

**norm****NEN-EN 12977-3**

Thermische zonne-energiesystemen en componenten - Op maat gebouwde systemen - Deel 3: Prestatieproeven van opslagvaten voor thermische zonne-energiesystemen

Publicatie uitsluitend voor commentaar

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

juli 2017

ICS 27.160; 91.140.10; 91.140.65

Commentaar vóór 2017-08-28

Zal vervangen NEN-EN 12977-3:2012

Als Europees normontwerp is gepubliceerd: FprEN 12977-3:2017, IDT

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EUROPEAN STANDARD  
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EUROPÄISCHE NORM

**FINAL DRAFT**  
**FprEN 12977-3**

July 2017

ICS 27.160; 91.140.10; 91.140.65

Will supersede EN 12977-3:2012

English Version

## Thermal solar systems and components - Custom built systems - Part 3: Performance test methods for solar water heater stores

Installations solaires thermiques et leurs composants - Installations assemblées à façon - Partie 3 : Méthodes d'essai des performances des dispositifs de stockage des installations de chauffage solaire de l'eau

Thermische Solaranlagen und ihre Bauteile - Kundenspezifisch gefertigte Anlagen - Teil 3: Leistungsprüfung von Warmwasserspeichern für Solaranlagen

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Orbis  
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## European foreword

This document (FprEN 12977-3:2017) 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 12977-3:2012.

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

The test methods for stores of solar heating systems as described in this European Standard are required for the determination of the thermal performance of small custom built systems as specified in FprEN 12977-1:2017.

The test method described in this European Standard delivers a complete set of parameters, which are needed for the simulation of the thermal behaviour of a store being part of a small custom built thermal solar system.

For the determination of store parameters such as the thermal capacity and the heat loss rate, the method standardized in EN 12897 can be used as an alternative.

NOTE 1 The already existing test methods for stores of conventional heating systems are not sufficient with regard to thermal solar systems. This is due to the fact that the performance of thermal solar systems depends much more on the thermal behaviour of the store (e.g. stratification, heat losses), than conventional systems do. Hence, this separate document for the performance characterization of stores for solar heating systems is needed.

NOTE 2 For additional information about the test methods for the performance characterization of stores, see [1] in Bibliography.

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**FprEN 12977-3:2017 (E)****1 Scope**

This European Standard specifies test methods for the performance characterization of stores which are intended for use in small custom built systems as specified in FprEN 12977-1:2017.

Stores tested according to this document are commonly used in solar hot water systems. However, the thermal performance of all other thermal stores with water as a storage medium can also be assessed according to the test methods specified in this document.

The document applies to stores with a nominal volume between 50 l and 3 000 l.

This document does not apply to combistores. Performance test methods for solar combistores are specified in FprEN 12977-4:2017.

**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 12828, *Heating systems in buildings — Design for water-based heating systems*

EN 12897, *Water supply - Specification for indirectly heated unvented (closed) storage water heaters*

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

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

**3 Terms and definitions**

For the purposes of this document, the terms and definitions given in EN ISO 9488:1999 and the following apply.

**3.1****ambient temperature**

mean value of the temperature of the air surrounding the store

**3.2****charge**

process of transferring energy into the store by means of a heat source

**3.3****charge connection**

pipe connection used for charging the storage device

**3.4****combistore**

one store used for both domestic hot water preparation and space heating



### 3.5 conditioning

process of creating a uniform temperature inside the store by discharging the store with  $\tilde{g}_{D,i} = 20\text{ °C}$  until a steady state is reached

Note 1 to entry: The conditioning at the beginning of a test sequence is intended to provide a well-defined initial system state, i.e. a uniform temperature in the entire store.

### 3.6 constant charge power

charge power which is achieved when the mean value  $\tilde{P}_c$  over the period of 0,5 reduced charge volumes is within  $P_c \pm \tilde{P}_c \times 0,1$

Note 1 to entry: The symbol "˜" above a certain value indicates that the corresponding value is a mean value.

### 3.7 constant inlet temperature

temperature which is achieved during charge ( $x = C$ ) or discharge ( $x = D$ ), if the mean value  $\tilde{g}_{x,i}$  over the period of 0,5 "reduced charge/discharge volume" (see 3.34) is within  $(\tilde{g}_{x,i} \pm 1)\text{ °C}$

Note 1 to entry: The symbol "˜" above a certain value indicates that the corresponding value is a mean value.

### 3.8 constant flow rate

flow rate which is achieved when the mean value of  $\tilde{V}$  over the period of 0,5 "reduced charge/discharge volumes" (see 3.34) is within  $V \pm \tilde{V} \times 0,1$

Note 1 to entry: The symbol "˜" above a certain value indicates that the corresponding value is a mean value.

