# SLOVENSKI STANDARD
# kSIST FprEN 12977-2:2017

**01-september-2017**

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**Toplotni sončni sistemi in sestavni deli - Neserijsko izdelani sistemi - 2. del: Preskusne metode za sončne grelnike vode in kombinirane sisteme**

Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems

Thermische Solaranlagen und ihre Bauteile - Kundenspezifisch gefertigte Anlagen - Teil 2: Prüfverfahren für solar betriebene Warmwasserbereiter und solare Kombianlagen

Installations solaires thermiques et leurs composants - Installations assemblées à façon - Partie 2 : Méthodes d'essai pour chauffe-eau solaires et installations solaires combinées



**Ta slovenski standard je istoveten z:** **FprEN 12977-2**



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**ICS:**

| | | |
|---|---|---|
| 27.160 | Sončna energija | Solar energy engineering |
| 91.140.10 | Sistemi centralnega ogrevanja | Central heating systems |
| 91.140.65 | Oprema za ogrevanje vode | Water heating equipment |

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# FINAL DRAFT
# FprEN 12977-2

July 2017

ICS 27.160; 91.140.10; 91.140.65

Will supersede EN 12977-2:2012

English Version

# Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems

Installations solaires thermiques et leurs composants - Installations assemblées à façon - Partie 2 : Méthodes d'essai pour chauffe-eau solaires et installations solaires combinées

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This draft European Standard is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/TC 312.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.



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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.



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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**



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# Contents

## European foreword

This document (FprEN 12977-2:2017) has been prepared by Technical Committee CEN/TC 312 "Thermal solar systems and components", the secretariat of which is held by ELOT.

This document is currently submitted to the Unique Acceptance Procedure.

This document will supersede EN 12977-2:2012.

This document has been prepared under the Mandate M/534 "Standardisation request to the European standardisation organisations pursuant to Article 10(1) of Regulation (EU) No 1025/2012 of the European Parliament and of the Council in support of implementation 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 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 the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device" which was given to CEN by the European Commission and the European Free Trade Association.

For relationship with EU Directive(s), see informative Annex ZA, ZB and ZC, which are integral parts of this document.

EN 12977 is currently composed with the following parts:

— *Thermal solar systems and components — Custom built systems — Part 1: General requirements for solar water heaters and combisystems*;

— *Thermal solar systems and components — Custom built systems — Part 2: Test methods for solar water heaters and combisystems*;

— *Thermal solar systems and components — Custom built systems — Part 3: Performance test methods for solar water heater stores*;

— *Thermal solar systems and components — Custom built systems — Part 4: Performance test methods for solar combistores*;

— *Thermal solar systems and components — Custom built systems — Part 5: Performance test methods for control equipment*.

# Introduction

a) Drinking water quality

In respect of potential adverse effects on the quality of drinking water intended for human consumption caused by the product covered by this document, it should be noted that

1) this document provides no information as to whether the product may be used without restriction in any of the Member States of the EU or EFTA,

2) while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of this product remain in force.

b) Factory made and custom built solar heating systems

EN 12976-1:2017, EN 12976-2:2017, FprEN 12977-1:2017, FprEN 12977-2:2017, FprEN 12977-3:2017, FprEN 12977-4:2017 and FprEN 12977-5:2017 distinguish two categories of solar heating systems:

1) factory made solar heating systems; and

2) 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 to the following definitions.

3) 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. Requirements and test methods for factory made solar heating systems are given in EN 12976-1:2017 and EN 12976-2:2017.

4) 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 FprEN 12977-1:2017, test methods are specified in FprEN 12977-2:2017, FprEN 12977-3:2017, FprEN 12977-4:2017 and FprEN 12977-5:2017. Custom built solar heating systems are subdivided into two categories:

i) large custom built systems are uniquely designed for a specific situation. In general, they are designed by HVAC engineers, manufacturers or other experts;

ii) 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 12976–1:2017 and EN 12976–2:2017) | Custom built solar heating systems (FprEN 12977–1:2017, FprEN 12977–2:2017, FprEN 12977–3:2017, FprEN 12977–4:2017 and FprEN 12977–5:2017) |
|---|---|
| Integral collector-storage systems for domestic hot water preparation | Forced circulation systems for hot water preparation and/or space heating/cooling, assembled using components and configurations described in a documentation 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/cooling (mostly large systems) |

NOTE 1 Forced circulation systems can be classified either as factory made or as custom built, depending on the market approach chosen by the final supplier.

