SRCC STANDARD
150-08

TEST METHODS
AND MINIMUM STANDARDS
FOR CERTIFYING
INNOVATIVE
SOLAR COLLECTORS

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Solar Rating and Certification Corporation
1679 Clearlake Road
Cocoa, FL 32922-5703
(321) 638-1537   Fax (321) 638-1010

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1.0 PURPOSE

This document sets forth the procedures for determining the thermal performance and indicating the durability of innovative solar collectors used for swimming pool heating, space heating, cooling and water heating. Any solar collector meeting the standards contained herein is eligible for certification by the Solar Rating & Certification Corporation (SRCC).

2.0 SCOPE

This document applies to liquid and air heating solar collectors and provides a means for evaluating the durability of solar collectors as well as data for determining a thermal performance rating for 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.

Certification: The act of attesting officially as being true and as meeting a standard.

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

Concentrating 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.

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.

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

Innovative Solar Collector: A solar collector which, due to its design, cannot be evaluated fairly and adequately by the test methods described in SRCC Standard 100.

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 solar collector 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 results 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.

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 collector's 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 Collector: A solar 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.

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.

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 AND ORGANIZATIONS

ANSI/ASHRAE Standard 93-1986, "Methods of Testing to Determine the Thermal Performance of Solar Collectors," The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA 30329. <http://www.ashrae.org>

ISO 9806-1:1994, Test methods for solar collectors – Part 1: Thermal performance of glazed liquid heating collectors including pressure drop, International Organization for Standardization, Geneva, Switzerland. <http://www.iso.ch/iso/en/ISOOnline.frontpage>

ISO 9806-2:1995, Test Methods for solar collectors – Part 2: Qualification test procedure, International Organization for Standardization, Geneva, Switzerland. <http://www.iso.ch/iso/en/ISOOnline.frontpage>

ISO 9806-3:1995, Test methods for solar collectors – Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop, International Organization for Standardization, Geneva, Switzerland. <http://www.iso.ch/iso/en/ISOOnline.frontpage>

5.0 TEST METHODS FOR SOLAR COLLECTORS

Collector testing shall be performed in a manner as close as possible to the procedures specified in this section. All deviations shall be approved by SRCC prior to the test being conducted.

Collector testing shall be performed in the following sequence:

A. Static Pressure Test
B. Exposure Test
C. Thermal Shock/Water Spray Test
D. Thermal Shock/Cold Fill Test
E. Static Pressure Test
F. Post-Exposure Thermal Performance Test
G. Incident Angle Modifier Test
H. Disassembly and Final Inspection

The identical serial-numbered collector must go through the above test sequence in the exact order specified.

5.1 STATIC PRESSURE TEST

A static pressure test shall be conducted prior to exposure testing as follows:

5.1.1 TYPES OF COLLECTORS

A. Street pressure solar collectors: Collectors which, by virtue of their installation in a municipal water system, will be directly subjected to variations in street water pressure and hot water tank pressure.

B. Low pressure service hot water (SHW) and swimming pool solar collectors: Collectors which, by virtue of their installation, will not have a direct fluid interchange with an auxiliary heater or street pressure. (Heat transfer from such collectors to the service water system would be accomplished by use of an appropriate heat exchanger.)

C. Hybrid and alternate fluid solar collectors: Collectors which, by virtue of design, are not intended to have a direct fluid connection to a SHW system. Such units may or may not be designed to accept street pressure.

5.1.2 BASIS OF TEST PRESSURE

A. The test pressure will be 1100 kPa Gauge (160 psig) for street pressure collectors based on:

   1. Two times the allowable street gauge pressure 550 kPa Gauge (80 psig) in a dwelling.

   2. The test pressure exceeding the required P-T valve relief setting on approved hot water tanks, which is 1030 Gauge (150 psig).

B. Collectors specified for positive operating pressure less than street pressure 550 kPa Gauge (80 psig) will be pressure-tested at 1.5 times the manufacturer's rated operating gauge pressure, but a minimum of 170 kPa (25 psig).

C. Collectors specified for operating pressures greater than 550 kPa Gauge (80 psig) will be pressure tested at 1.5 the manufacturer's rated operating gauge pressure or 1100 kPa (160 psig), whichever is less.

D. Collectors specified for operating at atmospheric pressure or below will be pressure tested at the discretion of the test director, but at no greater than 170 kPa gauge (25 psig).

