
**Solar energy — Solar thermal
collectors — Test methods**

Énergie solaire — Capteurs thermiques solaires — Méthodes d'essai

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[ISO 9806:2013](https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013)

[https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-
b36f5d90e35/iso-9806-2013](https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013)



iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 9806:2013

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2013

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

	Page
Foreword	vi
Introduction	vii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols and abbreviated terms	3
5 General	8
5.1 Test overview - Sequence of the tests.....	8
5.2 Particular aspects of collectors using external power sources and active or passive measures for normal operation and self-protection.....	9
6 Internal pressure tests for fluid channels	10
6.1 Inorganic fluid channels.....	10
6.2 Fluid channels made of organic materials (plastics or elastomers).....	10
6.3 Apparatus and procedure.....	10
6.4 Results.....	11
7 Leakage test (closed loop air heating collectors only)	11
7.1 Objective.....	11
7.2 Apparatus and procedure.....	11
7.3 Test conditions.....	12
7.4 Results.....	12
8 Rupture or collapse test (air heating collectors only)	12
8.1 Objective.....	12
8.2 Apparatus and Procedure.....	13
8.3 Test conditions.....	14
8.4 Results and reporting.....	14
9 High-temperature resistance test	14
9.1 Objective.....	14
9.2 Apparatus and procedure.....	14
9.3 Test conditions.....	15
9.4 Results.....	15
10 Standard stagnation temperature of liquid heating collectors	16
10.1 General.....	16
10.2 Measurement and extrapolation of standard stagnation temperature.....	16
10.3 Determining standard stagnation temperature using efficiency parameters.....	17
10.4 Results.....	17
11 Exposure and pre-exposure test	18
11.1 Objective.....	18
11.2 Apparatus and procedure.....	18
11.3 Test conditions.....	18
11.4 Results.....	19
12 External thermal shock test	19
12.1 Objective.....	19
12.2 Apparatus and procedure.....	19
12.3 Test conditions.....	20
12.4 Results.....	20
13 Internal thermal shock test	20
13.1 Objective.....	20
13.2 Apparatus and procedure.....	20
13.3 Test conditions.....	21

13.4	Results.....	21
14	Rain penetration test.....	21
14.1	Objective.....	21
14.2	Apparatus and procedure.....	21
14.3	Test conditions.....	22
14.4	Results.....	24
15	Freeze resistance test.....	24
15.1	Objective.....	24
15.2	Apparatus and procedure.....	24
15.3	Test conditions.....	25
15.4	Results.....	25
16	Mechanical load test with positive or negative pressure.....	25
16.1	Objectives.....	25
16.2	Apparatus and procedure.....	25
16.3	Test conditions.....	26
16.4	Results.....	26
17	Impact resistance test.....	26
17.1	Objective.....	26
17.2	Test procedure.....	27
17.3	Impact location.....	27
17.4	Method 1: Impact resistance test using ice balls.....	27
17.5	Method 2: Impact resistance test using steel balls.....	28
17.6	Results.....	28
18	Final inspection (related to Clauses 5 to 17).....	29
19	Test report (related to Clauses 5 to 18).....	29
20	Performance testing of fluid heating collectors.....	29
20.1	General.....	29
20.2	Steady-state efficiency test using a solar irradiance simulator.....	30
21	Collector mounting and location.....	31
21.1	General.....	31
21.2	Collector frame.....	31
21.3	Tilt angle.....	32
21.4	Collector orientation outdoors.....	32
21.5	Shading from direct solar irradiance.....	32
21.6	Diffuse and reflected solar irradiance.....	33
21.7	Thermal irradiance.....	33
21.8	Surrounding air speed.....	33
22	Instrumentation.....	34
22.1	Solar radiation measurement.....	34
22.2	Thermal radiation measurement.....	35
22.3	Temperature measurements.....	37
22.4	Flow rate measurement.....	39
22.5	Surrounding air speed measurement.....	40
22.6	Elapsed time measurement.....	41
22.7	Pressure measurement.....	41
22.8	Humidity measurement.....	42
22.9	Collector gross area.....	42
22.10	Collector fluid capacity.....	42
23	Test installation.....	42
23.1	Liquid heating collectors.....	42
23.2	Air heating collectors.....	46
24	Performance test procedures.....	48
24.1	General.....	48

iTech STANDARD PREVIEW
(standards.itech.ai)

