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Thermal solar systems and components - Solar collectors - Part 2: Test methods

Thermische Solaranlangen und ihre Bauteile - Kollektoren - Teil 2: Prüfverfahren

Installations solaires thermiques et leurs composants - Capteurs solaires - Partie 2 : Méthode d'essai

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Thermische Solaranlangen und ihre Bauteile - Kollektoren - Teil 2: Prüfverfahren

This European Standard was approved by CEN on 6 February 2006.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This European Standard (EN 12975-2:2006) 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of an identical text or by endorsement, at the latest by September 2006, and conflicting national standards shall be withdrawn at the latest by September 2006.

This European Standard supersedes EN 12975-2:2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, 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 and United Kingdom.

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Introduction

This standard specifies test methods for determining the ability of a liquid heating solar collector to resist the influence of degrading agents. It defines procedures for testing collectors under well-defined and repeatable conditions.

This standard also provides test methods and calculation procedures for determining the steady-state and quasi-dynamic thermal performance of glazed liquid heating solar collectors. It contains methods for conducting tests outdoors under natural solar irradiance and natural and simulated wind and for conducting tests indoors under simulated solar irradiance and wind.

This standard also provides methods for determining the thermal performance of unglazed liquid heating solar collectors. Unglazed collectors are in most cases used for heating swimming pools or other low temperature consumers. In general the collectors are put together on-site, connecting absorber strips with manifolds. Real absorber areas are mostly between ten to one hundred square meters. For unglazed absorbers, readily fabricated modules with a specific size are seldom used. Therefore, during the test, it should be checked that a realistic flow pattern and flow velocity is used.

This standard also provides test methods and calculation procedures for determining the steady-state as well as the all-day thermal performance parameters for liquid heating solar collectors, under changing weather conditions. It contains methods for conducting tests outdoors during whole days and under stationary inlet temperature conditions and natural solar irradiance and natural and/or simulated wind conditions. Important effects for the all-day performance of the collector, as the dependence on incident angle, wind speed, diffuse fraction of solar irradiance, thermal sky radiation and thermal capacity are taken into account. Dependence on flowrate is not included in this standard.

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Some of the advantages of the proposed extension of the present steady-state test methods of all-day testing are:

- shorter and less expensive outdoor test, suitable for European climate conditions.
- much wider range of collectors can be tested with the same method.
- at the same time, a much more complete characterisation of the collector is achieved.
- collector model is still directly compatible with that of the present basic test standards, and only correction terms are applied in this extended approach.
- all additions are based on long agreed collector theory.
- at any time, full backwards comparability to steady-state can be established by evaluating only periods of the test days that correspond to steady-state test requirements.

- same test equipment can be used as for stationary testing with only minor changes, which will also improve the accuracy of steady-state testing.
- commonly available standard PC software can be used for the parameter identification, such as spreadsheets or more advanced statistical packages that have Multiple Linear Regression (MLR) as an option.

SIST EN 12975-2:2006

1 Scope

This European Standard specifies test methods for validating the durability, reliability and safety requirements for liquid heating collectors as specified in EN 12975-1. This standard also includes three test methods for the thermal performance characterisation for liquid heating collectors.

It is not applicable to those collectors in which the thermal storage unit is an integral part of the collector to such an extent that the collection process cannot be separated from the storage process for the purpose of making measurements of these two processes.

It is basically applicable to tracking concentrating collectors, thermal performance testing as given in 6.3 (quasi dynamic testing) is also applicable to most concentrating collector designs, from stationary non-imaging concentrators as CPCs to high concentrating tracking designs. Parts of the solar radiation measurement should be adjusted in case of a tracking collector and in case a pyrheliometer is used to measure beam radiation.

Collectors that are custom built (built in; e.g. roof integrated collectors that do not compose of factory made modules and are assembled directly on the place of installation) cannot be tested in their actual form for durability, reliability and thermal performance according to this standard. Instead, a module with the same structure as the ready collector may be tested. The module gross area should be at least 2 m^2. The test is valid only for larger collectors than the tested module.

2 Normative references

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The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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EN 1991 (all parts), *Eurocode 1: Actions on structures*

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

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

ISO 9060, *Solar energy – Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN ISO 9488 apply.

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4 Symbols and units

a_1	heat loss coefficient at $(T_m - T_a)=0$	$Wm^{-2}K^{-1}$
a_2	temperature dependence of the heat loss coefficient	$Wm^{-2}K^{-2}$
A_A	absorber area of collector	m^2
A_a	aperture area of collector	m^2
A_G	gross area of collector	m^2
AM	optical air mass	
b_u	collector efficiency coefficient (wind dependence)	m^{-1} s
b_o	constant for the calculation of the incident angle modifier	
b_1	heat loss coefficient at $(T_m - T_a)=0$	$Wm^{-2}K^{-1}$
b_2	collector efficiency coefficient	$Wsm^{-3}K^{-1}$
c_1	heat loss coefficient at $(T_m - T_a)=0$	$Wm^{-2}K^{-1}$
c_2	temperature dependence of the heat loss coefficient	$Wm^{-2}K^{-2}$
c_3	wind speed dependence of the heat loss coefficient	$Jm^{-3}K^{-1}$
c_4	sky temperature dependence of the heat loss coefficient	$Wm^{-2}K^{-1}$
c_5	effective thermal capacity	$J\ m^{-2}K^{-1}$
c_6	wind dependence in the zero loss efficiency	sm^{-1}
c_f	specific heat capacity of heat transfer fluid	$Jkg^{-1}K^{-1}$
C	effective thermal capacity of collector	JK^{-1}
D	date	YYMMDD
E_L	longwave irradiance (λ >3μm)	Wm^{-2}
E_β	longwave irradiance on an inclined surface outdoors	Wm^{-2}
E_s	longwave irradiance	Wm^{-2}
F	radiation view factor	
F'	collector efficiency factor	
G	hemispherical solar irradiance	Wm^{-2}
G^*	global hemispherical solar irradiance	Wm^{-2}
G''	net irradiance	Wm^{-2}
G_b	direct solar irradiance (beam irradiance)	Wm^{-2}

