SLOVENSKI STANDARD
SIST ENV 12977-3:2002

01-november-2002

Toplotni sončni sistemi in sestavni deli - Neserijsko izdelani sistemi - 3. del: Določanje značilnosti hranilnikov toplote za sisteme ogrevanja s soncem

Thermal solar systems and components - Custom built systems - Part 3: Performance characterisation of stores for solar heating systems

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

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Installations solaires thermiques et leur composants - Installations assemblées a façon - Partie 3: Caractérisation des performances des dispositifs de stockage pour des installations de chauffage solaire

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Ta slovenski standard je istoveten z: ENV 12977-3:2001

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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2003-01.Slovenski inštitut za standardizacijo. Razmnoževanje celote ali delov tega standarda ni dovoljeno.

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EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

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ICS 27.160; 91.140.10; 91.140.65

English version

Thermal solar systems and components - Custom built systems - Part 3: Performance characterisation of stores for solar heating systems

Installations solaires thermiques et leur composants - Installations assemblées à façon - Partie 3: Caractérisation des performances des dispositifs de stockage pour des installations de chauffage solaire

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This European Prestandard has been prepared by Technical Committee CEN/TC 312 "Thermal solar systems and components", the secretariat of which is held by ELOT.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

The annexes A, B and C are normative.

Introduction

The test methods for stores of solar heating systems as described in this Prestandard are required for the determination of the thermal performance of small custom built systems as specified in ENV 12977-1.

These test methods deliver parameters, which are needed for the simulation of the thermal behaviour of a store being part of a small custom built system.

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

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NOTE 2 With the test methods for stores given in prEN 12897:1997 only a few parameters are determined in order to characterise the thermal behaviour of a store. These few parameters are not sufficient for the determination of the thermal performance of small custom built systems as described in ENV 12977-2.

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), as conventional systems do. Hence this separate Prestandard for the performance characterisation of stores for solar heating systems is needed.

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1 Scope

This Prestandard specifies test methods for the performance characterization of stores which are intended for use in small custom built systems as specified in ENV 12977-1.

Stores tested according to this Prestandard are commonly used in solar hot water systems. However, also the thermal performance of all other thermal stores with water as storage medium (e.g. for heat pump systems) can be assessed according to this Prestandard.

The Prestandard applies to stores with a nominal volume between 50 and 3000 litres and without integrated oil or gas burner.

2 Normative references

This European Prestandard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

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EN 12976-2:2000	Thermal solar systems and components - Factory made systems - Test Methods
ENV 12977-2:2001	Thermal Solar Systems and Components – Custom Built Systems – Test Methods
prEN 12828:1997	Heating systems in buildings – Design and installation of water heating systems
prEN 12897:1997	Water supply – Specification for indirectly heated unvented (closed) hot water storage systems
EN ISO 9488	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

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3 Terms and definitions

For the purposes of this European Prestandard the following terms and definitions together with EN ISO 9488 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 an heat source

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3.3
charge connection
pipe connection used for charging the storage device

3.4
combistore
store used for both domestic hot water preparation and space heating

3.5
constant inlet temperature ($\tilde{\vartheta}_{x,i}$)
temperature which is achieved during charge (x=C) or discharge (x=D), if the mean value $\tilde{\vartheta}_{x,i}$ over the period of 0,5 reduced charge / discharge volumes (see 3.34) is within ($\tilde{\vartheta}_{x,i} \pm 1$) ºC

3.6
constant flow rate ($\tilde{\dot{V}}$)
flow rate which is achieved, when the mean value $\tilde{\dot{V}}$ over the period of 0,5 reduced charge / discharge volumes (see 3.34) is within $\tilde{\dot{V}} \pm 10$ %

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3.7
constant charge power ($\tilde{P}_c$)
charge power which is achieved, when the mean value $\bar{P}_c$ over the period of 0,5 reduced charge volumes is within $\tilde{P}_c \pm 10$ %

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3.8
conditioning
process of creating a uniform temperature inside the store by discharging the store with $\tilde{\vartheta}_{D,i}$ = 20 ºC until a steady state is reached

NOTE The conditioning at the beginning of a test sequence is intended to provide a well defined initial system state, i. e. an uniform temperature in the entire store.