ISO 9806:2013

<https://standards.itech.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892->

[singapore/solar-irradiance-simulator](https://standards.itech.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-)

24.2	Test installation.....	49
24.3	Preconditioning of the collector.....	49
24.4	Test conditions.....	49
24.5	Test procedure.....	51
24.6	Measurements.....	52
24.7	Test period.....	54
24.8	Presentation of results.....	59
25	Computation of the collector parameters.....	59
25.1	Liquid heating collectors.....	59
25.2	Steady-state air heating collectors.....	63
26	Determination of the effective thermal capacity and the time constant of a collector.....	64
26.1	Measurement of the effective thermal capacity (separate measurement).....	64
26.2	Measurement of the effective thermal capacity (quasi dynamic method).....	66
26.3	Calculation method.....	66
26.4	Determination of collector time constant (optional).....	67
27	Determination of incident angle modifier.....	69
27.1	Modelling.....	69
27.2	Test procedures.....	73
27.3	Calculation of collector incidence angle modifier.....	74
28	Determination of the pressure drop across a collector (Liquid) (optional).....	75
28.1	General.....	75
28.2	Test installation.....	75
28.3	Preconditioning of the collector.....	75
28.4	Test procedure.....	75
28.5	Measurements.....	76
28.6	Pressure drop caused by fittings.....	76
28.7	Test conditions.....	76
28.8	Calculation and presentation of results.....	77
28.9	Pressure drop for air collectors.....	77
	Annex A (normative) Test reports.....	79
	Annex B (informative) Mathematical models for liquid heating collectors.....	104
	Annex C (normative) Properties of water.....	108
	Annex D (informative) General guidelines for the assessment of uncertainty in solar collector efficiency testing.....	111
	Annex E (informative) Measurement of the velocity weighted mean temperature.....	115
	Bibliography.....	117

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9806 was prepared by Technical Committee ISO/TC 180, *Solar energy*, and by Technical Committee CEN/TC 312, *Thermal solar systems and components* in collaboration.

This first edition cancels and replaces the first editions EN 12975-2:2006, ISO 9806-1:1994, ISO 9806-2:1995, and ISO 9806-3:1995, which have been technically revised.

ITEH STANDARD PREVIEW
(standards.iteh.ai)

[ISO 9806:2013](https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013)

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013>

Introduction

This International Standard defines procedures for testing fluid heating solar collectors for performance, reliability, durability and safety under well-defined and repeatable conditions. It contains performance test 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. Outdoor tests can be performed either steady-state or as all-day measurements, under changing weather conditions.

Collectors tested according to this International Standard represent a wide range of applications, e.g. tracking concentrating collectors for thermal power generation and process heat, glazed flat plate collectors and evacuated tube collectors for domestic water and space heating, unglazed collectors for heating swimming pools or other low temperature applications. Air heating collectors have been included in the scope of this International Standard. Similarly, collectors using external power sources for normal operation and/or safety purposes (overheating protection, environmental hazards, etc.) are also considered.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[ISO 9806:2013](https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013)

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90e35/iso-9806-2013>

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 9806:2013

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-b36f5d90ef35/iso-9806-2013>

Solar energy — Solar thermal collectors — Test methods

1 Scope

This International Standard specifies test methods for assessing the durability, reliability and safety for fluid heating collectors.