NOTE 2 Both factory made and custom built systems are performance tested under the same set of basic reference conditions as specified in EN 12976–2:2017, Annex B and in FprEN 12977–2:2017, Annex A. In practice, the installation conditions may differ from these reference conditions.

c) Test methods and procedures for the analysis of large custom built solar heating systems

Quality assurance is of primary importance for large custom built systems. The total investment cost for such systems is higher than for smaller ones, although the specific investment cost (i.e. per $m^2$ collector area) is lower. In several European countries, the potential of large custom built systems from the point of view of conventional energy savings is much larger than for smaller ones. Moreover, the return on investment is in many cases more favourable for large systems than for small ones. Hence, both the purchasers of large custom built systems and the governments are interested in efficient, reliable and durable systems, the thermal performance of which may be accurately predicted, checked and supervised.



The test methods in this document provide a means of verifying the compliance of large custom built systems with the requirements in FprEN 12977-1:2017.

NOTE 3 Within the framework of the EU ALTENER Programme the project “Guaranteed Solar Results” (GSR) was addressing similar objectives in respect of quality assurance (see [7], [8]). Similar procedures and monitoring equipment were used as described in Annexes C and D. It might be necessary to update Annexes C and D at a later stage during a revision of this document when more expertise is available.

As large custom built systems are by definition unique systems, only general procedures on how to check and supervise them may be given. An additional difficulty in the formulation of procedures is the fact that they have to be adapted to the dimension of the large custom built system considered, which may vary from typically 30 $m^2$ to 30 000 $m^2$ of collector area. Therefore, several possible levels of analysis are included (Annexes C and D).

The objective of the two short-term system tests presented in Annex C is the characterization of system performance and/or the estimation of the ability of the system to deliver the energy claimed by the designer. In principle, two approaches for short-term system testing are referred to in this European Standard:

1) a simplified check of short-term system performance, carried out by intercomparison of the measured thermal solar system heat gain with the one predicted by simulation, using the actual weather and operating conditions as measured during the short-term test;

2) a short-term test for long-term system performance prediction. The performance of the most relevant components of the solar heating system is measured for a certain time period while the system is in normal operation. More detailed measurements encompass

   i) energy gain of collector array(s) and

   ii) energy balance over storage vessel(s).

   Inter-comparison of the observed and simulated energy quantities provides the indirect validation of collector and storage design parameters. The measured data within the collector array are also used for direct identification of the collector array parameters. As far the component parameters are verified, the long-term prediction of the system gain as well as the detection of possible sources of system malfunctioning are possible.

   Annex D describes a procedure for long-term monitoring as a part of the supervision of a large custom built solar heating system. The objectives of supervision may be:

3) the early recognition of possible failures of system components, in order to get the maximum benefit from the initial solar investment as well as to minimize the consumption of non-solar energy and the resulting environmental impact,

4) the measurement of system performance (solar gains or other system indicators), if requested by a contractual clause, e.g. guaranteed results.

The long-term monitoring in Annex D is limited to the solar energy specific aspects, especially to the determination of the solar contribution to the total heat load. Instrumentation used in the long term monitoring should be an integrating part of the system, a part included from the very beginning of the design process. If adequately foreseen, it may also be used for system adjustment at start time.

# 1 Scope

This European Standard applies to small and large custom built solar heating systems with liquid heat transfer medium for residential buildings and similar applications, and gives test methods for verification of the requirements specified in FprEN 12977-1:2017.

This document also includes a method for thermal performance characterization and system performance prediction of small custom built systems by means of component testing and system simulation.

Furthermore, this document contains methods for thermal performance characterization and system performance prediction of large custom built systems.

This document applies to the following types of small custom built solar heating systems:

— systems for domestic hot water preparation only;

— systems for space heating only;

— systems for domestic hot water preparation and space heating;

— others (e.g. including cooling).

This document applies to large custom built solar heating systems, primarily to solar preheat systems, with one or more storage vessels, heat exchangers, piping and automatic controls and with collector array(s) with forced circulation of fluid in the collector loop.

This document does not apply to

— systems with a store medium other than water (e.g. phase- change materials),

— thermosiphon systems,

— integral collector-storage (ICS) systems.



