supplementary systems tested according to ISO 9459-5.

The long term performance calculation of the solar system shall be executed with the reference settings according to Table B.4, with the following exceptions:

— solar radiations is set to 0 W/m^2,

— outside air temperature is set at 10 °C,

— storage ambient temperature is set at 10 °C,

— calculation period of 6 d.

The volume of water withdrawn from the storage tank shall be calculated according to the long term performance calculation procedure of ISO 9459-5.

The settings are as follows.

Climate data	— Data per 5 s — Outside air temperature 20 °C — Solar irradiation: 0 W/m^2 — Period: 6 d						
Auxiliary (backup) heater	The set temperature, the heating power and operation time are according to supplier's settings.						
Draw-off	a) Demand temperature: equal to set temperature of auxiliary heater b) Cold water temperature: 10 °C c) Number of draw off: 1 d) Start time: 1) continuous auxiliary operation: 1 h, or 2) otherwise: after the first switch off of the auxiliary heater e) Fraction of daily volume: 100 %						
Load profile:	M	L	XL	XXL	3XL	4XL	
Flow rate:	6	10	10	16	48	96	l/min
Daily draw off volume:	65	130	210	300	520	1040	litres

The procedure shall be repeated for each of the relevant load profiles.

The normalized value of the average temperature is calculated according to the following formula:

$$\vartheta_{p} = (T_{set} - 10) \cdot \frac{(\vartheta_{p}' - \vartheta_{c})}{(T_{set} - \vartheta_{c})} + 10 \text{ in °C}$$

where

T_{set} (°C) set temperature of the auxiliary (backup) heater,

ϑ_c (°C) 10 °C,

ϑ_p' (°C) average temperature of outlet water from the start of the draw-off until the outlet temperature drops below 40 °C or until the daily volume is reached.

The quantity of hot water V_{40} in litres delivered with a temperature of at least 40 °C will be calculated by the following formula:

$$V_{40} = V_{40meas} \cdot \frac{(\vartheta_{p} - 10)}{30} \text{ in litres}$$

where

V_{40meas} (litres) corresponds to the quantity of water delivered at least 40 °C.

If V_{40} greater or equal to the daily load profile, the system is valid for that load profile.

The declared load profile shall be the maximum load profile or the load profile one below the maximum load profile.

5.11 Reverse flow protection

Visual inspection shall be performed on the existence of a check valve or other provisions.

For systems without check valve the system shall be tested according to ISO 9459-2:1995, 7.8.2. The difference between the heat loss coefficient of the storage tank with the collector loop connected and the heat loss coefficient of the storage tank with the collector loop disconnected should be less than 10 %.

5.12 Electrical safety

If the system contains any electrical device, the laboratory shall verify the presence of CE marking.

Annex A
(normative)

Thermal performance presentation sheet

Name and type	: .... Factory Made / Custom Built System[a]
Derived from test report	: ....
By test institute	: ....
This table filled in by	: ....
Date	: ....
Test method used	: Factory Made Systems: ISO 9459-2 / ISO 9459-5 [a]
	Custom Built Systems: EN 12977–2:2012[a]
Integrated auxiliary heater	: Electric / Indirect / Direct Gas / None / Other [a]................................

In case of solar heating systems with emergency heaters, instructions should be issued that this emergency heater shall only be used for emergency heating purposes.

NOTE The user of this form is allowed to copy this present form.

[a] Select appropriate option.

Figure A.1 — Thermal performance presentation sheet

Table A.1 — Presentation of the system performance indicators for solar-plus-supplementary systems

Performance indicators for solar-plus-supplementary systems on annual base for a demand volume of .... l/d			
Location (latitude)	Q_d MJ	$Q_{aux, net}$ MJ	Q_{par} MJ
Stockholm (59,6° N)	.....		
Würzburg (49,5° N)	.....		
Davos (46,8° N)	.....		
Athens (38,0° N)	.....		
..... [a]			

[a] For a location free to choose.

Table A.2 — Presentation of the system performance indicators for solar-only and solar preheat systems

Performance indicators for solar-only and solar preheat systems on annual base for a demand volume of .... l/d				
Location (latitude)	Q_d MJ	Q_L MJ	f_{sol} %	Q_{par} MJ
Stockholm (59,6° N)	.....			
Würzburg (49,5° N)	.....			
Davos (46,8° N)	.....			
Athens (38,0° N)	.....			
..... [a]				

[a] For a location free to choose.

Annex B
(normative)

Reference conditions for performance prediction

B.1 General

The conditions given in Table B.1 shall be used when calculating, reporting or comparing the performance of a system, either from a test or from a computer simulation. These conditions may also be applied to the system during any system performance test, if not specified otherwise.

NOTE Except the specification in respect of the status of the auxiliary heater for solar-plus-supplementary systems (see EN 12977–2:2012, Table A.1), the following reference conditions are identical for testing and simulating of Factory Made Systems in this standard and Custom Built Systems in EN 12977–2.

For systems tested according to ISO 9459-2, the Long Term Performance Prediction, will be in agreement with the reference conditions of this annex provided that the following changes in the calculation procedure are implemented:

Changes in ISO 9459-2:1995, Clause 9 (pages 21, 22, 23 and 24), Step 3 (Energy drawn off):

— **Calculations for Day 1:**

$Q_c(1)$ is calculated according to:

$$Q_c(1) = Q(1)\int_0^{V'} f(V)dV$$

where V' is determined by two conditions:

$$Q_c(1) \le V_{load}\rho_w C_{pw}(t_{load} - t_{main}) \quad \text{and} \quad V' \le V_{load}$$

— **Calculations for Day 2 and subsequent days:**

$Q_c(2{:}part1)$ is calculated according to:

$$Q_c(2{:}part1) = Q(2{:}part1)\int_0^{V'} f(V)dV$$

and $Q_c(2{:}part2)$ is calculated according to:

$$Q_c(2{:}part2) = Q(2{:}part2)\int_0^{V'} g(V)dV$$

The value V' is determined when the total energy extracted is calculated according to:

$$Q_c(2) = Q_c(2{:}part1) + Q_c(2{:}part2) \le V_{load}\rho_w C_{pw}(t_{load} - t_{main}) \quad \text{and} \quad V' \le V_{load}$$

The calculations done according to this procedure give lower values than with one load volume extracted every day, but will give higher values than with the consideration of a minimum load temperature.

Table B.1 — Reference conditions for performance presentation

Reference condition	Value	Remarks
SYSTEM		
Collector orientation	South	
Collector Tilt Angle	45°	For testing, (45 ± 5)° if not fixed for the system or specified by the manufacturer.
Total length of collector loop	20 m (10 m + 10 m)	If piping is not delivered with the system or specified by the manufacturer.
Pipe diameter and insulation thickness of collector loop	See B.2	If piping is not delivered with the system or specified by the manufacturer.
Location of collector loop pipes	Indoor, for systems with store situated indoors; Outdoor, for systems with store situated outdoors	As far as possible at the test rig
Store ambient temperature	15 °C	For systems where the store is located outside, the ambient temperature from the climate data shall be used.
For systems with indirect (hydraulic) auxiliary heating: Power to be applied on auxiliary heat exchanger	(100 ± 30) W per litre of store volume above the lowest end of heat exchanger	If the auxiliary heater is not delivered with the system and no restrictions have been given in the documentation. The auxiliary heater shall be modelled as an ideal heat source with no heat capacity and constant heating power.
Flowrate through auxiliary heat exchanger	The flowrate through the heat exchanger shall be chosen such that the temperature difference between the inlet and outlet of the auxiliary heat exchanger is (10 ± 2) K under steady-state conditions, unless specified otherwise by the manufacturer.	
For systems with electrical auxiliary heating: Power of electrical element	If an electrical element is normally delivered with the system or specified by the manufacturer, this element shall be used. Otherwise, (25 ± 8) W per litre of store volume above the electrical element.	
Temperature of integrated auxiliary heating	≥ 60 °C (minimum temperature of hysteresis)	Or a higher temperature, if recommended by the manufacturer in order to fulfil national or European specification such as e.g. CEN/TR 16355.
Status of the auxiliary heater (for solar-plus-supplementary systems)	Permanently activated	A different operation mode is possible if specified in the manufacturers manual, This should be stated in the test report...

