International Code Council (ICC) & Solar Rating and Certification Corporation (ICC-SRCC)

PUBLIC REVIEW DRAFT #1 (CORRECTED*)

SOLAR THERMAL COLLECTOR STANDARD

ICC 901/SRCC 100-202x

June 26, 2020

See Page 2 for Public Review Instructions. Comments due August 3, 2020.

**NOTE: The 6/5/2020 version of this document incorrectly indicated revisions to Section 401.14. The language in this section has been corrected in this 6/26/2020 version.*

PUBLIC REVIEW #1 INSTRUCTIONS

This draft document has been developed by the ICC Solar Thermal Standard Consensus Committee (IS-STSC) during a revision cycle that began in August 2019. Proposed changes to the standard were solicited between July 5, 2019 and August 31, 2019 for this standard. In a series of meetings conducted following this, the proposals were addressed, along with changes proposed by working groups appointed by the IS-STSC, resulting in this draft. This draft was balloted and approved for release for the First Public Review period by the committee in May 2020.

The First Public Review will begin on June 5, 2020 and will conclude on August 3, 2020. Any member of the public may submit comments during this time. Public comments must be submitted in accordance with the following requirements in order to be accepted and considered:

1. All public comments must be received by ICC midnight, Central Time on August 3, 2020 via e-mail (kaittaniemi@iccsafe.org), fax ((708) 799-0320) or by mail (International Code Council, 4051 W. Flossmoor Rd. Country Club Hills, IL 60478 USA).
2. All public comments must be submitted using the *ICC Standards – Public Comment Form.* This form can be downloaded from the ICC website at https://www.iccsafe.org/standards-public-forms/ and is also attached at the end of this document.
3. Public comment forms must be completed in its entirety and be signed. Electronic signatures are acceptable.
4. **COMMENTS ARE ONLY PERMITTED REGARDING SECTIONS OF THE STANDARD THAT HAVE UNDERGONE CHANGES.** Underlining is used to indicate text that has been added and text to be removed is indicated with ~~strikeout formatting~~. Comments relating to sections of the standard that have not undergone changes in this draft will not be accepted. Comments must indicate the specific section of this draft document to which they apply.
5. Comments must indicate the specific action requested. The options are: REVISE (with specific text to be changed), NEW (with specific text to be added), DELETE & SUBSTITUTE (with the specific text to be removed and replacement text) and DELETE (with the specific text to be removed). If the text to be changed, added or deleted is not provided, the comment will not be accepted.
6. Supporting information must be provided to substantiate the comment and specific action requested. If a reason statement is not provided, the comment will not be accepted.

All accepted comments will be formally considered individually by the IS-STSC after the comment period in according with ICC's standard development procedures. Meetings of the IS-STSC are open to the public. For more information on the IS-STSC, see the committee webpage at https://www.iccsafe.org/products-and-services/standards-development/is-stsc/

All standard revision processes are conducted in compliance with ICC's ANSI-approved standard development procedures. Click here for information on ICC's ANSI-approved standards development process. Any questions regarding ICC's Standard Development Procedures, this form, or the Public Comment Process should be directed to Karl Aittaniemi (kaittaniemi@iccsafe.org or (888) 422-7233 x 4205)

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CHAPTER 1 APPLICATION AND ADMINISTRATION

SECTION 101
GENERAL

101.1 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.

SECTION 102
SCOPE

102.1 Scope. This standard applies to solar thermal collectors using 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.

103 REFERENCED DOCUMENTS

103.1 Reference documents. The codes and standards referenced in this standard shall be ~~considered to be~~ part of the requirements of this standard to the prescribed extent of each such reference. Chapter 5 contains a complete list of all referenced standards.

CHAPTER 2 DEFINITIONS

201 GENERAL

201.1 General. For the purpose of this standard, the terms listed in Section 202 have the indicated meaning.

201.2 Undefined terms. The meaning of terms not specifically defined in this document or in referenced standards shall have ordinarily accepted meanings such as the context implies. Where a definition does not appear herein, informative reference is made to ISO 9488.

201.3 Interchangeability. Words, terms and phrases used in the singular include the plural and the plural the singular.

202 DEFINED TERMS

ABSORBER. 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.

~~**ABSORBER AREA.** The maximum area in which concentrated or un-concentrated solar radiation is admitted and converted to heat or power. Absorber Area does not include portions of the absorber/receiver where light is permanently screened and thermal barriers are in place.~~

ACTIVE CONTROLS. Control and actuator systems where external power and a computational device is used for operation and safety control purposes.