# 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 307, *Heat exchangers - Guidelines to prepare installation, operating and maintenance instructions required to maintain the performance of each type of heat exchangers*

EN 806-1, *Specifications for installations inside buildings conveying water for human consumption - Part 1: General*

EN 809, *Pumps and pump units for liquids — Common safety requirements*

EN 1991-1-3, *Eurocode 1 - Actions on structures - Part 1-3: General actions - Snow loads*

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

EN 12975-1:2006+A1:2010, *Thermal solar systems and components - Solar collectors - Part 1: General requirements*

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

EN 12976-2:2017, *Thermal solar systems and components - Factory made systems - Part 2: Test methods*

FprEN 12977-1:2017, *Thermal solar systems and components — Custom built systems — Part 1: General requirements for solar water heaters and combisystems*

FprEN 12977-3:2017, *Thermal solar systems and components — Custom built systems — Part 3: Performance test methods for solar water heater stores*

FprEN 12977-4:2017, *Thermal solar systems and components — Custom built systems — Part 4: Performance test methods for solar combistores*

FprEN 12977-5:2017, *Thermal solar systems and components — Custom built systems — Part 5: Performance test methods for control equipment*

EN 16297-1, *Pumps - Rotodynamic pumps - Glandless circulators - Part 1: General requirements and procedures for testing and calculation of energy efficiency index (EEI)*

EN 60335-1, *Household and similar electrical appliances — Safety — Part 1: General requirements (IEC 60335-1)*

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 9459-5:2007, *Solar heating — Domestic water heating systems — Part 5: System performance characterization by means of whole-system tests and computer simulation*

ISO/TR 10217, *Solar energy — Water heating systems — Guide to material selection with regard to internal corrosion*



## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12975-1:2006+A1:2010, EN 12976-1:2017, FprEN 12977-1:2017, FprEN 12977-3:2017, FprEN 12977-5:2017, ISO 9459-5:2007 and EN ISO 9488:1999 apply.



## 4 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

**Table 2 — Symbols, definition and unit**

| Symbol | Definition | Unit |
|---|---|---|
| $a_1$ | heat loss coefficient at $(\vartheta_m - \vartheta_a) = 0$ | $W/(m^2 \times K)$ |
| $A_c$ | reference area of collector | $m^2$ |
| $C_c$ | effective thermal capacity of collector or collector array | J/K |
| *Day* | day number of the year | |
| $D_s$ | shift term for the calculation of mains water temperature at reference location | |
| $f_{sav}$ | fractional energy savings | % |

| Symbol | Definition | Unit |
|---|---|---|
| $f_{sol}$ | solar fraction | % |
| $G_d$ | diffuse solar irradiance on tilted plane | $W/m^2$ |
| $G_g$ | global solar irradiance (on horizontal plane) | $W/m^2$ |
| $G_h$ | hemispherical solar irradiance on tilted plane | $W/m^2$ |
| $H_c$ | hemispherical solar irradiation on collector plane | $MJ/m^2$ |
| $K_{\alpha\tau}$ | incidence angle modifier | |
| $Q_{aux}$ | gross auxiliary energy demand of the solar heating system | MJ |
| $Q_{aux,net}$ | net auxiliary energy demand of the solar heating system delivered by the auxiliary heater to the store or directly to the heat distribution system | MJ |
| $Q_{conv}$ | gross energy demand of the conventional heating system | MJ |
| $Q_{conv,net}$ | net energy demand of the conventional heating system | MJ |
| $Q_d$ | heat demand | MJ |
| $Q_{d,hw}$ | heat demand for domestic hot water | MJ |
| $Q_{d,sh}$ | heat demand for space heating | MJ |
| $Q_L$ | energy delivered at the outlet of the solar heating system | MJ |
| $Q_l$ | store heat losses of the solar heating system | MJ |
| $Q_{l,a}$ | store heat losses of the store heated by auxiliary energy (in case of a two-store-solar-plus-supplementary system) | MJ |
| $Q_{l,s}$ | store heat losses of the store heated by solar energy (in case of a two-store-solar-plus-supplementary system) | MJ |
| $Q_{l,conv}$ | store heat losses of the conventional heating system | MJ |
| $Q_{ohp}$ | heat diverted from the store as active overheating protection, if any | MJ |
| $Q_{par}$ | parasitic energy (electricity) for the collector loop pump(s) and control unit | MJ |
| $Q_{sav}$ | energy savings due to the solar heating system | MJ |
| $Q_{sol}$ | energy delivered by the collector loop to the store | MJ |
| $T^*$ | reduced temperature difference; $T^* = (\vartheta_m - \vartheta_a)/G_h$ | $m^2 \times K/W$ |
| $(UA)_{hx}$ | heat transfer capacity rate of a heat exchanger | W/K |
| $(UA)_S$ | heat loss capacity rate of the store of the solar heating system | W/K |
| $(UA)_{S,conv}$ | heat loss capacity rate of the store of the conventional heating system | W/K |
| $(UA)_{sb,s,a}$ | is stand-by heat loss capacity rate of the store, in W/K, calculated according to FprEN 12977–1:2017, Formula (1) | |