Reference condition	**Value**	**Remarks**
CLIMATE		
Reference locations	Stockholm, Würzburg, Davos, Athens	In the reporting form, the performance of a different location of choice may also be given.
Climate Data	For Stockholm: CEC Test Reference Year; for Davos, Würzburg and Athens: Test Reference Year.	
HEAT LOAD		
Daily load pattern	For all systems: 100 % at 6 h after solar noon For testing, the load patterns shall be as specified in the test procedure.	
Cold water supply temperature	See B.3	For testing, the temperature shall be as specified in the test procedure
Desired (mixing valve) temperature	45 °C	If the daily or yearly loads are calculated in terms of energy, this energy shall be calculated using the cold water supply temperature and the desired temperature. NOTE 1 In practice higher temperatures may be necessary, e.g. for prevention of Legionella growth.
Daily load volume	The load volumes in litres per day shall be chosen from the following series: 50 l/d, 80 l/d, 110 l/d, 140 l/d, 170 l/d, 200 l/d, 250 l/d, 300 l/d, 400 l/d, 600 l/d. If larger loads are required, the series may be extended by repeatedly multiplying by $\sqrt{2}$ and rounding to the nearest multiple of 10. The manufacturer shall give a design load for the system. The nearest value given in the above series shall be used, as well as the next lower and higher values. It is recommended to use all lower and higher values from the series, which lie between 0,5 times and 1,5 times the design load. NOTE 2 Fixed load volumes have been chosen to facilitate comparison of the performance of different systems. For testing, the load volumes as specified in the test procedures shall be used.	
Draw-off flow rate	10 l/min	If the maximal design draw-off flow rate of the system is less than 10 l/min, the maximum design draw-off rate of the system shall be used.

B.2 Pipe diameter and insulation thickness

If the pipe and insulation for the collector loop are delivered with the system, or the pipe diameter and the insulation thickness to be used for the collector loop are clearly specified in the installation manual for the system, the delivered hardware or the specified values shall be used.

When piping and insulation are not delivered with the system or clearly specified, the pipe diameter, thickness and insulation thickness given in Table B.2 shall be used for forced-circulation systems.

When piping and insulation are not delivered with the system or clearly specified, the pipe diameter, thickness and insulation thickness given in Table B.3 shall be used for thermosiphon systems.

The material for the collector loop piping shall be copper, unless specified otherwise in the installation manual.

Table B.2 — Pipe diameter and insulation thickness for forced-circulation systems

Flow rate in collector loop l/h	**External pipe diameter** mm	**Pipe thickness** mm	**Thickness of one insulation layer** [a] mm
< 90	10 ± 1	1	20 ± 2
≥ 90 and ≤ 140	12 ± 1	1	20 ± 2
≥ 140 and ≤ 235	15 ± 1	1	20 ± 2
≥ 235 and ≤ 405	18 ± 1	1	20 ± 2
≥ 405 and ≤ 565	22 ± 1	1	20 ± 2
≥ 565 and ≤ 880	28 ± 1	1,5	30 ± 2
≥ 880 and ≤ 1445	35 ± 1	1,5	30 ± 2
≥ 1 445 and ≤ 1 500	42 ± 1	1,5	39 ± 2
> 1 500	Such that the flow velocity is approximately 0,5 m/s.	1,5	Same as internal pipe diameter

[a] Based on a thermal conductivity of 0,04 W/(m2*K) ± 0,01 for temperature of 10 °C.

Table B.3 — Pipe diameter and insulation thickness for thermosiphon systems

Collector array aperture area m^2	**External pipe diameter** mm	**Pipe thickness** mm	**Thickness of one layer insulation** [a] mm
≥ 1 and < 2	15 ± 1	1	20 ± 2
≥ 2 and < 6	18 ± 1	1,5	30 ± 2
≥ 6 and < 10	22 ± 1	1,5	39 ± 2

[a] Based on a thermal conductivity of 0,04 W/(m2*K) ± 0,01 for temperature of 10 °C.

B.3 Calculation of cold water temperature at reference location

The cold water temperature shall be calculated in accordance with:

$$\vartheta_{cw} = \vartheta_{average} + \Delta\vartheta_{amplit} \cos(([Day] - D_s)\, 2\pi / 365)$$

where

ϑ_{cw}	cold water temperature to be used for performance presentation
$\vartheta_{average}$	yearly average cold water temperature on reference location
$\Delta\vartheta_{amplit}$	average amplitude of seasonal variations on reference location
[Day]	day number of the year
D_S	shift term

The yearly average cold water temperature, average amplitude of seasonal cold water temperature variations and shift term given in Table B.4 shall be used for the reference locations.

Table B.4 — Data for calculation of the cold water temperature at the reference locations

Reference location	$\vartheta_{average}$ °C	$\Delta\vartheta_{amplit}$ °C	D_S d
Stockholm	8,5	6,4	45,75
Würzburg	10,0	3,0	45,75
Davos	5,4	0,8	45,75
Athens	17,8	7,4	45,75

B.4 Additional set of reference conditions for annual performance calculations

The references in Table B.5 shall be applied to calculate the annual performance for test results according to the method in ISO 9459-5.

Table B.5 — Reference conditions for performance presentation limited to the deviations from Table B.1

Reference condition	Value	Remarks
SYSTEM		
Storage ambient temperature:	20 °C	for systems where the storage is located outside, the ambient temperature from the climate data shall be used.
Temperature of integrated auxiliary heating:	≥ 60 °C (minimum temperature of hysteresis)	
Auxiliary heater:	Power as specified by supplier	
CLIMATE		
Irradiation area, azimuth:	0°	facing south
Irradiation area, inclination:	45°	with horizontal
Average climate:	Strasbourg	According to NOTE 1 in Table B.1
Colder climate:	Helsinki	According to NOTE 1 in Table B.1
Warmer climate:	Athens	Test reference year

HEAT LOAD												
Load profile:	**M**			**L**			**XL**			**XXL**		
	Start:	**Flow rate**	V_{tap}[a]	**Start:**	**Flow rate**	V_{tap}[a]	**Start:**	**Flow rate**	V_{tap}[a]	**Start:**	**Flow rate**	V_{tap}[a]
	hour	**l/m**	**%**	**hour**	**l/m**	**%**	**hour**	**l/m**	**%**	**hour**	**l/m**	**%**
Daily load pattern:	07:00	6	27,5	07:00	6	14,7	07:00	10	33,8	07:00	16	33,7
	08:00	3	7,19	08:00	10	33,6	08:00	3	2,20	08:00	3	1,71
	09:00	3	3,59	09:00	3	1,80	09:30	3	2,20	09:30	3	1,71
	10:30	3	5,39	10:30	3	2,70	11:00	3	1,65	11:00	3	1,28
	12:00	4	5,39	12:00	4	2,70	12:00	4	3,85	12:00	4	3,00
	15:00	3	3,59	14:30	3	1,80	14:30	3	1,65	14:30	3	1,28
	16:00	3	1,80	17:00	3	3,60	16:00	3	1,10	16:30	3	1,28
	19:00	3	7,19	19:30	4	7,21	17:30	3	2,2	18:00	3	1,28
	20:00	4	12,6	21:00	10	31,89	19:30	10	27,6	19:30	16	28,9
	21:00	6	25,76				21:00	10	23,75	21:00	16	25,86
Daily heat demand (=Q_{ref}):	4,161 kWh			7,647 kWh			12,096 kWh			15,372 kWh		
Desired (mixing valve) temperature (= T_{dem})	38,4 °C			39,2 °C			39,4 °C			39,6 °C		
Daily draw off volume:	$870 \cdot \frac{Q_{ref}}{(T_{dem} - 10)}$											
Cold water supply temperature	10 °C											
Daily load volume	See daily load pattern											
Draw-off flow rate	See daily load pattern											
[a] As percentage of the daily draw-off volume.												

The climate data for Strasbourg and Helsinki shall meet the following criteria.

— the average climate conditions shall be representative for the Strasbourg climate and the colder climate conditions shall be representative for the Helsinki climate.

— the annual average outside air temperature for the average and colder climate conditions shall be equal to the values in Table B.6 with a margin below or above of 2 %.

— the monthly average outside air temperature for the average and colder climate conditions shall be equal to the values in Table B.6 with a margin below or above of 5 % for each month.

