

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

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 12977-2:2012 sisaldab Euroopa standardi EN 12977-2:2012 ingliskeelset teksti.	This Estonian standard EVS-EN 12977-2:2012 consists of the English text of the European standard EN 12977-2:2012.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 04.04.2012.	Date of Availability of the European standard is 04.04.2012.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 27.160

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:
Aru 10, 10317 Tallinn, Eesti; www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:
Aru 10, 10317 Tallinn, Estonia; www.evs.ee; phone 605 5050; e-mail info@evs.ee

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

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

This European Standard was approved by CEN on 19 February 2012.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists 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.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



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

Management Centre: Avenue Marnix 17, B-1000 Brussels

Contents

Page

Foreword.....	4
Introduction	5
1 Scope	8
2 Normative references	8
3 Terms and definitions	9
4 Symbols and abbreviations	10
5 System classification	12
6 Test methods.....	12
6.1 Introduction	12
6.2 General.....	12
6.3 Materials	13
6.4 Components and pipework.....	13
6.5 Safety equipment and indicators	15
6.6 Installation	16
6.7 Initial operation, inspection and commissioning	16
6.8 Documentation.....	17
6.9 System performance (for small systems only).....	17
6.10 Water wastage (for small systems only)	17
7 Optional performance test of small custom built solar heating systems.....	17
7.1 General.....	17
7.2 Test of the solar collector	18
7.3 Test of the water store(s)	18
7.4 Test of the control equipment	18
7.5 Determination of the hot water comfort	18
7.6 System simulation model	19
7.7 Long-term performance prediction.....	19
7.8 Presentation of performance indicators	25
8 Performance test report	26
Annex A (normative) Reference conditions for performance prediction	28
A.1 General.....	28
A.2 Pipe diameter and insulation thickness	30
A.3 Calculation of mains water temperature at reference location.....	30
A.4 Space heating load	31
Annex B (normative) Additional information regarding the calculation of the fractional energy savings.....	37
B.1 Definition of a conventional reference water heating system	37
B.2 Calculation of fractional energy savings for other conditions	37
Annex C (informative) Short-term system testing	39
C.1 General.....	39
C.2 Instrumentation, data acquisition and processing	39
C.3 Check of short-term system performance	41
C.4 Short-term test for long-term system performance prediction.....	44
Annex D (informative) Long-term monitoring	51
D.1 General.....	51
D.2 Evaluation chart	52

D.3	Monitoring equipment.....	52
D.4	Data analysis.....	52
Annex E (informative) Determination of water wastage.....		53
Bibliography.....		54

Figures

Figure 1	— Energy balance for one-store and two-store solar-plus-supplementary systems	21
Figure 2	— Comparison of the gross auxiliary energy demand of the solar heating system, Q_{aux} , to the gross energy demand of the conventional heating system, Q_{conv}	22
Figure 3	— Energy balance for solar only systems	24
Figure 4	— Energy balance for solar preheat systems	25
Figure C.1	— Principle of the short term system performance check: Check and intercomparison of useful energy gain	41
Figure C.2	— Principle of the short-term test and of the subsequent long term system performance prediction	45
Figure C.3	— Example of the predicted performance dependence on load level and irradiation for a solar domestic hot water heating system (see [8]).....	50

Tables

Table 1	— Division for factory made and custom built solar heating systems	6
Table 2	— Symbols, definition and unit (1 of 2)	10
Table 2	— Symbols, definition and unit (2 of 2)	11
Table 3	— Presentation of system performance indicators for solar-plus-supplementary systems	26
Table 4	— Presentation of system performance indicators for solar-only and solar preheat systems	26
Table A.1	— Reference conditions for performance presentation (1 of 2).....	28
Table A.1	— Reference conditions for performance presentation (2 of 2).....	29
Table A.2	— External pipe diameter and insulation thickness for forced-circulation systems	30
Table A.3	— Data for calculation of the mains water temperature at the reference locations	31
Table A.4	— Space heating load file for Stockholm.....	32
Table A.5	— Space heating load file for Davos	33
Table A.6	— Space heating load file for Würzburg (1 of 2)	34
Table A.6	— Space heating load file for Würzburg (2 of 2)	35
Table A.7	— Space heating load file for Athens – Example to be updated	36
Table C.1	— Variables to be measured and corresponding maximum sampling intervals.....	43
Table C.2	— Variables to be measured during system test, and corresponding maximum sampling intervals.....	46
Table C.3	— Range of variations of the driving variables to be scanned during a test outdoors.....	47
Table C.4	— Permissible standard deviation for secondary collector parameters	49

Foreword

This document (EN 12977-2:2012) 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 October 2012, and conflicting national standards shall be withdrawn at the latest by October 2012.

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 CEN/TS 12977-2:2010.

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

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, 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:

- 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.

- 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. 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 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:

- 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 and EN 12976-2)	Custom built solar heating systems (EN 12977-1, EN 12977-2, EN 12977-3, EN 12977-4 and EN 12977-5)
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 EN 12977-2:2012, 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 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 EN 12977-1.

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 m² to 30 000 m² 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 EN 12977-1.

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 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*

EN 12977-1:2012, *Thermal solar systems and components — Custom built systems — Part 1: General requirements for solar water heaters and combisystems*

EN 12977-3:2012, *Thermal solar systems and components — Custom built systems — Part 3: Performance test methods for solar water heater stores*

EN 12977-4:2012, *Thermal solar systems and components — Custom built systems — Part 4: Performance test methods for solar combistores*

EN 12977-5:2012, *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 (IEC 60335-1)*

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, *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, EN 12977-1:2012, EN 12977-3:2012, EN 12977-5:2012, ISO 9459-5:2007 and EN ISO 9488:1999 apply.