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SRCC™ Standard 100-2014-07

MINIMUM STANDARDS FOR SOLAR THERMAL COLLECTORS

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SRCC Standard 100 - Minimum Standards for Solar Thermal Collectors

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Solar Rating & Certification Corporation™

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Disclaimer:

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Foreword

The intent of this standard is to provide minimum criteria for the efficiency, longevity and design of Solar Collectors. The focus of this standard is to provide minimum testing requirements, consistent methods and procedures to ensure that products covered by the standard operate in a safe, reliable, and effective manner. Consistent test methods ensure that the performance of various solar collector designs and configurations can be compared and evaluated.

The standard serves as the basis for insuring to the consumer and industry that reliability and safety standards are met. Providing unbiased performance and rating data based on this standard will help the consumer make informed purchase decisions.

The standard is intended to ensure the quality of the product can be assessed through a review process without imposing unreasonable costs and difficulty on the manufacturer to comply with this standard.

Background

SRCC is recognized by the Solar Industry as the Standards Development Body for Solar Collectors and Solar Water Heating Systems. SRCC™ Standard 100 has been adopted by federal and state authorities and recognized as a requirement for product certification in the tax code.

This Standard has been developed in a regimented process consistent with ANSI requirements for "voluntary consensus standards" which requires participation from a range of representation of manufactures, technical experts, incentive program administrators, public sector agencies, utilities and consumers.

The draft as a result of the Standard Development Effort was first adopted in 1981 and has undergone several revisions since. Advocates who made major contributions to this national Solar Water Heating System Standard - SRCC™ Standard 100 were DOE, NREL, ISCC/IREC, FSEC, and SEIA. References to Solar Rating & Certification Corporation appear in requirements in the Energy Policy Act of 2005; commonly referred to as the "2005 Energy Bill" for determining eligibility of certified Solar Collectors for federal tax incentives.

Foreword and Background: The Foreword and Background sections are included with this document for information purposes only, and are not part of the "SRCC™ Standard 100 - MINIMUM STANDARD FOR SOLAR THERMAL COLLECTORS.

1.0 PURPOSE

This standard sets forth minimum durability, construction, performance criteria and procedures for characterizing the thermal performance and indicating the durability of solar collectors used in applications such as swimming pool heating, space heating, cooling and water heating.

2.0 SCOPE

This standard applies to solar thermal collectors utilizing a fluid for the heat transfer. The standard sets forth minimum requirements for durability, construction and performance testing and provides the methodology and means for evaluating the durability and performance of tested solar thermal collectors. Resulting performance data serves as the basis for comparing solar collectors.

3.0 DEFINITIONS

Absorber: The absorber is that part of the solar collector that receives the incident solar radiation and transforms it into thermal energy. It usually is a solar surface through which energy is transmitted to the transfer fluid; however, the transfer fluid itself could be the absorber in certain configurations.

Ambient Air: Ambient air is the outdoor air in the vicinity of the solar collector being tested.

Available Energy: Is determined by the integrated solar irradiance.

Collected Energy: Is the product of the fluid mass, specific heat and integrated temperatures gain across the collector.

Collector Enclosure: The structural frame which supports the components of the collector and protects internal components from the environment.

Concentrating Thermal Collector: A solar collector which uses reflectors, lenses or other optical elements to concentrate the radiant energy passing through the aperture onto an absorber which has a surface area smaller than the aperture. Some collectors using concentrating elements also fit the definition of a flat-plate collector. Thus, this document treats non-concentrating flat plate collectors, concentrating flat-plate collectors, and concentrating tracking collectors.

Concentrator: The concentrator is that part of the concentrating collector which directs the incident solar radiation onto the absorber.

Corrosion: The deterioration of a substance or its properties caused by a chemical or electrochemical reaction with its environment.

Cover Plate: The cover plate is the material or materials covering the aperture and most directly exposed to the solar radiation. These materials generally are used to reduce the heat loss from the absorber to the surroundings and to protect the absorber.