— the annual solar irradiation for the average and colder climate conditions shall be equal to the values in Table B.7 with a margin below or above of 2 %.

— the monthly solar irradiation for the average climate conditions shall be equal to the values in Table B.7 with a margin below or above of 10 %.

— the monthly solar irradiation for the colder climate conditions shall be equal to the values in Table B.7 with a margin below or above of 25 %.

Table B.6 — Monthly and average annual reference outside air temperatures for two climate zones in °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	2,8	2,6	7,4	12,2	16,3	19,8	21,0	22,0	17,0	11,9	5,6	3,2	11,8
Colder	−3,8	−4,1	−0,6	5,2	11,0	16,5	19,3	18,4	12,8	6,7	1,2	−3,5	6,6

Table B.7 — Monthly and average annual reference solar irradiation for two climate zones in kWh/m²

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	70	104	149	192	221	222	232	217	176	129	80	56	154
Colder	22	75	124	192	234	237	238	181	120	64	23	13	127

The above requirements are met using Meteonorm data with the specifications in Table B.8.

Table B.8 — Specifications of the average and colder climate hourly data file according to Meteonorm

	Average climate	Colder climate
Location name:	Strasbourg	Helsinki airport
Latitude [°N]:	48,55	60,317
Longitude [°E]	7,633	24,967
Altitude [m.a.s.l.]:	150	53
Radiation model:	Standard	Standard
Temperature model:	Standard	Standard
Tilt radiation model:	Perez	Perez
Temperature period:	2009	2009
Radiation period:	2009	2009
Azimuth:	0°	0°
Inclination:	45°	45°

NOTE The ISO 9459-5 long-term calculation program has limitations that makes it necessary to simplify the table of draw-offs for the load profiles to that given in Table B.5.

B.5 Reference conditions for the performance of the auxiliary heater

The references in Table B.9 shall be applied to calculate the performance of the auxiliary heater for Solar-plus-Supplementary systems tested according to the method in ISO 9459-5.

Table B.9 — Reference conditions the performance of the auxiliary heater, limited to the deviations from Table B.1

<table>
<tr><th>Reference condition</th><th colspan="5">Value</th><th colspan="7">Remarks</th></tr>
<tr><td colspan="13">SYSTEM</td></tr>
<tr><td>Storage ambient temperature</td><td colspan="5">20 °C</td><td colspan="7">For systems where the storage is located outside, the ambient temperature from the climate data shall be used.</td></tr>
<tr><td>Temperature of integrated auxiliary heating</td><td colspan="5" rowspan="3">In conformity with the long term performance calculation</td><td colspan="7"></td></tr>
<tr><td>Auxiliary heater</td><td colspan="7"></td></tr>
<tr><td>Operation time</td><td colspan="7"></td></tr>
<tr><td>CLIMATE</td><td colspan="5"></td><td colspan="7"></td></tr>
<tr><td>Climate Data</td><td colspan="5">None</td><td colspan="7">Use a 6 day climate file with the irradiatiance set at < 0,01 W/m²</td></tr>
<tr><td colspan="13">HEAT LOAD</td></tr>
<tr><td>Load profile:</td><td colspan="3">**M**</td><td colspan="3">**L**</td><td colspan="3">**XL**</td><td colspan="3">**XXL**</td></tr>
<tr><td rowspan="12">Daily load pattern:</td><td>**Start:**</td><td>**Flow rate**</td><td>V_{tap}</td><td>**Start:**</td><td>**Flow rate**</td><td>V_{tap}</td><td>**Start:**</td><td>**Flow rate**</td><td>V_{tap}</td><td>**Start:**</td><td>**Flow rate**</td><td>V_{tap}</td></tr>
<tr><td>**hour**</td><td>**l/m**</td><td>**l**</td><td>**hour**</td><td>**l/m**</td><td>**L**</td><td>**hour**</td><td>**l/m**</td><td>**l**</td><td>**hour**</td><td>**l/m**</td><td>**l**</td></tr>
<tr><td>07:00</td><td>6</td><td>31,11</td><td>07:00</td><td>6</td><td>33,14</td><td>07:00</td><td>10</td><td>124,7</td><td>07:00</td><td>16</td><td>159,82</td></tr>
<tr><td>08:00</td><td>3</td><td>8,12</td><td>08:00</td><td>10</td><td>75,75</td><td>08:00</td><td>3</td><td>8,12</td><td>08:00</td><td>3</td><td>8,12</td></tr>
<tr><td>09:00</td><td>3</td><td>4,06</td><td>09:00</td><td>3</td><td>4,06</td><td>09:30</td><td>3</td><td>8,12</td><td>09:30</td><td>3</td><td>8,12</td></tr>
<tr><td>10:30</td><td>3</td><td>6,09</td><td>10:30</td><td>3</td><td>6,09</td><td>11:00</td><td>3</td><td>6,09</td><td>11:00</td><td>3</td><td>6,09</td></tr>
<tr><td>12:00</td><td>4</td><td>6,09</td><td>12:00</td><td>4</td><td>6,09</td><td>12:00</td><td>4</td><td>14,20</td><td>12:00</td><td>4</td><td>14,20</td></tr>
<tr><td>15:00</td><td>3</td><td>4,06</td><td>14:30</td><td>3</td><td>4,06</td><td>14:30</td><td>3</td><td>6,09</td><td>14:30</td><td>3</td><td>6,09</td></tr>
<tr><td>16:00</td><td>3</td><td>2,03</td><td>17:00</td><td>3</td><td>8,12</td><td>16:00</td><td>3</td><td>4,06</td><td>16:30</td><td>3</td><td>6,09</td></tr>
<tr><td>19:00</td><td>3</td><td>8,12</td><td>19:30</td><td>4</td><td>16,23</td><td>17:30</td><td>3</td><td>8,12</td><td>18:00</td><td>3</td><td>6,09</td></tr>
<tr><td>20:00</td><td>4</td><td>14,20</td><td>21:00</td><td>10</td><td>71,70</td><td>19:30</td><td>10</td><td>101,7</td><td>19:30</td><td>16</td><td>136,82</td></tr>
<tr><td>21:00</td><td>6</td><td>29,08</td><td></td><td></td><td></td><td>21:00</td><td>10</td><td>87,45</td><td>21:00</td><td>16</td><td>122,62</td></tr>
<tr><td>Daily draw off volume:</td><td colspan="2"></td><td>**113,0**</td><td colspan="2"></td><td>**225,2**</td><td colspan="2"></td><td>**368,5**</td><td colspan="2"></td><td>**474,0**</td></tr>
<tr><td>Cold water supply temperature</td><td colspan="5">10 °C</td><td colspan="7"></td></tr>
<tr><td>Desired temperature</td><td colspan="5">55 °C</td><td colspan="7">Maximum of the minimum temperatures for the Peak and useful temperature</td></tr>
<tr><td>Daily load volume</td><td colspan="5">See ‘Daily draw off volume’</td><td colspan="7"></td></tr>
<tr><td>Draw-off flow rate</td><td colspan="5">See Daily load pattern</td><td colspan="7"></td></tr>
</table>

NOTE The ISO 9459-5 long-term calculation program has limitations that makes it necessary to simplify the table of draw-offs for the load profiles to that given in Table B.9.

Annex C
(informative)

Assessment of the ability of solar DHW systems to resist the extreme climatic conditions

C.1 Indoor and outdoor test procedure for assessment of the frost resistance of solar DWH systems with outdoor storage tank or system using heat transfer fluid with the risk of freezing

C.1.1 Objective and applicability

The purpose of this test is to determine whether extreme frost conditions for a certain climate region will damage a solar domestic hot water (DHW) system or influence the proper functioning of such a system.

The test is applicable to ICS systems and other solar DHW systems with the storage tank placed outdoors as well as for DHW systems using fluids with the risk of freezing inside the collector loop (e.g. pure water), and takes into account the connecting piping and freeze protection device(s). It is suited for systems with or without active freeze protection devices (like a small internal heater).

For Drain down and Drain back DHW systems, the volumetric procedure described in EN ISO 9806 could be used for complete mounted collector arrays without the need of climate tests, unless the test criteria will be fulfilled.

C.1.2 Apparatus and mounting of the system

The solar DHW system is mounted in a climate chamber which is large enough to contain the complete system and the necessary mounting construction, and which is capable of generating the necessary test conditions with regard to the temperature. The procedure is also developed to perform the tests outdoors, if the required climate conditions are fulfilled.