This International Standard also includes test methods for the thermal performance characterization of fluid heating collectors, namely steady-state and quasi-dynamic thermal performance of glazed and unglazed liquid heating solar collectors and steady-state thermal performance of glazed and unglazed air heating solar collectors (open to ambient as well as closed loop).

This International Standard is also applicable to hybrid collectors generating heat and electric power. However it does not cover electrical safety or other specific properties related to electric power generation.

This International Standard is also applicable to collectors using external power sources for normal operation and/or safety purposes.

This International Standard 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.

iteh STANDARD PREVIEW

2 Normative references (standards.iteh.ai)

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.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

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

ISO 9488, *Solar energy — Vocabulary*

ASTM E330-02, *Standard Test method for Structural performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*

EN 779, *Particulate air filters for general ventilation - Determination of the filtration performance*

EN 13142, *Ventilation for buildings - Components/products for residential ventilation - Required and optional performance characteristics*

EN 13779, *Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems*

VDI 4670, *Thermodynamic properties of humid air and combustion gases*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 9488 and the following apply.

3.1 longitudinal angle of incidence
angle between the normal to the plane of the collector and incident sun beam projected into the longitudinal plane

Note 1 to entry: Not applicable to point-focus collectors and central receivers.

3.2 longitudinal plane
plane defined by the normal to the plane of the collector and the concentrator axis, or the largest symmetry line for flat biaxial geometries

3.3 maximum operating temperature
maximum temperature reached during collector or system normal operation, usually stated by the manufacturer

Note 1 to entry: Concentrating collector.

3.4 module
smallest unit that would function as a solar energy collection device

3.5 no-flow condition
condition that occurs when the heat transfer fluid does not flow through the collector array, due to shut-down or malfunction, and the collector is exposed to the same solar irradiance as under normal operating conditions

3.6 optical axis
symmetry line orthogonal to focal line and the plane of the collector in line-focus collectors

3.7 outgassing
process in which a solid material releases gases when it is exposed to elevated temperatures and/or reduced pressure

3.8 peak efficiency
efficiency of the collector at a temperature difference ($\vartheta_m - \vartheta_a = 0$) based on normal incidence of solar radiation and either hemispherical or beam irradiance

3.9 peak power
power output of the collector at a temperature difference ($\vartheta_m - \vartheta_a = 0$) based on normal incidence of solar radiation and either hemispherical or specific combinations of beam and diffuse irradiance

3.10 passive
operating condition where no human or mechanical intervention is required for operation as intended

Note 1 to entry: Concentrating collector.

3.11 reflector or reflective surface
surface intended for the primary function of reflecting radiant energy

Note 1 to entry: Concentrating collector.

Note 2 to entry: It includes also the optional reconcentrator.

3.12**Simulated Roof**

construction using materials of a quality typical to that used in roofs, from roof structure to roof coverings

3.13**transversal angle of incidence**

angle between collector the normal to the plane of the collector and incident sun beam projected into the transversal plane

Note 1 to entry: Not applicable to point-focus collectors and central receivers.

3.14**transversal plane**

plane defined by the normal to the plane of the collector and the line orthogonal to the concentrator axis, or the shortest symmetry line for flat biaxial geometries

3.15**trigger or safety activation temperature**

temperature value at which the safety controls are activated for fail safe operating condition

Note 1 to entry: Concentrating collector.

4 Symbols and abbreviated terms

A_G	gross area of collector	m^2
AM	optical air mass	-
a_1	heat loss coefficient at $(\vartheta_m - \vartheta_a) = 0$	$W/(m^2 \cdot K)$
a_2	temperature dependence of the heat loss coefficient	$W/(m^2 \cdot K^2)$
B	"earth position" around the sun during the year 0-360 deg	degrees
b_u	collector efficiency coefficient (wind dependence)	s/m
b_0	constant for the calculation of the incident angle modifier	
b_1	heat loss coefficient at $(\vartheta_m - \vartheta_a) = 0$	$W/(m^2 \cdot K)$
b_2	wind dependence of the heat loss coefficient	$Ws/(m^3 \cdot K)$
C	effective thermal capacity of collector	J/K
C_R	Concentration ration	
c_1	heat loss coefficient at $(\vartheta_m - \vartheta_a) = 0$	$W/(m^2 \cdot K)$
c_2	temperature dependence of the heat loss coefficient	$W/(m^2 \cdot K^2)$
c_3	wind speed dependence of the heat loss coefficient	$J/(m^3 \cdot K)$
c_4	sky temperature dependence of the heat loss coefficient	-

