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Toplotni sončni sistemi in sestavni deli - Industrijsko izdelani sistemi - 2. del: Preskusne metode

Thermal solar systems and components - Factory made systems - Part 2: Test methods

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

Installations solaires thermiques et leurs composants - Installations préfabriquées en usine - Partie 2 : Méthodes d'essai

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Thermal solar systems and components - Factory made systems - Part 2: Test methods

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This European Standard was approved by CEN on 30 December 2018.

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European foreword

This document (EN 12976-2:2019) 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of an identical text or by endorsement, at the latest by September 2019, and conflicting national standards shall be withdrawn at the latest by September 2019.

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

This document supersedes EN 12976-2:2017.

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 12976-1:2019 and EN 12976-2:2019 since the 2017 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:

— beside few editorial changes, more clarification with respect to testing requirements of reverse flow protection (Clause 5.11) and mechanical load testing (Clause 5.5).

— confusion about different Qref values in Table B.5 has been solved by using the complete equation for the annual loads. Finally, there should only be one Qref value.

— 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 document:

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

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

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 12977–2:2018, 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 document specifies test methods for validating the requirements for Factory Made Thermal Solar Heating Systems as specified in EN 12976-1. The document also includes two test methods for thermal performance characterization by means of whole system testing.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1489:2000, *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 ISO 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves (ISO 4126-1)*

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

EN 12977-2:2018, *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 9806:2017, *Solar energy — Solar thermal collectors — Test methods (ISO 9806:2017)*

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 9459-5:2007, *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 9806:2017, 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/m² 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/m² 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 ($1{,}66 \times 10^{-4} \pm 1{,}66 \times 10^{-5}$) m³/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;