The installation of the whole system should be similar to realistic conditions, taking into account the most severe conditions that are allowed in the installation manual.

The system should be mounted in accordance with the installation instruction. Special attention should be given to the following points:

— mounting and installation of the piping used for both the inlet and outlet of water from the solar DHW system, including non- return valve and any freeze protection measures;

— any freeze protection measures required in the installation manual;

— way the solar DHW system is mounted on the roof. If the installation instructions allow the system to be mounted on a flat roof, or otherwise in such a way that no thermal contact with the indoor climate is established, the system shall be mounted in such a way that all components are exposed to the cold air temperature in the climate chamber or outdoors as much as allowed. If however, in accordance with the installation instruction, the system may only be integrated into the roof or otherwise being in contact with the indoor ambient air temperature, the system should accordingly be mounted on a test roof. The test roof should be placed at the lowest tilt angle allowed in the installation instruction.

To cover the most critical situation with several days of freezing temperatures without any irradiation (e.g. if the collector is covered with snow) as well as periods without any water consumption, there is no need for tapping and measuring flow rates. If active heating will be used for freeze protection, the system may run in a freeze protection mode according to the manufacturer's requirements.

Water pressure sensors can be placed in the mains water and outlet pipes, in order to obtain extra pressure information and detect damages during the test. If any freeze protection requires electricity or any other external energy source, the consumption of energy should be measured throughout the test.

The system is filled with mains water in accordance with the installation instruction and checked for any leakage. The hot water outlet pipe is then shut off, and the cold water pipe is kept at mains pressure. The system is energized as specified by the manufacturer, including any freeze protection equipment. If the system contains an auxiliary heating which plays a role in freeze protection (as specified by the manufacturer), the auxiliary heater is switched on, otherwise kept switched off.

C.1.3 Test procedure

C.1.3.1 General

The test procedure consists of three freezing periods, which are described below.

If the test is performed indoors, the ambient air temperature between each freeze cycle shall reach 5°C for at least 4 h.

If the test is performed outdoor, the draw-off temperature of the system shall reach 5 °C for at least 5 h (during lower outdoor ambient air temperatures this can be reached by removing the solar-reflecting cover from the system). The draw-off temperature shall be measured and recorded at least at the beginning and the end of the 4 h period. For each draw-off at least 10 l shall be drained at 2 l/min (±1 l/min).

C.1.3.2 Freezing period

C.1.3.2.1 General

The test period C.1.3.1 consists of a number of hours with no solar irradiation as well as reference minimum ambient air temperature for the climate class considered.

The test starts after the system has been filled as recommended by the manufacturer as described above and the hot water valve has been shut off.

C.1.3.2.2 Procedure

Conduct the procedure as follows.

a) Conditioning of the system by drawing off at least three times the total volume while keeping the mains water temperature at ϑ_{cw}.

b) Indoor test: Immediately after conditioning, reduce the air temperature to ϑ_a and maintain this condition during t_1 h (starting from the moment when the air temperature reaches $\vartheta_{a,}$) without any irradiation. No water shall be withdrawn from the system. Outdoor test: The system shall be shielded from solar radiation by means of a solar-reflecting cover. The system shall be exposed to a maximum ambient air temperature of ϑ_a for a minimum time t1 h (starting from the moment when the air temperature reaches ϑ_a). No water shall be withdrawn from the system.

c) Record the pressure read out of the pressure sensors at least every two hours.

d) Record the moment and quantity of any water consumption or use of electricity or other external sources.

e) Record especially the consumption of water, which is not equalled by corresponding discharge through the outlet pipe or any safety device.

f) Implement the conditions described in C.1.3.2.1 that should prevail between the freezing periods.

g) Perform two additional freezing periods separated by one intermediate period according to f_1.

h) The first test period is finished, when both criteria for time $t1$ and temperature level ϑa are fulfilled.

i) Visually, inspect the solar DHW system for any leakage or frost damage immediately after the third period. During this inspection, the temperature in the test chamber or outdoor shall rise above 10 °C for a minimum period of 5 h.

j) If the visual inspection shows no leakage or damage, an additional pressure test of each circuit shall be performed according to 5.3.

C.1.4 Test conditions — Determination of the test conditions for freezing period

The conditions for this period are represented by:

— ϑ_a minimum hourly ambient air temperature, in °C;

— t_1 test period, in h given in Table C.1.

Table C.1 — Test conditions

Value	Class 1 Mediterranean climate with a limited no. of nights below 0 °C	Class 2 Mediterranean climate above sea level	Class 3 Central European climate at sea level	Class 4 Alpine, eastern and northern European climate	Class x (limit given by the manufacturer)
ϑ_a (°C)	−5	−10	−20	−30	-x
t_1 (h)	8	10	12	14	

The requested class will be given by the manufacturer and need to be described within the installation manual

If the system is mounted in thermal connection to a test roof, the air temperature to be maintained under the test roof ϑ_i should be equal to the minimum air temperature specified in the instruction manual. Again, more severe conditions, e.g. a longer test duration, may be chosen in consultation with the manufacturer.

C.1.5 Results

The following results should be reported:

a) make and model identification of the system including auxiliary freeze protection devices fitted;

b) details of installation of the solar DHW system: mounting on or in the test roof, inclination, connections, lay-out, insulation of piping, etc.; a sketch or photo of the installation should be included;

c) climate data class considered for determination of the test conditions;

d) realized test conditions (duration and ambient air conditions of each freezing period and warm-up period);

e) if the test is performed outdoor, record the draw-off temperature and draw-off volume during the warm-up period;

f) record of the time of activation of auxiliary freeze protection devices;

g) record of consumption of electricity or other external sources by freeze protection devices;

h) record of water pressure as measured by the pressure sensors (if available);

i) results of all visual inspections and pressure tests, including any evidence of ice formation or leakage.

C.2 Indoor test procedure for assessment of the reliability of solar DWH systems in respect of overheating protection

C.2.1 Objective and applicability

The purpose of this test is to assess if a solar DHW system is able to withstand extreme overheating conditions without being damaged.

The test is applicable to solar DHW systems, including connecting piping and overheating protection device(s). It is especially suited for systems that do not have an active overheating protection device, however, for systems that do have such a device, the capability of that device to protect the system is tested.

C.2.2 Apparatus and mounting of the system

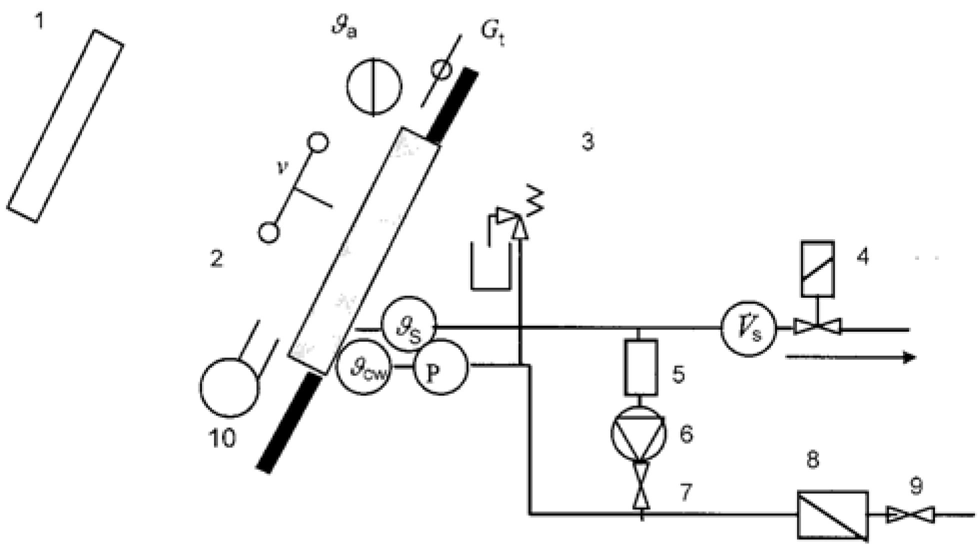
The solar DHW system is mounted in a solar irradiance simulator (similar to the solar simulators used for efficiency determination of solar collectors), capable of generating the necessary test conditions with regard to temperature, wind speed and irradiation (see Figure C.1). The installation should be similar to realistic conditions, taking into account the most severe conditions that are allowed in the installation manual. The collector tilt angle should be 45°, unless specified otherwise in the installation manual.