Crazing: Formation of minute surface cracks.

Delamination: Separation into constituent layers.

Design Life: Period for which a collector is expected to function at its designated capacity without major repairs.

Degradation: Is defined as that leading to significant permanent loss of collector performance and/or leading to elevated risk of danger to life, limb or product. “Repeated exposure” is defined as a minimum total of 1000 hours/year at stagnation conditions during the design life

Modes of degradation shall include, but are not limited to:

- Outgassing from coatings or insulation that results in harmful deposits or significant structural failure or significant reduction in insulation value.
- Structural weakening with permanent failure, melting, charring, ignition, etc. of wooden or polymer components exposed to temperatures greater than documented limits
- Release of undesirable compounds from the wall of the fluid passageway into the heat transfer fluid.

Flat-Plate Collector: A flat-plate collector is normally a solar collector (either liquid or air) in which the surface absorbing the incident radiation is essentially flat and employs no concentration. However, in this document the term refers to all collectors designed to perform satisfactorily with all parts of the collector in fixed positions.

Fluid: A fluid is defined as a substance that can flow and does not maintain a fixed shape. Gases and liquids are considered fluids.

Gross Collector Area: The maximum projected area of the complete module, including integral mounting means.

Heat Pipe: A heat transfer device that combines the principles of both thermal conductivity and phase change.

Innovative Equipment: Solar equipment which, due to its design, cannot be evaluated fairly and adequately by the test methods described in this document.

Instantaneous Efficiency: The instantaneous efficiency of a solar collector is defined as the amount of energy removed by the transfer fluid over a given measuring period divided by the total incident solar radiation onto the gross collector area during the measuring period.

Integrity of Construction: Those physical and mechanical properties of the solar collector which collectively are responsible for the overall thermal performance and physical structure of the solar collector.

Irradiance: Irradiance is the rate of solar radiation received by a unit surface area in unit time in W/m^2 ($Btu/hr\ ft^2$).

Model: A unit of solar equipment that is identifiable by a specified size, set of materials, and performance. A change in any of these basic characteristics constitutes a new model.

"No-Flow" Condition: The condition that result 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 amount of solar radiation that it would receive under normal operating conditions.

Non-Concentrating Solar Thermal Collector: A solar collector receives incident solar radiation at an integral absorber and transforms it into thermal energy. The transfer from solar energy to heat energy occurs at the absorber surface and heat energy is transmitted to a transfer fluid; however, the transfer fluid itself could be the absorber in certain configurations

Outgassing: The generation of vapors by materials usually during exposure to elevated temperature and/or reduced pressure.

Pitting: The process by which localized material loss is caused in materials or components by erosion, corrosion, or chemical decomposition.

Pyranometer: A radiometer used to measure the total solar radiation (direct, diffuse, and reflected) incident on a surface per unit time per unit area.

Rated Performance: The solar equipment thermal output characteristics determined by tests specified in this document.

Reflector or Reflective Surface: A surface intended for the primary function of reflecting radiant energy.

Site Dependent Collectors: A collector intended to be assembled only at the site of its application. This may be because parts of the building (e.g., rafters, insulation) are part of the collector or because the size of the collector makes delivery impractical.

Solar Thermal Collector: A solar thermal collector is a device designed to absorb incident solar radiation, to convert it to thermal energy, and to transfer the thermal energy to a fluid coming in contact with it. The materials and dimensions of the cover (if any) and the absorber must be specified. A solar collector must contribute net gain and be able to have its solar energy conversion efficiency characterized by recognized thermal performance equations.

Solar Energy: The energy originating from the sun's radiation primarily encountered in the wavelength region from 0.3 to 3.0 micrometers.

Standard: A document which specifies the performance, durability, or safety requirements of a product.

Thermal Efficiency: Is the ratio of collected energy to available energy falling upon collector area.