3.9
discharge connection
pipe connection used for discharging the storage device

3.10
dead volume / dead capacity
the volume / capacity of the store which is only heated due to heat conduction (e. g. below a heat exchanger)

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3.11
direct charge / discharge
transfer or removal of thermal energy in or out of the store, by directly exchanging the fluid in the store

3.12
discharge
process of decreasing thermal energy inside the store caused by the hot water load

3.13
double port
a corresponding pair of inlet and outlet connections for direct charge / discharge of the store

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

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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 $(UA)_{s,a}$
the overall heat loss of the entire storage device per K temperature difference between the store temperature and the ambient air temperature

NOTE The heat loss capacity rate depends on the flow conditions inside the store. Hence a stand-by heat loss capacity rate and a operating heat loss capacity rate are defined. If $(UA)_{s,a}$ is mentioned without specification, $(UA)_{s,a}$ represents the stand-by heat loss capacity rate.

3.18
heat transfer capacity rate
the thermal power transferred per K temperature difference

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3.19
immersed heat exchanger
heat exchanger which is completely surrounded with the fluid in the store tank

3.20
indirect charge / discharge
transfer or removal of thermal energy into or out of the store, via a heat exchanger

3.21
load
the 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 a way, that it forms a layer between the fluid in the store tank and ambient

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3.23
measured store heat capacity
the measured difference in energy of the store between two steady states on different temperature levels, divided by the temperature difference between this two steady states

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3.24
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

3.25
measured power ($P_{x,m}$)
power calculated from measured volume flow rate as well as measured inlet and outlet temperature

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

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appearance in reality, or if several physical effects are lumped in the model (e. g. a stratification number)

3.28
nominal flow rate ($\dot{v}_n$)
the nominal volume of the entire store divided by 1 h

3.29
nominal heating power (P_n)
the nominal volume of the entire store multiplied by 10 W/l

3.30
nominal volume (V_n)
fluid volume of the store as specified by the manufacturer

3.31
operating heat loss capacity rate $(UA)_{op,s,a}$
heat loss capacity rate of the store during charge or discharge

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3.32
predicted energy ($Q_{x,p}$)
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

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3.33
predicted power ($P_{x,p}$)
power calculated from measured volume flow rate, as well as measured inlet temperature and calculated outlet temperature. The outlet temperature is predicted by numerical simulation

3.34
reduced charge / discharge volume
integral of a charge / discharge flow rate divided by the store volume

3.35
stand-by
state of operation in which no energy is deliberately transferred to or removed from the store

3.36
stand-by heat loss capacity rate $(UA)_{sb,s,a}$
heat loss capacity rate of the store during stand-by

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3.37
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 temperature of the charging / discharging circuit is lower than 0,05 K

NOTE In cases of an isothermal charged store rather constant temperature differences between the inlet and outlet temperature of the discharge circuit may occur during the discharge of the first store volume before the outlet temperature drops rapidly. These state is not considered as steady state.

3.38
store temperature
temperature of the store medium

3.39
stratified
state when thermal stratification is inside the store

3.40
stratified charging
increase of thermal stratification in the store during charging

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3.41
stratifier
device that enables stratified charging of the store. Common used stratifiers are e.g. convection chimneys or pipes with radial holes

3.42
theoretical store heat capacity
the sum over all thermal capacities $m_i \times c_{p,i}$ of the entire store (fluid, tank material, heat exchangers) having part of the heat store process

3.43
thermal stratification
state when the local store temperature is a function of the vertical store height, with the temperature decreasing from top to bottom

3.44
transfer time ($t_{x,f}$)
time period during which energy is transferred through the connections for charge (x=C) or discharge (x=D). The transfer time is calculated over one or more test sequences, excluding time periods used for conditioning at the beginning of the test sequences