The system should be mounted in accordance with the installation instructions. Special attention should be given to the following points:

— the mounting and installation of the piping to and from the solar DHW system, including non-return valve and any overheating protection measures;

— any overheating protection measures required in the installation manual;

— the way the solar DHW system is connected to the roof.



Key

1 solar radiation simulator
2 SDHW system
3 safety valve (installed according to installers instructions)
4 draw-off valve A
5 heater
6 pump
7 valve C
8 non-return
9 valve B
10 fan
⌀ pyranometer
⚲ anemometer
○ fluid thermometer (ϑ), flow meter (V) or pressure sensor (P)
⏀ air thermometer

Figure C.1 — Scheme of the test set-up

The water flow rate into the solar DHW system should be measured in the mains water pipe and monitored throughout the test. The volume of water discharged through overheating protection devices or safety valves should also be measured and monitored.

If any overheating protection requires electricity or any other external energy source, the consumption of energy should be measured throughout the test. A water pressure sensor should be placed in the mains water line.

The cold water inlet and the hot water outlet of the solar DHW system are also connected to a circuit including a water heater and a pump, which has the purpose of heating up the solar DHW system water content at the start of the test period. This extra circuit is fitted with two valves to make it possible to separate the circuit from the normal mains water connection and outlet pipe. Furthermore, a connection is present to enable a pressure test to be made on the solar DHW system.

The system and test circuit are filled with mains water in accordance with the installation instruction. The hot water outlet pipe is then shut off.

C.2.3 Test procedure

Ensure that the solar simulator is switched off.

Carry out a pressure safety valve test by gradually raising the water pressure in the solar DHW system to the opening pressure of the safety valve. Read the pressure at which the valve opens, and check the system for any leakage or damage.

Restore the system to normal mains water pressure. Energize the system according to the manufacturer instruction, including any overheating protection equipment and auxiliary thermal sources.

Connect the water heater circuit to the solar DHW system. Switch on the pump and heat the water in the solar DHW system using the water heater until the water in the solar DHW system reaches (75 ± 2) °C.

If the solar DHW system is not designed ever to reach a temperature of 75 °C or if it will never reach that temperature during normal operation, a lower temperature may be chosen. This should be reported with the test results.

Disconnect the water heater circuit and switch the solar DHW system back to mains water supply. Set the ambient air temperature in the chamber to $\vartheta_{\mathrm{i},4}$ and the wind speed to $v_{\mathrm{w},4}$.

NOTE $\vartheta_{\mathrm{i},4}$ and $v_{\mathrm{w},4}$ are defined in C.2.4.

Keep the system under these temperature and wind conditions for a period of 5 d ± 1 h. During these 5 d, periodically apply an irradiation of $G_{\mathrm{sol},4}$ during a time $t_{\mathrm{sol},4}$. The daily irradiation should be equal to $H_{\mathrm{sol},4}$. The start of the first irradiation period may be chosen within the first 6 h of the test period. The start of the second irradiation period should be (24 ± 1) h after the start of the first irradiation period. The third irradiation period should start (48 ± 1) h after the start of the first irradiation period, and so on in a daily cycle.

Record the temperature and amount of the water discharged to prevent overheating.

At the end of the 5 d period, withdraw at least three times the system volume while keeping the mains water temperature constant to 1 °C around a value between 10 °C and 20 °C. Record the temperature of the drawn off water during this draw-off. Visually inspect the solar DHW system for any damage or permanent deformation.

C.2.4 Test conditions

C.2.4.1 General

In C.2.4.2 a procedure is described to obtain the test conditions from local weather data. In C.2.4.3 the test conditions are given for the climate region of the Netherlands.

All test conditions are determined from a series of weather data, which includes extreme weather conditions for a representative location. The series should consist of weather data, which contain the five most severe heat waves ever. If these data are not available, a representative weather data file of at least 10 consecutive years should be taken. In this case, the specified penalty as given below should be applied.

C.2.4.2 Determination of test conditions

The conditions for the test are represented by:

$\vartheta_{\mathrm{i},4}$ indoor ambient air temperature, in °C;

$\vartheta_{a,4}$	outdoor ambient air temperature, in °C;
$H_{sol,4}$	5-d average solar irradiation in the plane of the solar DHW system cover, in MJ/(m^2.d);
$G_{sol,4}$	peak hourly average solar irradiance in the plane of the solar DHW system cover within the 5-d period, in W/m^2;
$v_{w,4}$	lowest hourly average wind speed within the 5-d period, in m/s;
$t_{sol,4}$	duration of the irradiation period, in h.

The quantities $H_{sol,4}$, $G_{sol,4}$, $t_{sol,4}$, $\vartheta_{a,4}$, $\vartheta_{i,4}$ and $v_{w,4}$ are determined from the climate data described in C.2.4.1 as follows:

a) Select a 5-d period with an average daily irradiation in the plane of the solar DHW system cover $H_{sol,4}$ and an average daily temperature $\vartheta_{a,4}$, which holds the absolute maximum product of $H_{sol,4} \times \vartheta_{a,4}$.

b) For the selected period, determine ϑ_a, $\vartheta_{a,x}$, $\vartheta_{a,max}$, $H_{sol,4}$, $G_{sol,4}$ and $v_{w,4}$ where:

   1) ϑ_a is the 5-d average outdoor ambient air temperature, in °C;

   2) $\vartheta_{a,x}$ is the peak hourly average outdoor ambient air temperature within the 5-d period, in °C

   3) $\vartheta_{a,max}$ is the peak hourly average outdoor ambient air temperature ever registered, in °C;

   4) Investigate the local weather for $\vartheta_{a,max}$ as well.

c) Calculate the outdoor ambient air temperature for the test from the following formula:

$$\vartheta_{a,4} = \vartheta_a + \vartheta_{p,4} \text{ with}$$

$$\vartheta_{p,4} = 0,5 \times (\vartheta_{a,max} - \vartheta_{a,x})$$

where

$\vartheta_{p,4}$	is the penalty for correction of ϑ_a for more severe temperatures than those found in the decade (see C.2.4.1) investigated.

d) Next, the duration of the irradiation period will be determined. If the solar DHW system to be tested is equipped with a TIM (Translucent Insulation Material) one should account for an incidence angle dependent transmittance. In that case, the H_{sol} (not the G_{sol}) should be corrected with a factor cor_{sol}, in accordance with the integrated incidence angle modifier (IAM) function of the TI material:

$$cor_{sol} = 0,5 \text{ I } [\text{IAM}](\varphi) \times \cos\varphi$$

where

φ	is the incidence angle, taken from (0 to 90)°.

For a number of TIM's, IAM functions are already known. Typical range of cor_{sol} based on the IAM function for realistic TI materials is from 0,90 to 0,75. For a cover having an incidence angle independent transmittance, the cor_{sol} is 1,0. Apart from the cover material, the construction of the solar DHW system (deep-seated box structures, parabolic mirrors, etc.) may influence the value of the IAM function and cor_{sol}. Therefore, it is recommended to use a measured IAM function of the solar DHW system.

Taking into account the incidence angle correction, the duration of the daily insolation period is calculated by:

$$t_{sol,4} = 277{,}8 \times cor_{sol} \times H_{sol,4}/G_{sol,4x}$$

In order to take into account properties of common solar simulators, a solar irradiance lower than $G_{sol,4x}$ by at most 20 % can be used to calculate the corresponding $t_{sol,4}$.

e) If the system is mounted in thermal connection to a test roof as described in C.1.2, the ambient air temperature to be maintained under the test roof $\vartheta_{i,4}$ should be equal to the maximum ambient air temperature specified in the instruction manual. If no maximum ambient air temperature is specified, the ambient air temperature under the roof $\vartheta_{i,4}$ should be equal to ($\vartheta_{a,4}$ + 5) K.