~~**AMBIENT AIR.** The air in the vicinity of the solar collector.~~

APERTURE AREA. The maximum area projected on a plane perpendicular to the optical normal through which the ~~un-concentrated~~ solar radiant energy is captured. ~~In a concentrating collector, the following areas are excluded: 1) any area of the reflector or refractor permanently shaded by collector elements that are opaque, such as a secondary reflector or receiver; 2) structural elements such as supports; 3) gaps between reflector segments within the collector module.~~

~~**AVAILABLE ENERGY.** The time-integrated solar irradiance.~~

~~**COLLECTED ENERGY.** The product of the fluid mass, specific heat and integrated temperature gain across the collector.~~

COLLECTOR ENCLOSURE. The structural frame that supports the components of the collector and protects internal components from the environment.

~~**COMBINED ASSEMBLY.** A solar collector with one or more subcomponents that are not physically attached within a common structure or assembly at the point of manufacture, but are assembled in the field. Once assembled, collector modules shall not vary in geometry and performance from design specifications. A combined assembly would generally be comprised of subcomponents, each with individual nameplates and serial~~

~~numbers, and might be shipped from separate facilities and manufacturers to a common location for final assembly. A building integrated collector that requires specific shared external components for normal operation is an example of a combined assembly.~~

~~**COMPLETE ASSEMBLY.** A solar collector designed and constructed as a permanent, single unit. Complete assemblies cannot be physically separated for normal operation and would generally carry a single nameplate and serial number. A single parabolic trough with mounted receiver and tracking frame is an example of a complete assembly.~~

~~**CONCENTRATING PHOTOVOLTAIC.** A solar collector that uses optical elements, such as lenses or mirrors to concentrate sunlight onto solar photovoltaic cells to generate electrical energy.~~

CONCENTRATING THERMAL COLLECTOR. A solar collector that uses optical elements to concentrate solar energy onto an absorber. Concentrating collectors include flat plate and tubular collectors with mirrors.

~~**CONCENTRATION.** The direction of a quantity of solar insolation greater than normal incident insolation onto a solar collector absorber surface.~~

CONCENTRATOR. The concentrator is that part of the concentrating thermal collector that directs ~~the~~ and focuses incident solar radiation onto ~~the~~ an absorber. Concentrators may include, but are not limited to reflectors and lenses.

CONCENTRATION RATIO. The ratio of the projected area of the concentrator to the projected area of the absorber of a concentrating solar thermal collector in any given configuration.

~~**CORROSION.** The deterioration of a substance or its properties caused by a chemical or electrochemical reaction with its environment.~~

COVER PLATE. The material or materials covering the absorber. These materials generally are used to reduce the heat loss from the absorber to the surroundings and to protect the absorber. In some collector designs, materials in the shape of a tube serve as a cover plate by enclosing the absorber. (See Transparent Covers)

CRAZING. Formation of minute surface cracks.

DELAMINATION. Separation into constituent layers, as in one layer of material separating from another.

DESIGN LIFE. Period for which a collector is expected to function at its designated capacity without major repairs.

DEGRADATION. Leading to significant permanent loss of collector performance 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 include, but are not limited to:~~

~~Outgassing from coatings or insulation that result in harmful deposits or significant structural failure or significant reduction in insulation value.~~

~~Structural weakening with permanent failure, melting, charring, ignition 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.

DISTORTION. A change witnessed or measured during testing that suggests a change to the functional dimensional integrity of a product raising safety, reliability or performance concerns.

DISTRIBUTED ASSEMBLY. A solar collector using subcomponents that are not physically attached to each another or a common structure. When fully assembled, the geometry of the assembly can vary from module to module because of customization of design or installation. Distributed assemblies have the potential to be scaled by subcomponent count and collector geometry without changes to actual subcomponent specifications. An example of a distributed assembly would be a central receiver design where layout or count of heliostats can vary while the central receiver, and individual heliostat module designs and specifications remain fixed.

DRY COLLECTORS. Collectors where heat transfer fluid is not shared with other external components as part of a heat transfer loop.

FAIL-SAFE. An operating condition of a collector, where collector protection functions will continue under all collector and system failure modes.

FLAT-PLATE COLLECTOR. A solar collector, either liquid or air, in which the surface absorbing the incident radiation is essentially flat and employs no concentration. In this document the term refers to all collectors designed to perform satisfactorily with all parts of the collector in fixed positions.