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4 Symbols and abbreviations

C_s	thermal capacity of the entire store, in J/K
c_p	specific heat capacity, in J/(kg K)
P_n	nominal heating power, in W
$P_{x,m}$	measured power transferred through the charge (x=C) or discharge (x=D) circuit, in W
$P_{x,p}$	predicted power transferred through the charge (x=C) or discharge (x=D) circuit, in W
$Q_{x,m}$	measured energy transferred through the charge (x=C) or discharge (x=D) circuit, in J
$Q_{x,p}$	predicted energy transferred through the charge (x=C) or discharge (x=D) circuit, in J
t_{st}	time required to achieve a steady state, in s
$t_{x,f}$	transfer time for charging (x=C) or discharging (x=D) , in s
ϑ_a	ambient temperature, in °C
ϑ_s	store temperature, in °C
$\tilde{\vartheta}_{x,i}$	inlet temperature of the charge (x=C) or discharge (x=D) circuit, in °C
$\vartheta_{x,i}$	constant inlet temperature of the charge (x=C) or discharge (x=D) circuit, in °C
$\vartheta_{x,o}$	outlet temperature of the charge (x=C) or discharge (x=D) circuit, in °C
$(UA)_{hx,s}$	heat transfer capacity rate between heat exchanger and store, in W/K
$(UA)_{s,a}$	heat loss capacity rate of the store, in W/K
$(UA)_{op,s,a}$	operating heat loss capacity rate of the store, in W/K
$(UA)_{sb,s,a}$	stand-by heat loss capacity rate of the store, in W/K
V_n	nominal volume of the store, in l
$\dot{V}_n$	nominal flow rate, in l/h
$\tilde{\dot{V}}_x$	constant flow rate of the charge (x=C) or discharge (x=D) circuit, in l/h
$\Delta\vartheta_m$	mean logarithmic temperature difference, in K
$\varepsilon_{x,P}$	relative error in mean power transferred during charge (x=C) or discharge (x=D), in %
$\varepsilon_{x,Q}$	relative error in energy transferred during charge (x=C) or discharge (x=D), in %
ρ	density, in kg/m^3

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5 Store classification

Hot water stores are classified by distinction between different charge and discharge modes. Five groups are defined as shown in Table 1.

Table 1 - Classification of the stores

Group	charge mode	discharge mode
1	direct	direct
2	indirect	direct
3	direct	indirect
4	indirect	indirect
5	stores that cannot be assigned to groups 1 to 4	

NOTE 1 All stores may have one or more additional electrical heating elements.

NOTE 2 Stores that can be charged or discharged directly and indirectly (e. g. a store of a space heating system with an internal heat exchanger for the preparation of domestic hot water) can belong to more than one group. In this case the appropriate test procedures or the assignment to one of the groups respectively, shall be chosen depending on its mode of operation.

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6 Laboratory store testing

6.1 Requirements on the testing stand

6.1.1 General

The hot water store shall be tested separately from the whole solar system on a store testing stand.

The testing stand configuration shall be determined by the classification of hot water stores as described in clause 5.

An example of a representative hydraulic testing stand configuration is shown in Figure 1 and Figure 2.

The circuits are intended to simulate the charge and discharge loop of the solar system and to provide fluid flow with a constant or well controlled temperature. The full test stand consists of one charge and one discharge circuit.

NOTE 1 If the store consists of more than one charge or discharge devices (e.g. two heat exchangers), then these are tested separately.

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The testing stand shall be located in an air-conditioned room where the room temperature of 20 ºC should not vary more than ±1 K during the test.

Both circuits shall fulfil the following requirements:

- The flow rate shall be adjustable between 0,05 m^3/h and 3 m^3/h, by deviation < 2 %.
- The working temperature range shall be between 10 °C and 90 °C.
- The minimum heating power of the charge circuit shall be 15 kW.
- The minimum cooling power in the discharge circuit shall be 5 kW at a fluid temperature of 20 °C.

NOTE 2 If mains water at a constant pressure and a constant temperature below 20 °C is available, it is recommended to design the discharge circuit in a way, that it can be operated as closed loop or as open loop using mains water to discharge the store.