C.2.4.3 Test conditions elaborated for specific locations

The procedure given in C.2.4.2 has been elaborated for the climate region of the Netherlands. The results are:

$\vartheta_{a,4}$ = 27 °C ; $H_{sol,4}$ = 30 MJ/(m^2.d); $G_{a,4}$ = 1 000 W/m^2; $v_{W,4}$ = 0 m/s; $t_{sol,4}$ = 8,3 h

C.2.5 Results

The following results should be reported:

a) make and model identification of the system including auxiliary overheating protection devices fitted;

b) details of installation of the solar DHW system: mounting on or in the test roof, inclination, connections, lay-out, insulation of piping, etc; a sketch or photo of the installation should be included;

c) location and time span of the climate data considered for determination of the test conditions;

d) all test conditions as determined from the climate data;

e) volume of water discharged through overheating protection devices and/or safety valves;

f) record of the time of activation of auxiliary overheating protection devices;

g) record of consumption of electricity or other external sources by overheating protection devices;

h) results of all visual inspections, including any evidence of damage or leakage;

i) record of water pressure as measured by the pressure sensor. If during the pressure test the pressure valve did not open, or if it opened at a pressure higher than its rated pressure, this should be reported; if the pressure at any time exceeded the pressure rating of the pressure valve, this should also be reported;

j) record of the draw-off water temperature during the draw-off at the end of the test; if at any time the water temperature exceeded 100 °C, this should be reported.

Annex D
(informative)

Ageing test for thermostatic valves

D.1 General

This accelerated ageing test has the goal to assess the applicability of the specified maintenance frequency of a thermostatic valve, which is used as overheating protection valve in a solar heating system. Water of specified hardness is used in a cycle of operation and cooling down (closing). The correct functioning is regularly checked. When too large sediments of chalk are observed, the test duration is recalculated to an expected period in normal use. Therefore, the assumption is made that the valve will operate 250 times per year (This number has been estimated based on model simulations for Dutch climate with ICS and thermosiphon systems.)

D.2 Test arrangement

The test arrangement (see Figure D.1) consists of a mixing vessel V1 with sufficient volume. The vessel can be filled with drinking water through valve 1. Via the open lid, substances can be added. The water in the vessel is stirred using a stirring device R. In the vessel V1, the water is conditioned to the required hardness by adding a mixture of calcium and magnesium salts. Using a pump H, the conditioned water can be pumped into test vessel V2 where it can be heated electrically. On top of V2 there is a connection where the valve being tested (labelled T&P) is mounted. A flow meter F is used to register the amount of water drained by T&P.

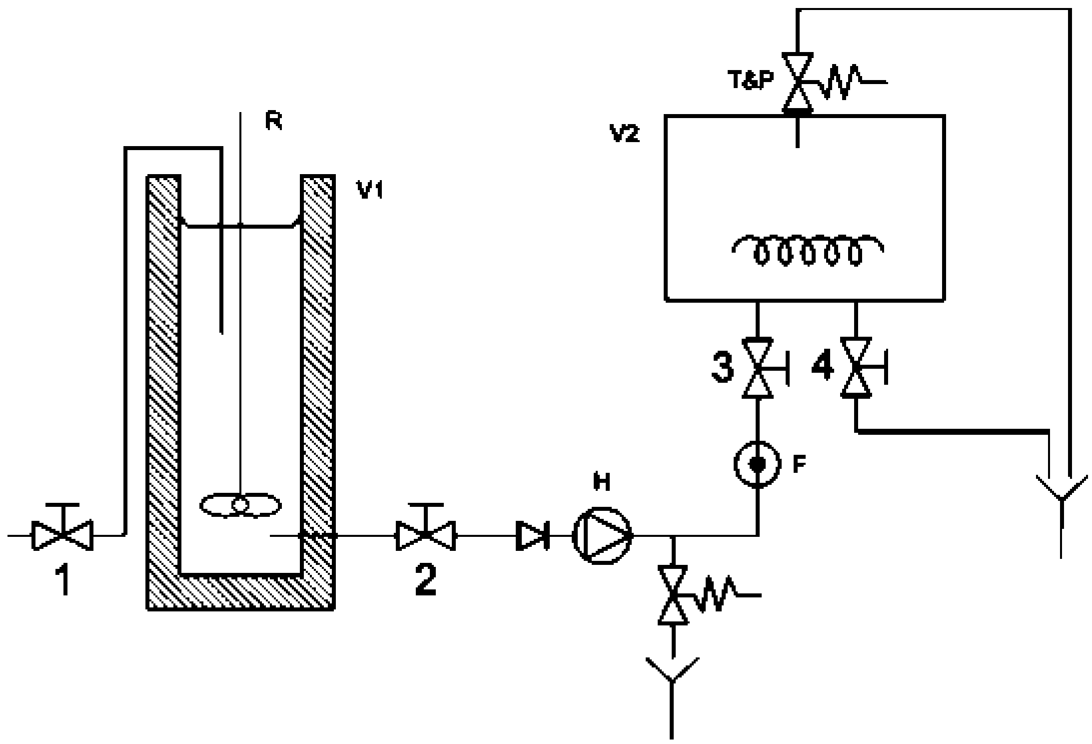


Figure D.1 — Test arrangement for thermostatic valve test

D.3 Test Procedure

D.3.1 Find out the specified maintenance frequency f_m [year⁻¹] of the thermostatic valve. If the maintenance frequency is not specified, assume a system lifetime of 15 years: f_m = 1/15 [year⁻¹].

D.3.2 Determine the number of cycles necessary for the test as n = 250 / f_m

D.3.3 Start up the test rig:

a) Rinse V1 with domestic hot water and subsequently fill it.

b) Add magnesium carbonate and calcium sulfate until the desired hardness is reached. Measure the hardness in accordance with ISO 6059. Start the stirring device and the pump. When refilling the store during the test, the amounts of salts to be added may be calculated from the amount of water refilled and the amounts of salts used to condition the first store volume.

NOTE 1 EN 60734 specifies procedures to obtain 'hard water to be used for testing the performance of some household electrical appliances'. This standard is however very labour intensive and expensive. Therefore a simplified method is given here to achieve the same result.

NOTE 2 At TNO, with drinking water in Delft (hardness 8,5 °D[1]) and a volume of V1 of 600 l, 180 g of magnesium carbonate and 290,4 g of calcium sulfate is needed to obtain the desired hardness of about 23 °D.

1) German index of hardness of water. The SI unit is mmol/l; 1 mmol/l = 5,6 °D.

c) Open valve 2, 3 and 4 to fill V2 with hard water. Close valve 4.

d) Start heating V2 using the electrical heater. At a certain point the valve will open and water will flow from V2 to the drain. Cold water is supplied from V1. After a certain time the temperature has dropped sufficiently for the valve T&P to close again.

e) When V1 is almost empty, close all valves and shut off the stirring device and the pump, refill V1 with water and restart at b).

D.3.4 After every 30th to 35th cycle, check visually if the valve is still functioning. When the valve does not function any more after less than *n* cycles, the number of cycles completed is reported.

D.3.5 After *n* cycles, report whether the valve is still functioning. Remove the valve and visually inspect the amount of sediments on the valve.

D.3.6 If *n* cycles have been completed with the valve functioning, the specified maintenance frequency is sufficient for the valve. Else, convert the number of test cycles to an expected operation period:

Expected operating period = number of cycles / 250 [year].

D.4 Results

Report *n*, the number of cycles completed and, if applicable, the expected operating period.

Annex E
(informative)

Lightning protection test for solar heating systems

E.1 Field of application

This test for lightning protection should be applied only to those parts of Factory Made solar heating systems that are normally exposed to outdoor weather/environment conditions.

Systems that contain few or no metallic parts may be excluded from this test.

Test methods for special devices, components and other items that may be applied to Factory Made solar heating systems or connected to solar heating systems on the roof with LPS installation are not covered by this standard.

The outdoor parts of the system may be considered as “natural components” on roof constructions and should be treated as “natural air termination components” in accordance with the relevant lightning protection standards.

NOTE This test is based on EN 62305–3, modified for the needs of thermal solar heating systems. It is included in this standard to assist the manufacturers in meeting these requirements.

E.2 Purpose

The purpose of this test is to assess the relative resistance of the Factory Made solar heating systems and to evaluate whether the solar heating system is adequately manufactured to ensure sufficient connections and protection against lightning in case of connecting with a Lightning Protection System (LPS) in the building.

The solar heating systems and components mounted on the roof surface should only be used as a part of the existing LPS with the agreement of the structure engineer or the owner.