c_5	effective thermal capacity	J/(m ² ·K)
c_6	wind dependence in the zero loss efficiency	s/m
c_f	specific heat capacity of heat transfer fluid	J/(kg·K)
$C_{f,i}$	specific heat capacity of heat transfer fluid at the collector inlet	J/(kg·K)
$C_{f,e}$	specific heat capacity of heat transfer fluid at the collector outlet	J/(kg·K)
$C_{f,a}$	specific heat capacity of the ambient air	J/(kg·K)
D	date	YYMMDD
E	formula of time correcting for the eccentric path	minutes of the earth around the sun.
E_L	long wave irradiance ($\lambda > 3 \mu\text{m}$)	W/m ²
E_β	long wave irradiance on an inclined surface outdoors	W/m ²
E_s	long wave irradiance	W/m ²
F	radiation view factor	
F'	collector efficiency factor	
G	hemispherical solar irradiance	W/m ²
G''	net irradiance	W/m ²
G_b	direct solar irradiance (beam irradiance)	W/m ²
G_d	diffuse solar irradiance	W/m ²
H	hemispherical irradiation on the collector plane	MJ/m ²
$h_{f,a}$	enthalpy of the air-water vapor mixture of the ambient air	J/kg
$h_{f,e}$	enthalpy of the air-water vapor mixture at the outlet of the air collector	J/kg
$h_{f,i}$	enthalpy of the air-water vapor mixture at the inlet of the air collector	J/kg
h_L	enthalpy of the leaking air-water vapor mixture	J/kg
$K_{\text{hem}}(\theta_L, \theta_T)$	incidence angle modifier	-
$K_b(\theta_L, \theta_T)$	incidence angle modifier for direct radiation	-
$K_{\theta_L, coll}$	incidence Angle Modifier along the coll. tubes or reflectors	-

iTeH STANDARD PREVIEW
(standards.iteh.ai)

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-6565d90e15/iso-9806-2013>

$K_{\theta T, coll}$	incidence Angle Modifier perpendicular to collector tubes or reflectors	-
K_d	incidence angle modifier for diffuse radiation	-
m	thermally active mass of the collector	kg
\dot{m}	mass flow rate of heat transfer fluid	kg/s
\dot{m}_{min}	minimum mass flow by the performance test	kg/h
\dot{m}_{max}	maximum mass flow by the performance test	kg/h
\dot{m}_{pe}	downstream air mass flow rate	kg/s
\dot{m}_{pi}	upstream air mass flow rate	kg/s
\dot{m}_{pl}	leakage air mass flow rate	kg/s
p_{fe}	static pressure of the heat transfer fluid (air) at the outlet to the solar collector	Pa
p_{fi}	static pressure of the heat transfer fluid (air) at the inlet to the solar collector	Pa
P_{abs}	absolute pressure of the ambient air	Pa
\dot{Q}	useful power extracted from collector	W
\dot{Q}_{peak}	power output of the solar collector module for normal incidence, $G = 1000 \text{ W/m}^2$ and $\vartheta_m - \vartheta_a = 0 \text{ K}$	W
\dot{Q}_t	mean power output during one time step	W
\dot{Q} / A_G	specific useful energy extracted from the collector	W/m ²
Q_{module}	useful energy extracted from the collector, annual energy gain	kWh per module
\dot{Q}_L	power loss of collector	W
R_D	gas constant for water vapor	461,4 J/(kgK)
rH_{amb}	(relative)humidity of the ambient air	%

iTeh STANDARD PREVIEW

(standards.iteh.ai)

