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Toplotni sonį ni sistemi in sestavni deli - Neserijsko izdelani sistemi - 2. del: Preskusne metode za sonį ne 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

Installations solaires thermiques et leurs composants - Installations personnalisées - Partie 2: Méthodes d'essai pour chauffe-eau solaires et installations mixtes

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Thermische Solaranlagen und ihre Bauteile - Kundenspezifisch gefertigte Anlagen - Teil 2: Prüfverfahren

This draft Technical Specification is submitted to CEN members for Technical Committee Approval. It has been drawn up by the Technical Committee CEN/TC 312.

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Foreword

This document (prCEN/TS 12977-2:2008) 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 Technical Committee Approval.

This document will supersede ENV 12977-2:2001.

Introduction

a) 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, it should be noted that

— 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;

— 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, EN 12976-2 and prCEN/TS 12977-1 to -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 to the following definitions:

1) **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.

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 prCEN/TS 12977-1, test methods are specified in prCEN/TS 12977-2 to -5. Custom Built solar heating systems are subdivided into two categories:

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

— **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, -2)	Custom built solar heating systems (prCEN/TS 12977-1, -2, -4, -5 and prEN 12977-3)
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 12976-2:2006, Annex B and in prCEN/TS 12977-2, 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 m² 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 favorable 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 prCEN/TS 12977-1.

NOTE 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 the Annexes C and D later on in a revision of this document when more experience 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 Technical Specification:

1) A simplified check of short-term system performance, carried out by intercomparison of the measured 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

   — energy gain of collector array(s) and

   — energy balance over storage vessel(s).

   Intercomparison 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:

— 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;

— 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 document (prCEN/TS 12977-2:2008) 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 prCEN/TS 12977-1.

This document includes also 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 referenced documents are indispensable for the application 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 307, *Heat exchangers — Guidelines to prepare installation, operating and maintenance instructions required to maintain the performance of each type of heat exchanger*

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 1151-1, *Pumps — Rotodynamic pumps — Circulation pumps having a rated power input not exceeding 200 W for heating installations and domestic hot water installations — Part 1: Non-automatic circulation pumps, requirements, testing, marking*

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, *Thermal solar systems and components — Solar collectors — Part 1: General Requirements*

EN 12975-2:2006, *Thermal solar systems and components — Solar collectors — Part 2: Test methods*

EN 12976-1:2006, *Thermal solar systems and components — Factory made systems — Part 1: General requirements*

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

prCEN/TS 12977-1:2006, *Thermal solar systems and components — Custom built systems — Part 1: General requirements for solar water heaters and combisystems*

prEN 12977-3:2008, *Thermal solar systems and components — Custom built systems — Part 3: Performance test methods for solar water heater stores*

prCEN/TS 12977-4:2006, *Thermal solar systems and components — Custom built systems — Part 4: Performance test methods for solar combistores*

prCEN/TS 12977-5:2006, *Thermal solar systems and components — Custom built systems — Part 5: Performance test methods for control equipment*

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

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

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 10217:1989, *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, EN 12976-1:2006, prCEN/TS 12977-1:2006, prEN 12977-3:2008, prCEN/TS 12977-4:2006, prCEN/TS 12977-5:2006, ISO 9459-5:2007 and EN ISO 9488:1999 apply.

4 Symbols and abbreviations

Symbol	Definition	Unit
a_1	heat loss coefficient at (ϑ_m - ϑ_a)=0	W/m^2K
A_c	reference area of collector	m²
C_c	effective thermal capacity of collector or collector array	J/K
Day	day number of the year	
Ds	shift term for the calculation of mains water temperature at reference location	
f_{sav}	fractional energy savings	%
f_{sol}	solar fraction	%
G_d	diffuse solar irradiance on tilted plane	W/m²
G_g	global solar irradiance on horizontal plane	W/m²
G_h	hemispherical solar irradiance on tilted plane	W/m²
H_c	hemispherical solar irradiance on collector plane	W/m²
$K_{\alpha\tau}$	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_L	energy delivered at the outlet of the solar heating system	MJ
Q_l	store heat losses of the solar heating system	MJ
$Q_{l,conv}$	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
$\vartheta_{average}$	yearly average mains water temperature on reference location	°C
ϑ_a	collector ambient or surrounding air temperature	°C
$\vartheta_{S,amb}$	store ambient air temperature	°C
$\vartheta_{ci/co}$	collector or collector array inlet/outlet fluid temperature	°C
ϑ_{cw}	mains water temperature	°C
ϑ_d	desired hot water temperature	°C

Symbol	Definition	Unit
ϑ_m	mean collector fluid temperature; $\vartheta_m = (\vartheta_{ci} + \vartheta_{co})/2$	°C
ϑ_{rci}	fluid temperature at circulation loop inlet	°C
ϑ_{rce}	fluid temperature at circulation loop outlet	°C
θ_{req}	required temperature for sensor high-temperature resistance	°C
ϑ_S	storage draw-off temperature	°C
θ_{sens}	sensor temperature	°C
$\vartheta_{start/stop}$	temperature for which controller operation starts/stops	°C
ϑ_{tank}	temperature of the storage tank	°C
T^*	reduced temperature difference; $T^* = (\vartheta_m - \vartheta_a)/G_h$	m^2K/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
U_L	overall heat loss coefficient of a collector or collector array	W/m^2K
V_d	demanded (daily) load volume	litre/d
$V_{S,conv}$	store volume of the conventional heating system	litre
$\dot{V}_c$	volume flow rate in collector loop	litre/h
$\dot{V}_{rc}$	volume flow rate in circulation loop	litre/h
$\dot{V}_s$	volume draw-off flow rate from storage	litre/h
v	surrounding air speed	m/s
$\Delta\vartheta$	temperature difference	°C
$\Delta\vartheta_{amplit}$	average amplitude of seasonal mains water temperature variations on reference location	°C
η_0	zero-loss collector efficiency (efficiency at $T^* = 0$)	
η_{aux}	overall generation efficiency of the auxiliary heater of the solar heating system	
η_{conv}	overall generation efficiency of the heater of the conventional heating system	
$\Delta\eta$	drop in system efficiency induced by a heat exchanger	%
$\Delta\vartheta$	average temperature difference induced by a heat exchanger	°C

5 System classification

See prCEN/TS 12977-1:2006, clause 5.