The connection with LPS cannot guarantee absolute protection to structures, solar heating systems and components or persons, but will significantly reduce risk of damage caused by lightning.

E.3 Requirements

The system should conform to the requirements given in EN 62305-3.

When the water tank is mounted outdoors, the separation distance S_t (see E.5.4) should either fulfil:

$$S_t > D_t$$

or there should be at least one connection (bonding cable or strip) between the tank and the outer cover sheet (i.e. in front and rear bottom). This bonding cable or strip should have at least the sizes as given in Table F.1, when measured in accordance with E.5.5.

where

D_t is the minimum separation distance $(K_i \times K_c / K_m) \times L_t = 0{,}044\ L_t$;

L_t is the overall length of the tank, in millimetres;

K_i = 0,05;

K_c = 0,44;

K_m = 0,50.

When the tank is mounted outdoors, the bridging between the tank and the supports should have a total contact (connection) area of at least 100 cm^2 (overlapping surface bolted or spot welded), when measured in accordance with E.5.6.

The bridging between the collectors and supports (as determined in E.5.7) should have a contact (connection) surface of at least 100 cm^2 (overlapping surface bolted or welded).

E.4 Apparatus

No special apparatus is required except:

— a platform on which the complete solar heating system can be installed in accordance with the manufacturer's instructions and

— measuring instruments for distances, etc. (see test procedures below).

E.5 Test procedure

E.5.1 Test conditions

The test is normally carried out on solar heating systems, which are installed in a testing structure in accordance with the manufacturer's instructions.

E.5.2 Solar heating system installation

Install the Factory Made solar water heating system in accordance with the manufacturer's instructions, using his material for connections on the testing base stand and between components. Fill up the solar heating system and the close loop, for indirect systems, with water and take care for removing air from all parts through the air vents.

E.5.3 Separation distance S_t

Measure the overall length L_t of the tank, in millimetres.

Measure the existing separation distance S_t between the tank and the outer cover sheet.

Calculate the minimum permitted separation distance D_t.

E.5.4 Size of the bonding cable or strip

Check the existence of the above mentioned bonding connections.

Measure the size of bonding and calculate the cross section surface (or determine the size from electric cable tables).

E.5.5 Bridging between tank and supports

Check if there are bolts or rivets, etc. between tank and supports.

Measure and calculate the overlapping surface between these parts.

Compare the results with the lower limit of 100 cm^2, overlapping surface.

E.5.6 Bridging between collectors and supports

Check if there are bolts or rivets etc. between collectors and supports.

Measure and calculate the overlapping surface between these parts.

Compare the results with the lower limit of 100 cm^2, overlapping surface.

E.5.7 Bridging between collectors and tank

No special inspections. There is sufficient electrical continuity via metal supports.

E.5.8 Connecting terminal with Lightning Protection System (LPS)

Check the existence of the holes and measure the sizes d, l and h.

E.5.9 Metal sheets covering parts of the solar heating system

The electrical continuity check is not covered by this standard, but the relevant standards should be applied.

Check the thickness of metal sheet.

E.5.10 Heating effects due to lightning currents

The heating effects are considered as negligible.

E.5.11 Mechanical durability due to lightning mechanical loads

The mechanical loads in the solar components are too low and the influence on durability and stability is considered as negligible.

E.6 Report

Report the results of the tests, measurements and calculations in a formal Lightning Protection Testing Sheet given in Annex F.

E.7 Conclusions

The conclusions include the final evaluation that the Factory Made solar heating system is adequately manufactured and capable of connecting with an existing Lightning Protection System (LPS) on the roof of a building. In this way it should be protected against damage due to lighting effects.

Final conclusions are reported and included in the Lighting Protection Testing Sheet.

Annex F
(informative)

Lightning Protection testing sheet

Table F.1 — Size of bonding cable

Protection Level	**Cable material**	**Cable cross-section F_c** mm²	
		Large load of lightning	**Non large load of lightning**
I - II - III - IV (IEC TC 81)	Copper (Cu)	16	6
	Aluminium (Al)	25	10
	Steel (Fe)	50	16

NOTE Four lightning protection levels LPL (I to IV, with 4 types of relevant protection measures for the design of LPS) are introduced; for each one, a set of maximum and minimum lightning current parameters is fixed: the maximum values of lightning current parameters relevant to LPL I will not be exceeded with a probability of 99 %; they are reduced to 75 % for LPL II and to 50 % for LPL III and IV. The minimum values of lightning current amplitude for the different LPL are used to derive the rolling sphere radius R in order to define the lightning protection zone which cannot be reached by direct strikes, a minimum peak current of 3 kA (LPL I), 5 kA (LPL II), 10 kA (LPL III) and 16 kA (LPL IV) leads to a rolling sphere radius R equal to 20, 30, 45 and 60 m respectively.

Table F.2 — Size of metal cover sheets

Metal cover sheet	**Minimum thickness** mm
Galvanized steel	0,50
Stainless steel	0,40
Copper	0,30
Aluminium	0,70
Zinc	0,70
Lead	2,00

Table F.3 — Lightning protection testing sheet

Laboratory	: ....
No of Test	: ....
Date	: ....
Standard	: ....
Solar heating system No.	: ....

Manufacturer : ....

(From manufacturer specifications and by laboratory examination of the sample)

Open system	:	Yes ☐	No ☐	
Closed system	:	Yes ☐	No ☐	
Tank Capacity	:	l	Collector area :	.....m²

Construction Materials

Solar Tank

Tank walls	: ....
Internal coating	: ....
Flange and sealings	: ....
Heating element	: ....
Pipes	: ....
Heat exchanger	: ....
Safety devices	: ....
Welding/soldering	: ....
Other materials	: ....

Solar Collector

Absorber pipes	: ....
Connecting pipes	: ....
Sealings	: ....
Welding/soldering materials	: ....
Other materials	: ....

Supports

Materials	: ....
Bolts/rivets/welding	: ....
Coating	: ....
Other materials	: ....

Connecting pipes

Pipes	: ....
Welding/soldering materials	: ....
Other materials	: ....

Laboratory	: ....
No of Test	: ....
Date	: ....
Standard	: ....
Solar heating system No.	: ....

1. Special components for connection with LPS	:		□Yes	□No
2. Test in accordance with other standards	:		□Yes	□No
3. Installation on testing platform	:		□Yes	□No
4. Length of tank L_t	: .... mm			
Separation distance S_t	: .... mm			
Calculation for D_t	: .... mm			
Comparison	:	$S_t > D_t$	□Yes	□No
	:	$S_t < D_t$	□Yes	□No
Need for bonding	:		□Yes	□No
Number of bonding cable	: .... items			
5. Existence of bonding cable	:		□Yes	□No
Number of cables or strips	: .... items			
Dimensions of cable	: .... mm .			
Cross section surface F_c: .... mm^2				
Comparison	: F_c > .... mm^2 (from Table F.1)			
	: F_c < .... mm^2 (from Table F.1)			
6. Tank support bridging				
Existence of bolts, etc	:		□Yes	□No
Dimensions of overlapping	: .... cm. Surface of overlapping Fov			
:........ cm^2				
Comparison	: $F_{ov} > 100$ cm^2	□Yes	□No	
	: $F_{ov} < 100$ cm^2	□Yes	□No	
7. Collector support bridging				
Existence of bolts, etc	:		□Yes	□No
Dimensions of overlapping	: .... cm Surface of overlapping Fov			
:........ cm^2				
Comparison	: $F_{ov} > 100$ cm^2	□Yes	□No	
	: $F_{ov} < 100$ cm^2	□Yes	□No	
8. Existence of 2 Holes ∅10	:		□Yes	□No
Dimensions $d = 12$ mm	: d = ... mm	□Yes	□No	
$l = 22$ mm	: l = ... mm	□Yes	□No	

	h = 200 mm :	h = ... mm □Yes □No
9. Cover sheet thickness t		: .... mm
Comparison (Table F.2)		: t > ... mm □Yes □No
		: t < ... mm □Yes □No

Laboratory	: ....
No of Test	: ....
Date	: ....
Standard	: ....
Solar heating system No.	: ....