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G_d	diffuse solar irradiance	Wm^{-2}
LT	local time	h
K_θ	incidence angle modifier	
$K_{\theta b}$	incidence angle modifier for direct radiation	
$K_{\theta d}$	incidence angle modifier for diffuse radiation	
m	thermally active mass of the collector	kg
$\dot{m}$	mass flowrate of heat transfer fluid	kgs^{-1}
$\dot{Q}$	useful power extracted from collector	W
$\dot{Q}_L$	power loss of collector	W
SF	safety factor	
t	time	s
t_a	ambient or surrounding air temperature	°C
t_{dp}	atmospheric dew point temperature	°C
t_e	collector outlet (exit) temperature	°C
t_{in}	collector inlet temperature	°C
t_m	mean temperature of heat transfer fluid	°C
t_s	atmospheric or sky temperature	°C
t_{stg}	stagnation temperature	°C
T	absolute temperature	K
T_a	ambient or surrounding air temperature	°C
T^*_m	reduced temperature difference (= $(t_m - t_a)/G^*$)	m^2KW^{-1}
T_s	atmospheric or equivalent sky radiation temperature	K
U	measured overall heat loss coefficient of collector, with reference to T^*_m	$Wm^{-2}K^{-1}$
U_L	overall heat loss coefficient of a collector with uniform absorber temperature t_m	$Wm^{-2}K^{-1}$
u	surrounding air speed	ms^{-1}

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V_f	fluid capacity of the collector	m^3
Δp	pressure difference between fluid inlet and outlet	Pa
Δt	time interval	s
ΔT	temperature difference between fluid outlet and inlet (t_e - t_{in})	K
α	solar absorptance	
β	tilt angle of a plane with respect to horizontal	degrees
γ	azimuth angle	degrees
ε	hemispherical emittance	
ω	solar hour angle	degrees
θ	angle of incidence	degrees
Φ	latitude	degrees
λ	wavelength	µm
η	collector efficiency, with reference to T^*_m	
η_o	zero-loss collector efficiency (η at T^*_m = 0), reference to T^*_m	
σ	Stefan-Boltzmann constant	$Wm^{-2}K^{-4}$
ρ	density of heat transfer fluid	kgm^{-3}
τ_c	collector time constant	s
τ	transmittance	
$(\tau\alpha)_e$	effective transmittance-absorptance product	
$(\tau\alpha)_{ed}$	effective transmittance-absorptance product for diffuse solar irradiance	
$(\tau\alpha)_{en}$	effective transmittance-absorptance product for direct solar radiation at normal incidence	
$(\tau\alpha)_{e\theta}$	effective transmittance-absorptance product for direct solar radiation at angle of incidence θ	

NOTE 1 In the field of solar energy the symbol G is used to denote solar irradiance, rather than the generic symbol E for irradiance.

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NOTE 2 *C* is often denoted $(mC)_e$ in basic literature (see also Annex F)

NOTE 3 For more information about thermal performance coefficients (parameters) c1 to c6, see Annex F.

5 Reliability testing of liquid heating collectors

5.1 General

The details regarding the number of collectors and sequences used to carry out the qualifications tests detailed in the list below (Table 1) shall be given in the report.

For some qualification tests, a part of the collector may have to be tampered with in some way, for example a hole may have to be drilled in the back of the collector to attach a temperature sensor to the absorber. In these cases care should be taken to ensure that any damage caused does not affect the results of subsequent qualification tests, for example by allowing water to enter into a previously raintight collector.

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Table 1 - Test List

Subclause	Test
5.2	Internal pressure
5.3	High-temperature resistance [a, b]
5.4	Exposure [b]
5.5	External thermal shock [c]
5.6	Internal thermal shock [c]
5.7	Rain penetration [d]
5.8	Freeze resistance [e]
5.9	Mechanical load
5.10	Impact resistance (optional test)
6.1-6.2-6.3	Thermal performance [f]

[a] For organic absorbers, the high-temperature resistance test shall be performed first in order to determine the collector stagnation temperature needed for the internal pressure test.

[b] The high temperature and exposure test shall be carried out on the same collector

[c] The external and internal thermal shock tests may be combined with the exposure test or the high-temperature resistance test.

[d] The rain penetration test shall be carried out only for glazed collectors.

[e] The freeze resistance test shall be carried out only for collectors claimed to be freeze resistant.

[f] The Thermal performance test shall be carried out on a collector that had not been used for other tests.

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NOTE Regarding the durability and reliability of elastic materials it is recommended to refer to ISO 9808 and ISO 9553.

5.2 Internal pressure tests for absorbers

5.2.1 Inorganic absorbers

5.2.1.1 Objective

The absorber shall be pressure-tested to assess the extent to which it can withstand the pressures which it might meet in service.