FLUID. A substance that can flow and does not maintain a fixed shape. Gases and liquids are considered to be fluids.

GLAZED. A typed of solar collector with a cover over the absorber plate

GROSS AREA. The maximum projected area of the complete module, including integral mounting means.

HAIL. Precipitation in the form of small balls or lumps, usually consisting of concentric layers of clear ice and compact snow.

HEAT TRANSFER FLUID. Air, water, or other fluid that is used to transfer thermal energy between collectors and other components in a system.

INTEGRATED COLLECTOR STORAGE (ICS). Acronym for Ss olar collectors in which the solar energy collection function is integrated with storage of the heated fluid, thus: Integral Collector Storage collector. In this type of collector the collection and storage functions cannot be separated for testing or operation.

INCIDENT ANGLE MODIFIER (IAM). The measurement of changes in collector efficiency as a function of the angle at which light enters the aperture.

INSTANTANEOUS EFFICIENCY. 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 that collectively are responsible for the overall thermal performance and physical structure of the solar collector.~~

IRRADIANCE. The rate of solar radiation received by a unit surface area in unit time. Irradiance is expressed in Btu per hour square ft. (Btu/hr-ft.^{2}) or (W/m^2).

IRRADIANCE, BEAM. Irradiance, on a defined plane, originating from a narrow solid angle centered on a solar disk.

IRRADIANCE, DIFFUSE. Scattered irradiance, on a defined plane, originating from outside the solar disk.

IRRADIANCE, GLOBAL. Hemispherical irradiance on a horizontal surface.

IRRADIANCE, HEMISPHERICAL. The sum of direct and diffuse irradiance.

MANUAL. The total documentation package provided by the supplier to the purchaser that describes the installation, operation, and maintenance of the collector.

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. A condition where thermal energy is not transferred from the collector by means of heat transfer fluid flow.

NON-CONCENTRATING SOLAR THERMAL COLLECTOR. A solar collector without optical elements that ~~redirect~~ concentrate incident solar radiation onto ~~an integral flat~~an absorber.

~~**NORMAL SOLAR ANGLE, GEOMETRIC.** An imaginary line perpendicular to the surface of an optical medium. The word normal is used in the mathematical sense, meaning perpendicular.~~

OPTICAL NORMAL SOLAR ANGLE. The angle at which the sun is perpendicular to each axis of the solar collector optical plane, as determined by the manufacturer. The aperture optical plane can be characterized as an invisible datum plane that can be orthogonal to or have any symmetrical relationship to the aperture, reflecting elements, heat collecting apparatus, or the solar collector frame. An optical based definition of the normal solar angle is necessary when the collector is geometrically asymmetrical or has a tailored and non-symmetrical solar response.

OUTGASSING. The generation of vapors by solar collector components or construction materials usually occurring during periods of solar collector exposure to elevated temperatures or reduced pressure.

~~**PASSIVE.** An operating condition of a solar concentrating collector where human or mechanical intervention is not required for operation as intended.~~

PASSIVE CONTROLS. Control ~~and actuation~~ systems used to maintain safe operating conditions where an external energy source is not required ~~and computational device is not used~~.

PHOTOVOLTAIC THERMAL HYBRID SOLAR COLLECTOR (PVT). A photovoltaic thermal hybrid solar collector is a solar collector using photovoltaic panels or cells as a thermal absorber and therefore converts solar radiation into electrical and thermal energy.

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

POWER. The amount of energy produced over time, expressed as watts or Btu per hour.

PYRANOMETER. A radiometer used to measure the total *hemispherical irradiance* incident on a surface.

RECEIVER. The part of the solar collector to which the solar irradiance is finally directed or redirected, including the absorber and any associated glazing through which the redirected energy must pass.

REFLECTOR OR REFLECTIVE SURFACE. A surface intended for the primary function of reflecting radiant energy.

SITE DEPENDENT COLLECTOR. A collector intended to be assembled only at the site of its application because the fully assembled size of the collector or other construction characteristics make delivery in operational form impractical.

SOLAR ENERGY. Energy originating from the sun's radiation primarily encountered in the wavelength region from 0.3 to 3.0 micrometers.

SOLAR THERMAL COLLECTOR. A device designed to absorb solar radiation and to transfer the ~~thermal~~ energy ~~so produced~~ to ~~a fluid passing through it~~thermal energy in a fluid.

STAGNATION. The solar collector temperature at which the energy gain is balanced by the heat loss.