- The minimum heating power of the discharge circuit shall be 5 kW.
- The control deviation of the store inlet temperature shall be less than 0,05 K.
- The minimum heating up rate of the charge circuit with disconnected store shall be 3 K/min.
- The minimum available electrical heating power for electrical auxiliary heaters shall be 6,0 kW.

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NOTE 3 The electrical power of the pump (P102) shall be chosen in such a way that the temperature increase induced by the pump (P102) is less than 0,6 K/h when the charge circuit is "short circuited" and operated at room temperature. ("short circuited" means that no storage device is connected and SV102, V113, V115 and V116 are closed, see Figure 1).

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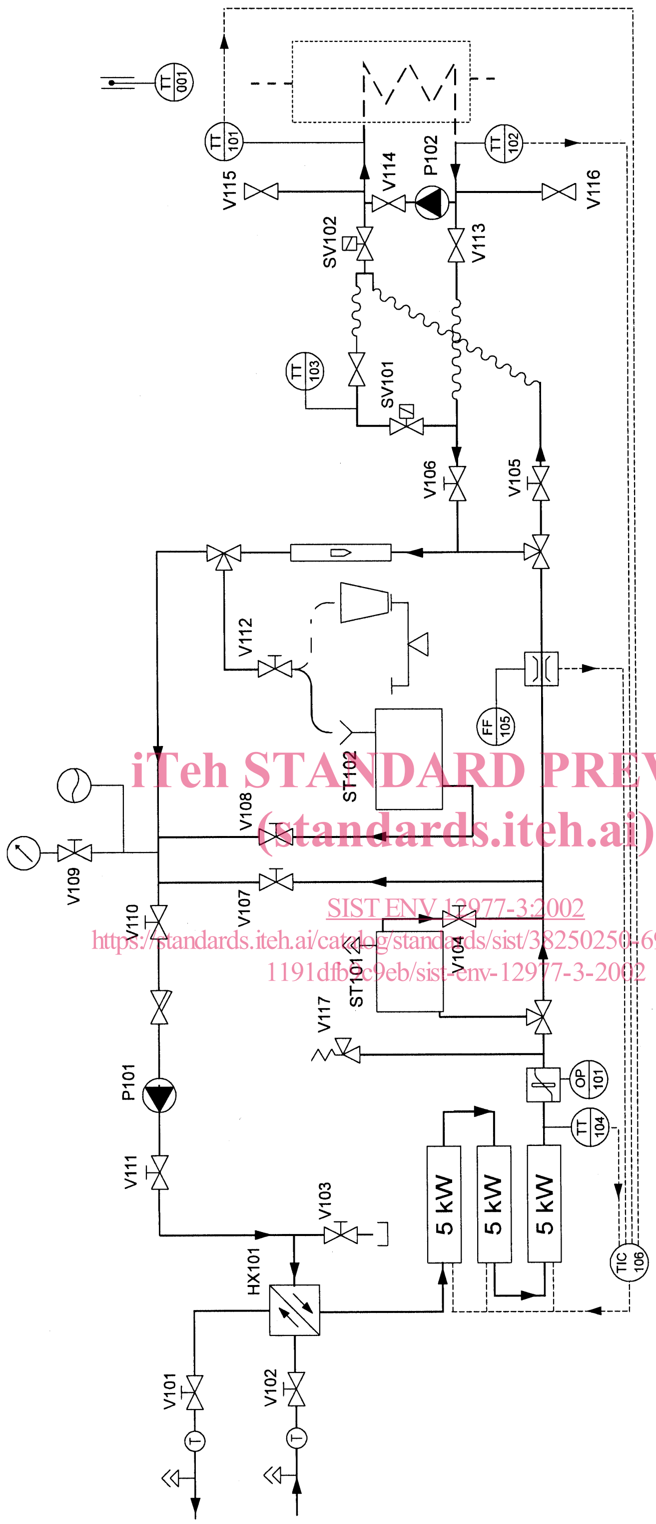

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Key

FF Flow meter
HX Heat exchanger
OP Overheating protection
P Pump
ST Store
SV Solenoid valve
TT Temperature sensor
TIC Temperature indicator and controller
V Valve

Figure 1 - Charge circuit of the store testing stand