### 3.9 dead volume/dead capacity

volume/capacity of the store which is only heated due to heat conduction (e.g. below a heat exchanger)

### 3.10 direct charge/discharge

transfer or removal of thermal energy in or out of the store, by directly exchanging the fluid in the store

### 3.11 discharge

process of decreasing thermal energy inside the store caused by the hot water load

### 3.12 discharge connection

pipe connection used for discharging the storage device

**FprEN 12977-3:2017 (E)****3.13****double port**

corresponding pair of inlet and outlet connections for direct charge/discharge of the store

Note 1 to entry: Often, the store is charged or discharged via closed or open loops that are connected to the store through double ports.

**3.14****effective volume/effective capacity**

volume/capacity which is involved in the heat storing process if the store is operated in a usual way

**3.15****electrical (auxiliary) heating**

electrical heating element immersed into the store

**3.16****external auxiliary heating**

auxiliary heating device located outside the store. The heat is transferred to the store by direct or indirect charging via a charge loop. The external auxiliary heating is not considered as part of the store under test

**3.17****heat loss capacity rate**

$(UA)_{s,a}$

overall heat loss of the entire store during stand-by per K of the temperature difference between the medium store temperature and the ambient air temperature

**3.18****heat transfer capacity rate**

thermal power transferred per K of the temperature difference

**3.19****immersed heat exchanger**

heat exchanger which is completely surrounded with the fluid in the store

**3.20****indirect charge/discharge**

transfer or removal of thermal energy into or out of the store, via a heat exchanger

**3.21****load**

heat output of the store during discharge. The load is defined as the product of the mass, specific thermal capacity and temperature increase of the water as it passes the solar hot water system

**3.22****mantle heat exchanger**

heat exchanger mounted to the store in such a way that it forms a layer between the fluid in the store and ambient

**3.23****measured energy** $Q_{x,m}$ 

time integral of the measured power over one or more test sequences, excluding time periods used for conditioning at the beginning of the test sequences

**3.24****measured power** $P_{x,m}$ 

power calculated from measured volume flow rate as well as measured inlet and outlet temperatures

**3.25****measured store heat capacity**

measured difference in energy of the store between two steady states on different temperature levels, divided by the temperature difference between these two steady states

**3.26****mixed**

state when the local store temperature is not a function of the vertical store height

**3.27****model parameter**

parameter used for quantification of a physical effect, if this physical effect is implemented in a mathematical model in a way which is not analogous to its appearance in reality, or if several physical effects are lumped in the model (e.g. a stratification number)

**3.28****nominal flow rate** $\dot{V}_n$ 

nominal volume of the entire store divided by 1 h

**3.29****nominal heating power** $P_n$ 

nominal volume of the entire store multiplied by 10 W/l

**3.30****nominal volume** $V_n$ 

fluid volume of the store; determined as described in formula (E.2)

**3.31****predicted energy** $Q_{xp}$ 

time integral of the predicted power over one or more test sequences, excluding time periods used for conditioning at the beginning of the test sequences

**FprEN 12977-3:2017 (E)****3.32****predicted power** **$P_{xp}$** 

power calculated from measured volume flow rate, as well as measured inlet temperature and calculated outlet temperature

Note 1 to entry: The outlet temperature is predicted by numerical simulation.

**3.33****reduced charge/discharge volume**

integral of a charge/discharge flow rate divided by the store volume

**3.34****stand-by**

state of operation in which no energy is deliberately transferred to or removed from the store

**3.35****stand-by heat loss capacity rate** **$(UA)_{sb,s,a}$** 

heat loss capacity rate of the store during stand-by

**3.36****steady state**

state of operation at which at charge or discharge during 0,5 “reduced charge/discharge volume” (see 3.34) the standard deviation of the temperature difference between store inlet and store outlet temperatures of the charging/discharging circuit is lower than 0,1 K

Note 1 to entry: In cases of an isothermal charged store, constant temperature differences between the inlet and outlet temperatures of the discharge circuit may occur during the discharge of the first store volume before the outlet temperature drops rapidly. This state is not considered as steady-state.

**3.37****store temperature**

temperature of the store medium

**3.38****stratified**

state when thermal stratification is present inside the store

**3.39****stratified charging**

increase of thermal stratification in the store during charging

**3.40****stratifier**

device that enables stratified charging of the store. Commonly used stratifiers are e.g. convection chimneys or pipes with radial holes

**3.41****theoretical store heat capacity**

sum over all thermal capacities  $m_i \times c_{p,i}$  of the entire store (fluid, store material, heat exchangers) having part of the heat store process

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