~~**STANDARD.** A document that specifies the performance, durability, or safety requirements of a product.~~

THERMAL EFFICIENCY. The ratio of thermal energy removed from a collector to the available solar energy falling upon the collector area.

TIME CONSTANT. The time required for the fluid leaving a solar collector to attain 63.2% of its steady state value following a step change in solar radiation or inlet fluid temperature.

TRACKING SOLAR COLLECTOR. A solar collector that moves ~~so as~~ to follow the apparent motion of the sun. Tracking can be accomplished by rotation about a single axis in the transverse direction for tracking the sun through the day or by longitudinal adjustment. Two axis tracking can be employed to ~~precisely~~ track the sun in both the longitudinal and transverse axes.

~~**TRANSPARENT COVER.** Radiation-transmitting material covering the absorber.~~

~~**TRANSFER FLUID.** A medium such as air, water, or other fluid that passes through or comes in contact with a system component, such as the solar collector, and carries thermal energy to another component.~~

TRANSPIRED. A type of solar collector in which fluid is drawn through holes in the absorber plate rather than flowing through tubes or across the absorber plate.

UNGLAZED. A type of solar collector without a cover over the absorber plate.

WET COLLECTOR. A concentrating collector where thermal subcomponents share a common heat transfer fluid with and are part of a fluid circuit with external components.

CHAPTER 3 GENERAL REQUIREMENTS

301
~~GENERAL~~DESIGN & CONSTRUCTION

301.1 ~~Collector standards~~.Design and construction General. This chapter establishes minimum requirements for durability and safety in collector design and construction.

301.2 Operating conditions. Solar thermal collectors shall be designed to operate within manufacturer(s) specified pressure and temperature ranges and shall be designed to withstand environmental extremes anticipated in actual service without reducing the *design life* of the collector.

301.2.1 Stagnation. The collector shall be able to withstand *stagnation* without degradation of performance and with no maintenance. This requirement includes conditions that occur during loss of electric power to the collector, if applicable.

301.2.2 Freeze tolerance. Where the collector is designated as "Freeze-Tolerant", it shall be designed to withstand freezing conditions without damaging the collector or reducing the design life of the collector. Freeze tolerance must be verified by means of the Freeze Resistance Test specified in Section 401.10.

301.2.3 Condensation. Solar thermal collectors shall be designed to prevent condensate build-up within the collector.

301.2.4 Impact resistance. Solar thermal collectors shall be designed to withstand impact from hail, sleet and other anticipated wind-borne materials consistent with the intended use. Impact resistance shall be quantified by means of the Impact Resistance Test specified in Section 401.19, as applicable.

301.2.5 Mechanical loading. Solar thermal collectors shall be designed to withstand wind and snow loads consistent with the intended use. Compliance shall be assessed by means of the Mechanical Load Test specified in Section 401.18, as applicable.

301.2.6 Supply pressure. Solar thermal collectors subjected to pressure from building water distribution systems shall be designed to withstand 100 psi without the use of a pressure-reducing valve.

301.3 Roof-Integrated Collectors. Where solar thermal collectors are integrated into a roof assembly or serve as the roof covering for a building, they shall comply with the Chapter 15 of the International Building Code or Chapter 9 of the International Residential Code, as applicable.

301.4 Electrical safety. Electrical wiring shall be sized and installed in accordance with NFPA 70. Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the device and NFPA 70.

301.5 Protection of piping. Exterior piping and pipe insulation incorporated into the collector shall be protected from ultraviolet radiation, corrosion, degradation and moisture damage and shall be approved for outdoor use.

301.6 Pipe connections. Where pipe threads are used to connect to the solar water heating system, they shall comply with ASME B1.20.1. Where hose threads are used to connect to the solar water heating system, they shall comply with ASME B1.20.7. Where push-fit fittings are used to connect to a solar water heating system under street pressure, they shall comply with ASSE 1061.

302
MATERIALS

302.1 General. Solar thermal collectors shall be compatible with fluids approved for use with the collector under the design operating conditions.

302.1.1 Protection of combustible materials. Combustible materials used in solar equipment shall not be exposed to temperatures that could cause ignition.

302.1.2 Solar degradation. Materials exposed to direct sunlight shall not be affected by exposure to sunlight to an extent that will deteriorate their function beyond design specifications during their *design life*.

302.1.3 Incompatible materials. Incompatible materials shall be isolated or treated to prevent degradation to the extent that their function could be impaired under in-service conditions.