Final Conclusions

Needs for special labelling-identification:

Remarks:

Tested by:

Issued by:

Annex G
(normative)

Reporting format in the framework of the EU Regulations CDR 811, 812 and 814 dated 2013

The report shall be completed, for systems whose annual performance is determined according to the long term performance calculation according to ISO 9459-5, in order to be applicable for the Ecodesign and energy labelling requirements.

Multiple reports are allowed for different combinations of the solar system and the type of auxiliary (backup) heater.

Brand name :

Type name :

Model name :

System type [1]: :

Auxiliary heat source : Integrated / External [2]:

Auxiliary power source : Fuel / Electrical [2]:

Auxiliary thermostat setting [3]:................ : °C

Power of auxiliary heaters [3]: :................ kW

Annual performance parameters:

Load profile:	M	L	XL	XXL	
Annual heat demand:	1519	2791	4415	5611	In kWh
Auxiliary heat contribution:	Q_{nonsol}				Subclause 5.9.3.6
Average climate in kWh:					in kWh, Strasbourg
Colder climate in kWh:					in kWh, Helsinki
Warmer climate in kWh:					in kWh, Athens
Comply to the load profile					Yes/No, Subclause 5.10.6
$\eta_{wh,nonsol}$ [3]:					in %, Subclause 5.9.3.5
Q_{elec} [3]:					in kWh, Subclause 5.9.3.5
Q_{fuel} [3]:					in kWh, Subclause 5.9.3.5
$V_{40,measured}$ [3]:					in litres, Subclause 5.10.7
Q_{aux}:					In kWh, Subclause 5.9.3.4

[1] According to ISO 9488:1999

[2] Select appropriate option

[3] Solar-plus-supplementary systems only

Annex ZA
(informative)

Relationship between this European Standard and the energy labelling requirements of Commission Delegated Regulation (EU) No 811/2013 aimed to be covered

This European standard has been prepared under a Commission's standardisation request **with regard to the energy labelling of space heaters, combination heaters, packages of space heaters, temperature control and solar device and packages of combination heater, temperature control and solar device 'M/535/C(2015) 2626'** to provide one voluntary means of conforming to the energy labelling requirements of Commission Delegated Regulation (EU) No 811/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of space heaters, combination heaters, packages of space heaters, temperature control and solar device and packages of combination heater, temperature control and solar device.

Once this standard is cited in the Official Journal of the European Union under that Regulation, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding energy labelling requirements of that Regulation and associated EFTA Regulations.

Table ZA.1 —Correspondence between this European Standard and Commission Delegated Regulation (EU) No 811/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of space heaters, combination heaters, packages of space heaters, temperature control and solar device and packages of combination heater, temperature control and solar device and Commission's standardisation request 'M/535/C(2015) 2626'

Energy labelling requirements of Regulation (EU) No 811/2013	Clauses and sub-clauses of this EN	Remarks/ Notes
Annex V, 4, (f), Q_{nonsol}	Annex G	
Annex V, 4, (f) solpump solstandby	Annex G	Not applicable. The ISO 9459-5 test method determines the Q_{aux} directly. Moreover, due to the integrated nature of the components in the solar device, it is impossible to determine the value of the items.
Annex V, 4, (f): Q_{aux}	Annex G	In case of test results according to EN 12976-2, Annex IV, 3, (l): Q_{aux} shall be calculated assuming an annual pump operation time of 2 000 h.
Annex V, 2, (f), table 7 and table 8: $\eta_{wh,nonsol}$ Q_{elec} declared load profile Q_{fuel}	Annex G	Solar-plus-supplementary systems only

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the products falling within the scope of this standard.

Annex ZB
(informative)

Relationship between this European Standard and the energy labelling requirements of Commission Delegated Regulation (EU) No 812/2013 aimed to be covered

This European standard has been prepared under a Commission's standardisation request **with regard to energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device 'M/534/C(2015) 2625'** to provide one voluntary means of conforming to the energy labelling requirements of Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device.

Once this standard is cited in the Official Journal of the European Union under that Regulation, compliance with the normative clauses of this standard given in Table ZB.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding energy labelling requirements of that Regulation and associated EFTA Regulations.

Table ZB.1 — Correspondence between this European Standard and Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device and Commission's standardisation request 'M/534/C(2015) 2625'

Energy labelling requirements of Regulation (EU) No 812/2013	**Clauses and sub-clauses of this EN**	**Remarks/ Notes**
Applicable for **Solar water heaters** only		
Annex V, 1, (f), referring to Annex VII, 7: (a) Q_{elec} (b) declared load profile (d) Q_{fuel}	Annex G	Not applicable in case of a preheater with an external auxiliary heater
Annex V, 1, (f), referring to Annex VII, 7: (i) A_{sol} (j) η_o (k) a_1 (l) a_2 (m) IAM (n) solpump	Annex G	See NOTE

(o) solstandby		
Annex V, 1, (g), referring to Annex VIII, 2: (d) $\eta_{wh,nonsol}$ (e) Q_{aux} (g) Q_{nonsol}	Annex G	
Applicable for **Solar devices** only		
Annex V, 3, (f), referring to annex VII, 9: (a) A_{sol} (b) η_o (c) a_1 (d) a_2 (e) IAM (f) Solpump (g) solstandby	Annex G	See NOTE
Annex V, 3, (f), referring to Annex IV, 3: (c) A_{sol} (d) η_o (e) a_1 (f) a_2 (g) IAM (h) V_{nom}	Annex G	See NOTE
Annex V, 3, (f), referring to Annex IV, 3, (i): Q_{nonsol}	Annex G	
Annex V, 3, (f), referring to Annex IV, 3: (j) solpump (k) solstandby	Annex G	See NOTE
Annex V, 3, (f), referring to Annex IV, 3, (i) Q_{aux}	Annex G	In case of test results according to EN 12976-2, Annex IV, 3, (l): Q_{aux} shall be calculated assuming an annual pump operation time of 2 000 h.

NOTE Not applicable. Although the item refers to a test results required in the regulation, the item is not needed using the ISO 9459-5 test method. Moreover, due to the integrated nature of the components in the solar device, it is impossible to determine the value of the items.

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the products falling within the scope of this standard.

Annex ZC
(informative)

Relationship between this European Standard and the ecodesign requirements of Commission Regulation (EU) No 814/2013 aimed to be covered

This European standard has been prepared under a Commission's standardisation request to **ecodesign requirements for water heaters and hot water storage tanks 'M/534/C(2015) 2625'** to provide one voluntary means of conforming to the ecodesign requirements of Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks.

Once this standard is cited in the Official Journal of the European Union under that Regulation, compliance with the normative clauses of this standard given in Table ZC.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding ecodesign requirements of that Regulation and associated EFTA Regulations.

Table ZC.1 — Correspondence between this European Standard and Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks and Commission's standardisation request 'M/534/C(2015) 2625'

Energy labelling requirements of Regulation (EU) No 814/2013	Clauses and subclauses of this EN	Remarks/ Notes
Annex IV, 2: $\eta_{wh,nonsol}$ Q_{nonsol}	Annex G	
Annex IV, 2, (d): Q_{aux}	Annex G	In case of test results according to EN 12976-2, Annex IV, 3, (l): Q_{aux} shall be calculated assuming an annual pump operation time of 2 000 h.
Annex IV, 2, (d), V40	Annex G	
Annex IV, 6: (a) Q_{elec} (b) declared load profile (d) Q_{fuel}	Annex G	Not applicable in case of a preheater with an external auxiliary heater.
Annex IV, 6: (l) A_{sol} (m) η_o (n) a_1 (o) a_2 (p) IAM (q) solpump (r) solstandby	Annex G	Not applicable. Although the item refers to a test results required in the regulation, the item is not needed using the ISO 9459-5 test method. Moreover, due to the integrated nature of the components in the solar device, it is impossible to determine the value of the items.

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the products falling within the scope of this standard.

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[2] EN 1991-1-4, *Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions*

[3] EN 12977-1, *Thermal solar systems and components — Custom built systems — Part 1: General requirements for solar water heaters and combisystems*

[4] EN 12977-3, *Thermal solar systems and components — Custom built systems — Part 3: Performance test methods for solar water heater stores*

[5] EN 12977-4, *Thermal solar systems and components — Custom built systems — Part 4: Performance test methods for solar combistores*

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[14] AS/NZS 2712, *Solar and heat pump water heaters — Design and construction*

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[16] Solar Keymark Document SKN N0157R0 [2)]

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