ISO 9806:2013

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-f365d90e35/iso-9806-2013>

rH_e	(relative)humidity of the fluid (air) at the outlet of the solar collector	%
rH_i	(relative)humidity of the fluid (air) at the inlet of the solar collector	%
R_L	gas constant for air	287,1 J/(kgK)
T	absolute temperature	K
T^*_m	reduced temperature difference (= $(\vartheta_m - \vartheta_a)/G$)	m ² K/W
$\vartheta_{m,max}$	maximum operating temperature as stated by the manufacturer	
T_s	atmospheric or equivalent sky radiation temperature	K
t	time	s
U	measured overall heat loss coefficient of collector with reference to T^*_m	W/(m ² K)
U_L	overall heat loss coefficient of a collector with uniform absorber temperature ϑ_m	W/(m ² K)
u	surrounding air speed	m/s
V_f	fluid capacity of the collector	m ³
\dot{V}_p	volumetric flow	m ³ /s
$\dot{V}_{p,e}$	volumetric flow at the outlet of the solar collector	m ³ /s
$\dot{V}_{p,i}$	volumetric flow at the inlet of the solar collector	m ³ /s
$\dot{V}_{p,L}$	volumetric leakage flow rate	m ³ /s
$X_{W,a}$	water content of the ambient air	kg H ₂ O/kg dry air
$X_{W,e}$	water content at the exit of the solar collector	kg H ₂ O/kg dry air
$X_{W,i}$	water content at the inlet of the solar collector	kg H ₂ O/kg dry air
α	solar absorptance	%
α_s	solar altitude angle	degrees
β	tilt angle of a plane with respect to horizontal	degrees
γ	collector azimuth angle (0 = south, east negative)	degrees

iteh STANDARD PREVIEW
(standards.iteh.ai)

<https://standards.iteh.ai/catalog/standards/sist/7c86aba6-80bf-475a-9892-65615d90e35/iso-9806-2013>

γ_s	solar azimuth angle (0 = south, east negative)	degrees
Δp	pressure difference between fluid inlet and outlet	Pa
Δt	time interval	s
ΔT	temperature difference between fluid outlet and inlet ($\vartheta_e - \vartheta_{in}$)	K
δ	solar declination	degrees
ε	hemispherical emittance	%
η	collector efficiency, with reference to T^*_m	-
η_b	collector efficiency, with reference to T^*_m , based on beam irradiance G_b	-
η_{hem}	collector efficiency, with reference to T^*_m , based on hemispherical irradiance G	-
$\eta_{0,b}$	peak collector efficiency (η_b at $T^*_m = 0$), reference to T^*_m , based on beam irradiance G_b	-
$\eta_{0,hem}$	peak collector efficiency (η_{hem} at $T^*_m = 0$), reference to T^*_m , based on hemispherical irradiance G	-
$\eta_{max,0m/s}$	maximum collector efficiency (at 0 m/s and one fixed mass flow rate)	-
η_m	collector efficiency, with reference to $\eta_{max,0m/s}$	-
θ	angle of incidence	degrees
$\theta_{T,def}$	reference angle in T-direction for determination of IAM. Normally = 0	degrees
$\theta_{L,def}$	reference angle in L-direction for determination of IAM. Normally = 0	degrees
θ_z	solar zenith angle (= 90 - θ_H)	degrees
θ_{II} or θ_L	longitudinal angle of incidence	degrees
θ_{\perp} or θ_T	transversal angle of incidence	degrees
ϑ_a	ambient or surrounding air temperature	°C
ϑ_{dp}	atmospheric dew point temperature	°C
ϑ_e	collector outlet (exit) temperature	°C
ϑ_{in}	collector inlet temperature	°C