302.1.4 Protection of potable water from contamination. Materials that come in direct contact with *potable water* shall not adversely affect the taste, odor or physical quality and appearance of the water and shall comply with NSF 61 and NSF 372, and shall have a weighted average lead content of 0.25 percent or less.

302.2 Glazing. Glazing incorporated into solar thermal collectors shall comply with the requirements of this section.

302.2.1 Tempered glass. Where the outer cover of a solar collector is flat and constructed of glass, the glass shall be tempered in accordance with ASTM C1048 or equivalent.

302.2.2 Light-transmitting plastics. Light-transmitting plastics, including thermoplastic, thermosetting or reinforced thermosetting plastic material, shall have a self-ignition temperature of 650°F (343 °C) or greater where tested in accordance with ASTM D1929; a smoke-developed index not greater than 450 where tested in the manner intended for use in accordance with ASTM E84 or UL 723, or a maximum average smoke density rating not greater than 75 where tested in the thickness intended for use in accordance with ASTM D2843 and shall conform to one of the following combustibility classifications:

Class CC1: Plastic materials that have a burning extent of 1 inch (25 mm) or less where tested at a nominal thickness of 0.060 inch (1.5 mm), or in the thickness intended for use, in accordance with ASTM D635.

Class CC2: Plastic materials that have a burning rate of 2 ½ inches per minute (1.06 mm/s) or less where tested at a nominal thickness of 0.060 inch (1.5 mm), or in the thickness intended for use, in accordance with ASTM D635.

302.3.1 Pipe insulation. Pipe insulation installed as part of solar thermal collectors shall be tested in accordance with ASTM E84 or UL 723.

302.4 Solar air heating collector materials. *Solar air heating* construction materials that are exposed to the airflow shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723.

302.2 Non-concentrating solar collectors. Materials used in the construction of non-concentrating solar collectors shall withstand not less than 1000 hours per year at stagnation temperature without significant degradation over the design life. Stagnation temperature shall be determined in accordance with ISO 9806, Section 10.

302.3 Concentrating solar collectors. Materials used in the construction of concentrating solar collectors shall withstand the maximum temperature to which the solar collector is tested in accordance with ~~307.2.1 and 307.2.2~~401.6.

~~**302.3.1 No controls employed**. If controls are not employed, collector stagnation temperature shall be determined in accordance with ISO 9806, Section 10.~~

~~**302.3.2 Controls employed**. If controls are employed, collector stagnation temperature shall be determined in accordance with manufacturer's stated maximum operating temperature.~~

~~**302.4 Photovoltaic collectors.** When a photovoltaic module is incorporated into the collector design, the photovoltaic module shall be listed and labeled to UL 1703.~~

~~**Exception:** The photovoltaic module portion of a photovoltaic-thermal collector shall comply with UL 1703.~~

303
COMPONENTS

303.1 General. Individually listed components incorporated into solar thermal collector assemblies shall comply with the requirements of this section.

303.2 Plumbing components. Where pressure reducing valves, vacuum relief valves, pressure relief valves, check valves, backflow preventers, expansion tanks, hot water storage tanks, piping or pipe fittings are incorporated within the collector, they shall comply with ICC 900/SRCC 300.

303.2 Electrical components. Electrically powered components over 24 volts installed within collectors shall be listed and labeled to standards referenced by NFPA 70 or CSA C22.1.

303.2.1 Photovoltaic modules. Photovoltaic modules incorporated as part of photovoltaic thermal hybrid collectors shall be listed and labeled to UL 1703 or UL 61730.

303.2.2 Electrical heating elements. Electrical heating elements incorporated as part of solar thermal collectors shall comply with ICC 900/SRCC 300.

CHAPTER 4 TESTING METHODS REQUIREMENTS

401
REQUIREMENTSGENERAL

401.1 General. Minimum testing requirements for solar collectors shall be in accordance with Sections 401.2 through 401.19

401.2 Testing requirements. Table 401.2 specifies the tests that shall 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 if two collectors are used to complete testing requirements. The testing sequence is determined by identifying the type of collector, identifying the method of testing to be used, and then following the requirements in Table 401.2 (a) and 401.2 (b) and sections 401.2.1 and 401.2.2.

401.2.1 Methods for conducting tests. There are two methods for conducting the test and Table 401.2 demonstrates the appropriate requirements for each type of collector and each method as follows:

1. When all of the tests are conducted on a single collector, the testing requirements for each type of collector are designated with the column heading "1."
2. When two collectors are tested, one shall be subjected to the qualification tests, designated in column heading of "2Q", and the other shall be subjected to the performance tests, designated in column heading of "2P."