Thermal Performance Curve: For a collector is determined when the insolation incident to the collector is within 30 degrees of normal to the aperture of the collector. To predict collector performance over a wide range of conditions, tests will be conducted to determine the collector incident angle modifier. This is used to modify the efficiency curve (determined within 30 degrees of normal incidence) to account for changes in performance as a function of the sun's incidence angle.

Time Constant: The time constant is the time required for the fluid leaving a solar collector to attain 63.2% of its steady state value following a step change in insolation or inlet fluid temperature.

Transfer Fluid: The transfer fluid is a medium such as air, water, or other fluid which passes through or in contact with the solar collector and carries the thermal energy away from the collector.

Transparent Frontal Area: The transparent frontal area is the projected area of that part of the collector designed to transmit incident solar energy to the interior of the collector.

4.0 REFERENCED STANDARDS

ISO 9806:2013, Solar energy — Solar thermal collectors — Test methods, International Organization for Standardization, Geneva, Switzerland. http://www.iso.org

5.0 TEST METHODS FOR SOLAR COLLECTORS

Table 1 below specifies which tests are to be conducted on each type of solar collector. An "X" in the table indicates the test shall be conducted. An "O" indicates the test shall be conducted, but can be conducted on either collector. All tests shall be conducted in accordance with ISO 9806:2013.

There are two methods for conducting the tests:

1. (Indicated in the table as "1") All of the tests are conducted on a single collector.
2. (Indicated in the table as "2Q" and "2P") Two collectors are tested with one of them being subjected to the qualification tests (2Q) and one of them being subjected to the performance tests (2P).

The test sequence shall follow the order in which the tests are listed in Table 1 below with the following exceptions:

a. The following tests can be conducted in any sequence relative to each other: Thermal capacity / time constant, Thermal performance, Incident angle modifier, Pressure drop
b. The following tests can be conducted in any sequence relative to each other: High-temperature resistance, Exposure, Stagnation temperature, External thermal shock, Internal thermal shock
c. All solar collectors containing heat pipes shall be subjected to the exposure test in accordance with Subclause 11 of ISO 9806 before the thermal performance test is conducted. The same serial numbered collector shall be subjected to the exposure test and then the thermal performance test.

Table 1

Test Description	Section Reference		Liquid Heating						Air Heating					
	This Doc	ISO 9806	Unglazed			Glazed (flat plate, tubular)			Closed and Open Loop			Transpired		
			1	2 Q	2 P	1	2 Q	2 P	1	2 Q	2 P	1	2 Q	2 P
Test Specimen Selection	5.1	n/a	X	X	X	X	X	X	X	X	X	X	X	X
Baseline Inspection	5.2	n/a	X	X	X	X	X	X	X	X	X	X	X	X
High-temperature resistance	5.3	9	X	X		X	X		X	X		X	X	
Stagnation temperature	5.4	10	X	X		X	X		X	X		X	X	
Exposure	5.5	11	X	X		X	X		X	X		X	X	
External thermal shock	5.6	12	X	X		X	X		X	X		X	X	
Internal thermal shock	5.7	13	X	X		X	X		X	X		X	X	
Internal Pressure	5.8	6	X	X		X	X							
Leakage	5.9	7							X	X				
Rupture and Collapse	5.10	8							X	X		X	X	
Freeze resistance (only when freeze tolerance claimed)	5.11	15	X	X		X	X							
Thermal capacity / time constant	5.12	26	X		X	X		X	X		X	X		X
Thermal performance	5.13	24	X		X	X		X	X		X	X		X
Incident angle modifier	5.14	27	X		X	X		X	X		X	X		X
Pressure drop	5.15	28	X	O	O	X	O	O	X	O	O			

Test Description	Section Reference		Liquid Heating						Air Heating					
	This Doc	ISO 9806	Unglazed			Glazed (flat plate, tubular)			Closed and Open Loop			Transpired		
			1	2 Q	2 P	1	2 Q	2 P	1	2 Q	2 P	1	2 Q	2 P
Rain penetration (glazed only)	5.16	14				X	X		X	X				
Mechanical load	5..17	16				X	X		X	X		X	X	
Impact resistance	5.18	17	X	X		X	X		X	X		X	X	
Final inspection	5.19	18	X	X		X	X		X	X		X	X	

5.1 TEST SPECIMEN

Collector shall be selected at random for testing and shall be tested as received from the manufacturer.