| Symbol | Definition | Unit |
|---|---|---|
| $U_L$ | overall heat loss coefficient of a collector or collector array | $W/(m^2 \times K)$ |
| $\dot{V}_c$ | volume flow rate in collector loop | l/h |
| $V_d$ | demanded (daily) load volume | l/d |
| $\dot{V}_{rc}$ | volume flow rate in circulation loop | l/h |
| $\dot{V}_s$ | volume draw-off flow rate from storage | l/h |
| $V_{S,conv}$ | store volume of the conventional heating system | l |
| $v$ | surrounding air speed | m/s |
| $\Delta\vartheta$ | average temperature difference induced by a heat exchanger | K |
| $\Delta\vartheta_{amplit}$ | average amplitude of seasonal mains water temperature variations on reference location | K |
| $\Delta\eta$ | drop in system efficiency induced by a heat exchanger | % |
| $\vartheta_a$ | collector ambient or surrounding air temperature | °C |
| $\vartheta_{average}$ | yearly average mains water temperature on reference location | °C |
| $\vartheta_{ci/co}$ | collector or collector array inlet/outlet fluid temperature | °C |
| $\vartheta_{cw}$ | mains water temperature | °C |
| $\vartheta_d$ | desired hot water temperature | °C |
| $\vartheta_m$ | mean collector fluid temperature; $\vartheta_m = (\vartheta_{ci} + \vartheta_{co})/2$ | °C |
| $\vartheta_{rce}$ | fluid temperature at circulation loop outlet | °C |
| $\vartheta_{rci}$ | fluid temperature at circulation loop inlet | °C |
| $\vartheta_S$ | storage draw-off temperature | °C |
| $\vartheta_{S,amb}$ | store ambient air temperature | °C |
| $\vartheta_{start/stop}$ | temperature for which controller operation starts/stops | °C |
| $\vartheta_{store}$ | temperature of the hot water store | °C |
| $\eta_0$ | zero-loss collector efficiency (efficiency at $T^* = 0$) | |
| $\eta_{aux}$ | overall generation efficiency of the auxiliary heater of the solar heating system | |
| $\eta_{conv}$ | overall generation efficiency of the heater of the conventional heating system | |
| $\theta_{req}$ | required temperature for sensor high-temperature resistance | °C |
| $\theta_{sens}$ | sensor temperature | °C |

# 5 System classification

See FprEN 12977-1:2017, Clause 5.

# 6 Test methods

## 6.1 Introduction

Subsequent test methods refer to the requirements given in FprEN 12977-1:2017.

## 6.2 General

### 6.2.1 Suitability for drinking water

See EN 806-1.

### 6.2.2 Water contamination

Check the design of all circuits to avoid water contamination for backflow from all circuits to drinking main supplies.

### 6.2.3 Freeze resistance

See EN 12976-2:2017, 5.1.

### 6.2.4 High-temperature protection

#### 6.2.4.1 Scald protection

If the temperature of the domestic hot water in the system can exceed 60 °C, check the design plan or the system documentation to see whether the system is provided with an automatic cold water mixing device or any other device to limit the maximum tapping temperature to 60 °C.

#### 6.2.4.2 High-temperature protection of materials

Ensure by checking the hydraulic scheme and/or by calculation and taking into account the most adverse conditions for the materials of all parts of the system, that the maximum temperatures which may occur do not exceed the maximum permissible temperatures for the respective materials, taking into account also pressure conditions and/or mechanical stress if relevant.

NOTE Both transients (high temperature peaks of short duration) and stagnation of longer duration may create adverse conditions for the respective material.

### 6.2.5 Reverse circulation prevention

Check the hydraulic scheme included in the documentation (see 6.8) to ensure that no unintentional reverse circulation will occur in any hydraulic loop of the system.

### 6.2.6 Pressure resistance

In case that it is not documented that the store(s) and the heat exchanger(s) withstand at least 1,5 times the manufacturer's stated maximum individual working pressures, the procedures specified in EN 12976-2:2017, 5.3 should be applied on the store(s) and the heat exchanger(s).

EN 12976–2:2017, 5.3 specifies a pressure resistance test method for a complete solar thermal system. For the purpose of this subclause, this method should be principally applied on the store(s) and heat exchanger(s).

Check if the system documentation for the installer describes a pressure resistance test procedure for the collector loop of the system.