401.2.2 Active mechanisms. If the collector assembly has active mechanisms that are intended to be functional during operation, those mechanisms shall be operational during all testing. The function and activation of all controls during testing shall be reported.

401.2.3 Testing sequence. The test sequence shall follow the order as listed in Table 401.3.

Exceptions:

1. The following tests can be conducted in any sequence relative to each other: thermal capacity and time constant, thermal performance, incident angle modifier, pressure drop.
2. The following tests can be conducted in any sequence relative to each other: high-temperature resistance, exposure, external thermal shock, internal thermal shock
3. All solar collectors containing heat pipes shall be subjected to the exposure test in accordance with Section 401.7, 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.
4. It is permissible to conduct the internal pressure test according to Section 401.9 to confirm the flow passages are in a condition suitable for testing.

401.2.4 PVT Assemblies. All tests shall be conducted using the fully assembled PVT, with all electrical generation and solar thermal components installed. Testing prescribed below shall be conducted where the electrical power generation components are not connected to any electrical load, in an open-circuit configuration in accordance with ISO 9806, Section 5.2.3.1. The operating mode of the electrical generating components shall be reported for all tests in accordance with ISO 9806, Section 5.2.3.2.

> **Exception**: Thermal Performance Testing shall be conducted with electrical power generation components operating at maximum power as specified in ISO 9806, Section 5.2.3.1.

TABLE 401.2(a)

SOLAR LIQUID HEATING COLLECTOR TEST REQUIREMENTS

TEST	SECTION	UNGLAZED			GLAZED (FLAT PLATE, TUBULAR)			PROTECTED BY CONTROLS (UNABLE TO WITHSTAND DRY STAGNATION)			NONSEPARABLE STORAGE (ICS)		
		1	2 Q	2 P	1	2 Q	2 P	1	2 Q	2 P	1	2 Q	2 P
~~Test Specimen Selection~~	~~401.3~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
~~Baseline Inspection~~	~~401.4~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
High-Temperature Resistance	401.5	X	X		X	X		X	X		X	X	
Stagnation Temperature	401.6	X	X		X	X					X	X	
Exposure	401.7	X	X		X	X		X	X		X	X	
External Thermal Shock	401.8.1	X	X		X	X		X	X		X	X	
Internal Thermal Shock	401.8.2	X	X		X	X					X	X	
Internal Pressure	401.9	X	X		X	X		X	X		X	X	
Freeze Resistance (only when freeze tolerance claimed)	401.12	X	X		X	X		X	X		X	X	
Thermal Capacity/Time Constant	401.13	X		X	X		X	X		X	X		X
Thermal Performance	401.14.1	X		X	X		X	X		X			
Thermal Performance	401.14.2										X		X
Incident Angle Modifier	401.15	X		X	X		X	X		X			
Pressure Drop (optional)	401.16	~~X~~	~~O~~	~~O~~	~~X~~	~~O~~	~~O~~	~~X~~	~~O~~	~~O~~			
Rain Penetration ~~(glazed only)~~	401.17				~~X~~	~~X~~		~~X~~	~~X~~		~~X~~	~~X~~	
Mechanical Load	401.18				X	X		X	X		X	X	
Impact Resistance	~~302.1~~401.19	X	X		X	X		X	X		X	X	
~~Final Inspection~~	~~401.19~~	~~X~~	~~X~~		~~X~~	~~X~~		~~X~~	~~X~~		~~X~~	~~X~~	

TABLE 401.2(b)3

SOLAR AIR HEATING COLLECTOR TEST REQUIREMENTS

TEST	SECTION	CLOSED LOOP			TRANSPIRED		
		1	2 Q	2 P	1	2 Q	2 P
~~Test Specimen Selection~~	~~401.3~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
~~Baseline Inspection~~	~~401.4~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
High-Temperature Resistance	401.5	X	X		X	X	
Stagnation Temperature	401.6	X	X		X	X	
Exposure	401.7	X	X		X	X	
External Thermal Shock	401.8.1	X	X		X	X	
Internal Thermal Shock	401.8.2	X	X		X	X	
Leakage	401.10	X	X				
Rupture & Collapse	401.11	X	X		X	X	
Thermal Capacity/Time Constant	401.13	X		X	X		X
Thermal Performance	401.14.1	X		X	X		X
Incident Angle Modifier	401.15	X		X	X		X
Pressure Drop	401.16	X	O	O			
Rain Penetration (glazed only)	401.17	X	X				
Mechanical Load	401.18	X	X		X	X	