5.2 BASELINE INSPECTION

Test specimens shall be inspected prior to testing and any visible damage or assembly flaws shall be recorded.

5.2.1 PRE-EXPOSURE PRESSURE TEST

It is permissible to conduct the internal pressure test according to Section 5.8 to confirm the flow passages are in a condition suitable for testing.

5.3 HIGH TEMPERATURE RESISTANCE TEST

A high temperature resistance test shall be conducted in accordance with Section 9 of ISO 9806.

5.4 STAGNATION TEMPERATURE

The collector stagnation temperature shall be determined in accordance with Section 10 of ISO 9806.

5.5 EXPOSURE TEST

The purpose of this test is to verify integrity of construction after a minimum of 30 days of exposure to adverse conditions. The test shall be conducted in accordance with Section 11 of ISO 9806 under climate class B.

5.6 EXTERNAL THERMAL SHOCK/WATER SPRAY TEST

The external thermal shock test shall be conducted in accordance with ISO 9806, Section 12under climate class B. Where testing is conducted outdoors, one external shock shall be performed on each of two different days of the exposure test. Where testing is conducted indoors under a solar simulator, the second test may be performed on the same day as the first test provided that the collector has cooled to ambient air temperature before the second test is begun. Any test specimen whose integrity is permanently compromised by this test such that it obviously will not be able to perform later shall be considered to have failed the test.

5.7 INTERNAL THERMAL SHOCK/COLD FILL TEST

The internal thermal shock test shall be conducted as specified in ISO 9806Section 13,under climate class B. Where testing is conducted outdoors, one Internal shock shall be performed on each of two different days of the exposure test. Where testing is conducted indoors under a solar simulator, the second test may be performed on the same day as the first test provided that the collector has cooled to ambient air temperature before the second test is begun. If this test is conducted indoors under a solar simulator, it may be performed on the same day as one or both of the external thermal shock tests, provided that the collector has cooled to ambient air temperature before this test is begun.

A collector shall be considered to have failed the test when the test specimen experiences permanent distortion, damage or degradation of performance.

5.8 INTERNAL PRESSURE TEST

An internal pressure test shall be conducted in accordance with Section 6of ISO 9806.

5.9 LEAKAGE TEST

A leakage test shall be conducted on closed loop air heating collectors in accordance with Section 7 of ISO 9806.

5.10 RUPTURE AND COLLAPSE TEST

A rupture and collapse test shall be conducted on air heating collectors in accordance with Section 8 of ISO 9806.

5.11 FREEZE RESISTANCE TEST

A freeze resistance test shall be conducted on collectors claimed to be resistant to freezing in accordance with Section 15 of ISO 9806.

5.11.1 Freeze resistance test for heat pipes used in solar collectors

5.11.1.1 Objective

This test is intended to evaluate the impact of freeze/thaw cycles on heat pipes. The test shall be performed in a suitable controllable climate chamber (freezer) for the duration of a set number of freeze and thaw cycles (see Table 2 below). This test shall be performed on heat pipes that are part of the solar collector submitted for testing, regardless of collector loop design heat transfer fluid

5.11.1.2 Procedure

5.11.1.2.1 Selection

During the disassembly phase (5.19) of the testing protocol (following the qualification tests) a minimum of 6 heat pipes shall be selected to undergo a freeze resistance test. In addition, at least one heat pipe shall be retained as a control sample for comparison with the tested samples. It may be necessary to destroy part of the collector (evacuated tubes, collector housing, etc.) to extract the heat pipes. However, when theheat pipes cannot be separated from the evacuated tube without damage to the heat pipe it is permissible to conduct the test with the evacuated tube in place.