E. Determination of test pressure will be based on documentation supplied with the collector and markings referenced in the Application for Certification.

5.1.3 METHOD OF TESTING

Either hydrostatic or pneumatic pressure sources may be used on liquid filled collectors. Pneumatic pressure sources will be used for air collectors.

A. Liquid Collectors:

1. a. A pressure gauge shall be attached to read pressure at the collector, the collector shall be completely filled with fluid between 5^0C (41^0F) and 30^0C (86^0F), and the exit port shall be closed off. The ambient temperature shall be between 5^0C (41^0F) and 30^0C (86^0F).

2. Hydraulic pressure will be applied via the inlet port until the gauge indicates the test pressure.

3. After stable test pressure has been achieved, the exit port shall be closed and the pressure shall be monitored for 10 minutes.

4. If the pressure drops by more than 17kPa (2.5 psi) or 10% of the test pressure, whichever is less, the collector shall be deemed to have failed the test.

B. Air Collectors:

1. A pressure tap, pipe, or tubing would be sealed into the exit port of the test specimen and connected to a manometer that can be read directly to 12.5 Pa (0.05 inches water column) or to a pressure gauge of equivalent accuracy. An air flow meter , accurate to within ±23.6 liters/s (±25 cubic feet per minute) shall be placed in the air supply system between the supply source and the collector.

2. Apply pressure via the inlet port of 125 Pa (0.5 inch water column) and monitor pressure for one hour. The volume of air added or removed in order to maintain the required pressure shall be documented.

5.2 EXPOSURE TEST

The purpose of this test is to verify integrity of construction after at least 30 days of exposure to adverse conditions.

5.2.1 METHOD OF TESTING

a. The collector unit shall be tested under worst case conditions. The collector shall be dry. However, units which use a sealed container or loop charged with a refrigerant, other phase change material or fluid, shall be tested with a normal charge of the material (according to manufacturer specifications).

b. Exposure conditions shall consist of 30 days of cumulative exposure to a minimum daily incident solar radiation flux of 17 $MJ/m^2 \cdot day$ (1,500 $Btu/ft^2 \cdot day$) as measured in the plane of the collector aperture.

c. Data recorded and reported during exposure testing shall include integrated daily solar radiation and ambient air temperature. A regularly scheduled weekly visual inspection shall also be made, and a record of changes in the physical appearance of the collector shall be kept.

5.3 THERMAL SHOCK/WATER SPRAY TEST

The external thermal shock test shall be performed as close as possible to the procedure specified in ISO 9806-2, Section 8, Class B. One external shock shall be performed on each of three different days of the exposure test. Measurement of the absorber temperature is not required. Any collector whose integrity is permanently compromised by this test such that it obviously will not be able to perform later, is deemed to have failed the test.

5.4 THERMAL SHOCK/COLD FILL TEST

Following the last water spray test, and on a different day, the internal thermal shock test shall be performed as close as possible to the procedure specified in ISO 9806-2, Section 9, Class B.

Any collector whose integrity is permanently compromised by this test such that it obviously will not be able to perform later, is deemed to have failed the test.

5.5 STATIC PRESSURE TEST

A static pressure test following the provisions of Section 5.1 shall be conducted after exposure and prior to thermal performance testing.

5.6 THERMAL PERFORMANCE TEST

A thermal performance test will be conducted on those collectors that have passed the requirements of Sections 5.1 through 5.5. The thermal performance test determines "instantaneous" efficiency of the solar collector over a wide range of operating temperatures. Efficiency is defined as the ratio of collected energy to the available energy falling upon the collector area. Collected energy is determined by the product of fluid mass flow, specific heat and integrated temperature gain across the collector. Available energy is determined by the integrated solar irradiance. Typically, four data points of at least five-minute duration are taken at each of the four different inlet fluid temperatures. For unglazed collectors, the inlet fluid temperatures include test temperatures below and above ambient air temperature. Glazed collectors are normally tested over a range of inlet fluid temperatures from near ambient to approximately 70^{o}C (126^{o}F) above ambient temperature. Unglazed collectors are normally tested over a range of inlet fluid temperatures from just above the dew point up to the point where the temperature rise across the collector is 10 times the accuracy of the differential temperature measurement.