6 Test methods

Subsequent test methods refer to the requirements given in prCEN/TS 12977-1.

6.1 General

6.1.1 Suitability for drinking water

See EN 806-1.

6.1.2 Water contamination

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

6.1.3 Freeze resistance

See EN 12976-2:2006, 5.1.

6.1.4 High-temperature protection

6.1.4.1 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 tapping temperature to at most (60 ±5)°C.

6.1.4.2 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 if relevant.

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

6.1.5 Reverse circulation prevention

Check the hydraulic scheme included in the documentation (see 6.7) to ensure that no unintentional reverse circulation will occur in any hydraulic loop of the system.

6.1.6 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 12976-2:2006 ,5.3, should be applied on the store(s) and the heat exchanger(s).

NOTE EN 12976-2:2006, 5.3, specifies a pressure resistance test method for a complete solar thermal system. For the purpose of this clause this method has to be applied on the store(s) and heat exchanger(s) principally.

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

6.1.7 Electrical safety

See EN 60335-1.

6.2 Materials

Check if the documentation for the installer includes information about the durability of the materials exposed to weathering with regard to UV radiation and other weather conditions.

Check if the materials used in the collector loop comply with ISO/TR 10217 concerning internal corrosion.

6.3 Components and pipework

6.3.1 Collector and collector array

The collector should be tested according to EN 12975-2.

The design of the collector array should be checked with regard to flow distribution.

6.3.2 Supporting frame

Check the calculation proving the resistance of the frame to snow and wind loads in accordance with EN 1991-1-3 and EN 1991-1-4 where applicable.

6.3.3 Collector and other loops

With regard to the collector loop check if the requirements listed in prCEN/TS 12977-5:2006, Table 10 are fulfilled.

6.3.4 Circulation pump

See EN 809, EN 1151-1 and prCEN/TS 12977-5.

6.3.5 Expansion vessels

For systems without a separate expansion vessel (e. g. drain-back systems) check both by calculation and the hydraulic scheme to see whether the integrated expansion facility is able to fulfil its task.

6.3.5.1 Open expansion vessels

Check the volume and design of the open expansion vessel by calculation and by checking the hydraulic scheme.

In addition, check the connection of the vessel to the atmosphere, the spill line and the expansion lines on the hydraulic scheme.

6.3.5.2 Closed expansion vessels

For small custom built systems only: Check the fulfilment of the requirements given in prCEN/TS 12977-1:2006, 6.3.5.2, by calculation and by visual check of the hydraulic scheme and operating instruction.

6.3.6 Heat exchangers

Apart from the tests in compliance with EN 307, check the design of the heat exchanger(s) with respect to scaling or the availability of cleaning facilities.

In addition, the drop in system efficiency $\Delta\eta$ induced by a heat exchanger in the collector loop of a small custom built system should be estimated by formula (1):

$$\Delta\eta = \frac{\eta_0 \; A_c \; a_1}{(UA)_{hx}} 100\ \% \qquad (1)$$

For small systems $(UA)_{hx}$ is delivered by the store performance test of prEN 12977-3 or prCEN/TS 12977-4 ($(UA)_{hx}$ to be chosen for store temperatures of 20 °C, an average temperature difference of 10 K and a flow rate similar to the one used for the determination of the collector parameters). For large systems $(UA)_{hx}$ is taken from the heat exchanger performance data sheet provided by the manufacturer.

NOTE 1 In the latter case, since performance data of external heat exchangers (which are mostly used in large custom built systems) are generally quite reliable, no additional measurements are needed.

For heat exchangers in other loops (e.g., a load side heat exchanger), the average temperature difference on the primary side $\Delta\vartheta$ which is induced by the presence of the heat exchanger should be estimated by calculation. The drop in efficiency may then be estimated by:

$$\Delta\eta = (a_1 \; \Delta\vartheta / G_{ref}) \; 100\ \% \qquad (2)$$

where the reference solar irradiance G_{ref} is set to 1000 W/m^2.

NOTE 2 More accurate calculation methods are given in [1]. In special cases the thermal stratification in the store should be taken into account, to obtain an accurate figure for the efficiency drop.

6.3.7 Store

For small custom built systems only

- the performance of their stores should be tested according to prEN 12977-3, in the case of a solar water heater, or prCEN/TS 12977-4, in the case of a solar combisystem;

- the heat loss rate of these hot water stores, obtained from performance tests according to prEN 12977-3 and prCEN/TS 12977-4, respectively, should be compared with the requirements given in prCEN/TS 12977-1:2006, clause 6.3.7.

6.3.8 Pipework

Check the design plan and system documentation in respect of design and material of pipes and fittings.

For the pipework in the collector loop check its compliance with ISO/TR 10217.

6.3.9 Thermal insulation

Check the design plans and system documentation.

6.3.10 Control equipment

See prCEN/TS 12977-5.

6.4 Safety equipment and indicators

6.4.1 Safety valves

Check the design plan and the system documentation to verify that each collector or each section of collector array which can be shut off is fitted with at least one suitable safety valve.

Check the specification of the safety valves, whether the materials fulfil the requirements given in prCEN/TS 12977-1:2006, clause 6.4.1.