After the heat pipes are extracted from the collector, they shall be kept at a minimum tilt angle of 15^o with respect to horizontal with the condenser at the upper end. This is to keep all components of the fluid (inhibitors, particles, etc.) in the bottom part of the heat pipe. If the solar collector was stored at less than a 15^o tilt between the qualification tests and disassembly, the heat pipes must be tilted to at least 15^o then raised to and held for one hour at what their normal operating temperature would be when exposed to 800 W/m^2.

5.11.1.2.2 Preparation

5.11.1.2.2.1 Inspection and measurement

A detailed initial inspection of all of the heat pipes shall document the following:

- The shape (round, oval, cylindrical, conical, etc.) of all parts of the heat pipe.
- The outside dimension of all parts of the heat pipe.
- Photographic record of all test samples.

5.11.1.2.2.2 Temperature sensors

Two heat pipes shall have a temperature sensor attached to ensure an accurate and average temperature is measured. Each temperature sensor (standard uncertainty of +/- 1 K) shall be mechanically and thermally attached to the lower end of a heat pipe near the fluid level when all of the fluid inside the heat pipe is condensed and the heat pipe is held at the tilt to be used in this test. The temperature indicated by these sensors will be assumed to represent the temperature of the fluid inside the heat pipe.

Heat pipes which cannot be separated from the evacuated tube without damage may be tested with the evacuated tube in place. On one sample, the condenser shall be opened by drilling a hole so that a temperature sensor can be inserted and run to the location where the heat pipe heat transfer fluid rests. The temperature sensor shall have a maximum standard uncertainty of +/-1 K. Every effort shall be made to minimize disruption to the basic structure of the heat pipe, while maximizing the accuracy of temperature measurement at this location.

5.11.1.2.3 Test Conditions

All conditions in Table 2 must be met.

Table 2 Required Test Conditions

Test Parameter	Required value
Tilt angle	The highest of 60° or the manufacturer's highest recommended tilt angle
Freezing temperature	Negative 20 +/- 2°C
Freezing time	The temperature sensor shall indicate the freezing temperature for at least 30 minutes per cycle
Thawing temperature	Positive 10 +/- 2°C
Thawing time	The temperature sensor shall indicate the thawing temperature for at least 30 minutes per cycle
Number of cycles	20

A visual inspection of all heat pipes shall be conducted after the initial five freeze/thaw cycles. If there is a failure, (e.g. fluid leaking, burst pipe etc.) as a result of the freeze/thaw cycling in any of the test samples, the test shall be terminated.

5.11.1.2.3.1 Final Inspection

A detailed final inspection of all samples shall document the following for each sample tested:

- Any permanent change in shape or dimension of all parts of the heat pipe.
- Any evidence of fluid leaking from the heat pipe.
- Photographic record of all test samples.

5.11.1.3 Results

The following shall be reported:

- The tilt angle of the heat pipes during the test.
- All changes to the physical condition of the heat pipes and that of any collector components adjacent to the heat pipe.
- The number of temperature cycles that were performed.
- The temperature indicated by the temperature sensor(s) during the required dwell periods.
- The time the heat pipes were exposed to each dwell period.
- Before and after photographs of the tested heat pipes.
- Any deviations from procedure as defined in other sections of this test procedure.

5.12 THERMAL CAPACITY AND TIME CONSTANT TEST

The thermal capacity shall be determined in accordance with Section 26 of ISO 9806. If the time constant is measured, the test shall be performed as specified in ISO 9806, Section 26.4.

5.13 THERMAL PERFORMANCE TEST

The thermal performance test determines "instantaneous" efficiency of the solar collector over its normal range of operating temperatures. The thermal performance test shall be conducted in accordance with Section 24 of ISO 9806.

5.14 COLLECTOR INCIDENT ANGLE MODIFIER

The incident angle modifier shall be determined in accordance with Section 27 of ISO 9806.

Biaxial incident angle modifiers are required on collectors that are non-symmetrical in their response to irradiance as solar altitude and azimuth change. Data shall be taken in each of the two perpendicular planes that characterize the collector geometry.