5.6.1 TESTING METHOD

Determination of the “instantaneous” efficiency shall be done as close as possible to the ISO and ASHRAE standards referenced in sections 5.6.1.1 and 5.6.1.2, which specify the accuracy of instrumentation used for determination of energy streams and determine “instantaneous” efficiency. All deviations from these standards must be approved by SRCC prior to testing.

All sensors, signal transducers, conditioning elements, and data acquisition equipment used to measure efficiency shall have a cumulative accuracy of less than 5%.

5.6.1.1 LIQUID HEATING

The test method used for glazed collectors shall conform as close as possible to ISO 9806-1. The test method used for unglazed collectors shall conform as close as possible to ISO 9806-3 with the option that the test may be conducted at a flow rate up to 0.07 $kg/s \cdot m^2$ (0.10 gpm/ft^2). Any deviations from these standards shall be delineated in the test report.

5.6.1.2 AIR HEATING

The test method for air heating collectors shall conform as close as possible to ASHRAE 93-1986.

5.7 REVIEW OF TEST APPARATUS

The SRCC shall review all apparatus and equipment used to determine the thermal performance of the solar collector to be characterized by the thermal performance test(s) of section 6.0. The purpose of the review is to ensure that the test will result in an accurate determination of collector efficiency in accordance with the proposed test method.

The applicant shall be responsible for reimbursing the SRCC for any expenses related to the review of the test apparatus.

5.8 COLLECTOR INCIDENT ANGLE MODIFIER

The 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 shall 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. The test method shall conform as close as possible to ISO 9806-1 or ISO 9806-3.

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.

As an alternate method, the incidence angle modifier may be calculated analytically under circumstances where the optical calculations are well known and understood.

5.9 DISASSEMBLY AND FINAL INSPECTION

After exposure and performance testing, the collector shall be disassembled and causes or conditions that may lead to impairment of function or abnormally short collector life will be identified. See Section 6.0 for collector quality standards.

6.0 COLLECTOR STANDARDS

The following criteria represent the requirements for durability in collector design and construction in order to qualify for certification.

6.1 COVER PLATE

All glass cover plates shall be of a nonshattering or tempered type.

6.2 CONDENSATION

The collector shall be designed to prevent condensate build-up. The use of desiccants to control condensation will be permitted. Test reports shall note any unusual condensate build up.

6.3 PRESSURE TEST RESULTS

6.3.1 LIQUID

A collector, after testing, shall be considered passable if: (a) a loss of pressure greater than that specified in Section 5.3.3 does not occur; (b) there is no evidence of fluid leakage; and (c) there is no evidence of fluid path deterioration, e.g., swelling, stretching, etc.

6.3.2 AIR

A collector, after testing, shall be considered passable if there is no evidence of permanent fluid path deterioration, e.g., swelling, stretching, etc.

6.4 THERMAL SHOCK/WATER SPRAY 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 plate.

6.5 EXPOSURE TEST RESULTS

The test shall be terminated if it is apparent without collector disassembly that the unit no longer meets the quality requirements of Section 6.6

6.6 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 9806-2, Appendix A.14, “Final inspection results,” shall be used to report conditions observed. Listed below are the items covered.

Collector component	Potential problem
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

Conditions that, in the judgment of SRCC, may lead to abnormally short collector life will be justification for denying certification.

These conditions are:

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.

6.7 Protection of Materials

The materials used in a solar collector shall be able to withstand, without significant degradation, repeated exposure to stagnation temperatures over the life of the collector. The "stagnation temperature" is defined in Annex B of ISO 9806-2 with G_s = 1100 W/m^2 and T_{as} = 50^{o}C. "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. Examples of degradation include:

- 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.

All materials used in the collector must be identified. At the Technical Director's discretion, materials will be reviewed by the Design Review Team (DRT) for degradation potential. The applicant may be required to provide proof of the suitability of a material subjected to the stagnation conditions as defined, to the satisfaction of the DRT, prior to the material's acceptance within a certified collector. An applicant may use mechanical or other means to reduce the expected stagnation temperature, provided the means can be proven to be passive and fail-safe, to the satisfaction of the DRT.

SRCC will use Approach 1 from Annex B.1 of ISO 9806-2 to establish the stagnation temperature. An applicant may, at its expense, request that the stagnation temperature be established using Approach 2 from Annex B.2 of ISO 9806-2.