TEST	SECTION	CLOSED LOOP			TRANSPIRED		
		1	2 Q	2 P	1	2 Q	2 P
Impact Resistance	~~302.1~~<u>401.19</u>	X	X		X	X	
~~Final Inspection~~	~~401.19~~	~~X~~	~~X~~		~~X~~	~~X~~	

401.3 ~~Test specimen~~ Sample selection for laboratory testing. Collectors to be tested in a testing laboratory shall be selected at random in accordance with Sections 401.3.1 through 401.3.2.

401.3.1 Selection method. Random selection of test collectors shall be accomplished through a personal visit by the laboratory, certification body, or authority having jurisdiction or selection from photographs of the collectors in stock. The selected collectors, or collector components, shall be affixed with non-removable serial numbered labels.

401.3.2 Selection process. Collectors shall be randomly selected from a group of at least five collectors. Where final assembly of the collector components occurs only at the installation site, each of the components shall be randomly selected from a group of at least five components. The collector's final assembly geometry shall not change from its design specification.

Exceptions:

- Large collectors greater than 4.6 m^2 (50 ft^2) shall be randomly selected from a group of at least two collectors where either:

  1.1 Transport in a fully-constructed condition is impractical.

  1.2 Collectors are not inventoried in a fully-constructed condition.

- ~~If the collector design to be tested is always built for a specific installation, the collector is to be tested in-situ without random selection.~~

- For distributed assembly solar concentrating collectors where the subcomponents are not physically connected to each other, the manufacturer shall specify the geometric parameters and configuration of all subcomponents and the total collector.

  3.1 Parameters shall include orientation, distance, height, and angle of all solar collector subcomponents in relation to each another and the installation site, including the quantity of each.

  3.2 The manufacturer's specifications shall include minimum and maximum values for each geometric parameter defining the configuration's final assembly with minimum and maximum operating specifications.

  3.3 The configuration(s) to be tested shall fall within these specified ranges, representing operating conditions closest to the minimum and maximum allowed. The most rigorous test conditions applicable shall be used.

401.3 In-Situ Testing. Collectors that are unable to be tested in due to size or transportability or are designed for a specific installation may be tested in-situ, in whole or in part.

401.4 Baseline inspection. The collectors shall be tested as received from the manufacturer when assembled per manufacturers' documentation. Test specimens shall be inspected prior to testing and any visible damage or assembly flaws shall be recorded. Documentation shall include photographs of the collector or its constituent parts, as received, showing all visible surfaces. Any abnormalities shall be noted and photographed in detail.

> **401.4.1 PVT Inspection.** Collectors Where the electrical generation and thermal components are received separately or in a disassembled state, inspection shall be conducted prior to assembly. Following assembly in accordance with manufacturer's documentation, the completed assembly shall also be inspected.
>
> In addition to the inspection and reporting prescribed in Section 401.4, photovoltaic cells shall be inspected, and any abnormalities noted and photographed in detail. Photovoltaic component abnormalities include but are not limited to physical damage, melted solder, enclosure openings, delamination, and burn spots.

402 Test Methods

The solar absorptivity and emissivity of absorbers in ~~a perforated or non-perforated, metal~~open loop solar air heating ~~absorbers' colour (coating) be measured and recorded at time of testing~~in accordance with ASTM C1549. The -measured value shall be reported with the with the coating type, manufacturer and color ~~stated absorptivity~~ and emissivity ~~of the same color manufacturer.~~

The manufacturer of the solar air heating system incorporating a perforated or non‐perforated, metal solar air heating absorber is to provide 6" x 6" samples of all colour per coating options provided by the coatings' manufacturer for their product including colour name, number and its solar absorptivity.

401.5 High temperature resistance test. A high temperature resistance test shall be performed as specified in Section 9 of ISO 9806.

401.6 Stagnation temperature. The collector stagnation temperature shall be determined as specified ~~in Section 10 of ISO 9806~~in Section 401.6.1 and 401.6.2.

> **401.6.1 No controls employed**. If controls are not employed, collector's standard stagnation temperature shall be determined in accordance with ISO 9806, Section 10.
>
> > **Exception:** Stagnation temperature testing for PVT collectors shall be performed as specified in ISO 9806, Section 9.4. The standard stagnation temperature shall be calculated as specified in ISO 9806, Clause 9.3.
>
> **401.6.2 Controls employed**. If fail-safe controls are employed, collector's standard stagnation temperature shall be determined in accordance with manufacturer's stated maximum operating temperature.