5.15 PRESSURE DROP TEST

The pressure drop across the collector using a heat transfer fluid prescribed by the manufacturer shall be determined in accordance with Section 28 of ISO 9806.

5.16 RAIN PENETRATION TEST

A rain penetration test shall be conducted on glazed collectors in accordance with Section 14 of ISO 9806.

5.17 MECHANICAL LOAD TEST

A mechanical load test shall be conducted on all collectors in accordance with Section 16 of ISO 9806.

5.18 IMPACT RESISTANCE TEST

The outer cover of one test specimen shall be tested in accordance with Section 17 of ISO 9806 with the exception that the test must be conducted in accordance with method 2 using steel balls. Where the outer cover is constructed of tempered glass, testing shall not be required.

5.19 DISASSEMBLY AND FINAL INSPECTION

After the completion of testing, test specimens shall be disassembled and inspected in accordance with Section 18 of ISO 9806.

6.0 COLLECTOR STANDARDS

Section 6.0 establishes minimum requirements for durability in collector design and construction.

6.1 CONDENSATION

The collector shall be designed to prevent condensate build-up. The use of desiccants to control condensation shall be permitted. Test reports shall note any unusual condensate build up during any point in the testing.

6.2 PRESSURE TEST RESULTS

A collector, after testing, shall be considered passable if it meets the requirements stated in Section 6.4 of ISO 9806.

6.3 THERMAL SHOCK RESULTS

The collector structure and performance shall not be degraded by moisture penetration. There shall be no cracking, crazing, warping or buckling of the cover or the absorber.

6.4 DISASSEMBLY AND FINAL INSPECTION

After completing the test sequence outlined in Section 5.0, the collector shall be disassembled and subassemblies visually inspected and their condition noted. The format specified in ISO 9806, Annex A.15, "Final inspection results," shall be used to report conditions observed. Listed below are the items covered.

Collector component	Inspection Criteria
a. Collector box/fasteners	Cracking/warping/corrosion/rain prevention
b. Mountings/structure	Strength/safety
c. Seals/gaskets	Cracking/adhesion/elasticity
d. Cover/reflector	Cracking/crazing/buckling/delamination/ warping/outgassing
e. Absorber coating	Cracking/crazing/blistering
Absorber tubes and headers	Deformation/corrosion/leakage/loss of bonding
Absorber mountings	Deformation/corrosion
f. Insulation	Water retention/outgassing/degradation

Test specimens and their components shall exhibit no conditions capable of producing premature failure including, but not limited to:

a. Severe deformation* of the absorber.

b. Severe deformation* of the fluid flow passages.

c. Loss of bonding between fluid flow passages and absorber plate.

d. Leakage from fluid flow passages or connections.

e. Loss of mounting integrity.

f. Severe corrosion* or other deterioration caused by chemical action.

g. Crazing, cracking, blistering or flaking of the absorber coating or reflective surfaces.

h. Excessive retention of water anywhere in the collector.

i. Swelling, severe outgassing or other detrimental changes in the collector insulation which could adversely affect collector performance.

j. Cracking, loss of elasticity, or loss of adhesion of gaskets and sealants.

k. Leakage or damage to hoses used inside the collector enclosure, or leakage from mechanical connections.

l. Cracking, crazing, permanent warping or buckling of the cover plate.

m. Cracking or warping of the collector enclosure materials.

* Deformation or corrosion shall be considered severe if it impairs the function of the collector or there is evidence that it will progress.

6.5 PROTECTION OF MATERIAL

Materials used in the construction of solar collectors shall be capable of withstanding no less than 1000 hours per year at stagnation temperature without significant degradation over the design life. Stagnation temperature shall be determined in accordance with Section 10 of ISO 9806.

6.6 PHOTOVOLTAIC - THERMAL COLLECTORS

When a photovoltaic module is incorporated into the solar collector, the photovoltaic module shall be certified to UL 1703.