401.7 Exposure test. Exposure testing shall be in accordance with Section ~~11~~ 10 of ISO 9806, using a minimum of Class B climate conditions, for no less than 30 days of exposure to adverse conditions.

401.7.1 PVT Exposure testing. Exposure testing shall be performed as specified in ISO 9806, Section 10 for a half-exposure, using a minimum of Class B climate conditions, for no less than 15 days of exposure to adverse conditions for all PVT types.

Exception: Where the PVT assembly is subjected to Damp Heat and Thermal Cycling (DH + TC) tests as specified in UL 1703 or UL 61730, and the stagnation temperature (as determined by the efficiency equation or using active controls) is below 85 °C, exposure testing per ISO 9806, Section 10, shall be considered to be satisfied.

401.8 Thermal shock tests. All collectors shall comply with Sections 401.8.1 through 401.8.7.

401.8.1 Outdoor testing option. When testing is conducted outdoors, each shock shall be performed on a different day.

401.8.2 Indoor testing option. When testing is conducted indoors under a solar simulator, it is permissible to conduct multiple shock tests on the same day provided the collector is allowed to cool to ambient air temperature between shock tests.

401.8.3 Factory sealed containers. When the solar collector design incorporates one or more factory-sealed containers charged with a refrigerant, other fluid, or phase-change material, these containers shall not be removed for these tests.

401.8.4 Test failure. Any test specimen having integrity that is permanently compromised by this test such that it obviously will not be able to perform shall be considered to have failed the test.

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

401.8.4.2 Thermal Shock/Water Spray. The collector structure and performance shall not be degraded by moisture penetration. There shall not be cracking, crazing, warping or buckling of the *cover plate*.

401.8.4.3 Thermal Shock/Cold Fill. The collector's fluid pathway shall not leak. The absorber shall not be permanently distorted such that performance is degraded.

401.8.5 External thermal shock/water spray test. Two external thermal shock tests shall be performed as specified in ISO 9806, Section 12, using a minimum of Class B conditions.

Exception: External thermal shock testing shall only be required for PVT collectors where any portion of the fluid channels extends beyond the photovoltaic cells and is therefore exposed to direct solar irradiance. In this case, external thermal shock testing shall be performed as specified in ICC 901/SRCC 100, Section 401.8.6.

401.8.6 Internal thermal shock/cold fill test. Two internal thermal shock tests shall be performed as specified in ISO 9806, Section 13, using a minimum of Class B conditions. All parts of the solar collector assembly that are not factory sealed shall be subjected to this test.

Exception: This test is not applicable to collectors in which heat transfer fluid is continuously flowing for protection purposes. In such cases, control(s) used to manage a no-flow condition shall be validated to be functional in such a way that any failure can be detected. Control functions that have been verified shall be described and reported with the test results.

401.9 Internal pressure test. An internal pressure test shall be performed as specified in ISO 9806, Section 6.

401.9.1 Liquid. A collector, after testing, shall be considered to be passable if: 1) a loss of pressure greater than that specified in Section 401.5.1.2 – 4 does not occur; 2) there is no evidence of fluid leakage; 3) there is no evidence of fluid path deterioration, including but not limited to swelling and stretching.

401.9.2 Air. A collector, after testing, shall be considered to be passable if there is no evidence of permanent fluid path deterioration, including but not limited to swelling and stretching.

401.10 Leakage test. A leakage test shall be performed on closed loop air heating collectors as specified in ISO 9806, Section 7.

401.11 Rupture and collapse test. A rupture and collapse test shall be performed on air heating collectors as specified in ISO 9806, Section 8.

401.12 Freeze resistance test. A freeze resistance test shall be performed on collectors claimed to be resistant to freezing as specified in ISO 9806, Section 15.

401.12.1 Freeze resistance test for heat pipes used in solar collectors. All heat pipes used in solar collectors claiming freeze tolerance shall meet the requirements of 401.14.1.1 through 401.14.1.9

401.12.1.1 Purpose. This test evaluates the impact of freeze/thaw cycles on heat pipes. The test shall be performed in a controllable climate chamber for the duration of a set number of freeze and thaw cycles (see Table 401.16.1.6.1).

This test shall be performed on heat pipes that are part of the solar collector submitted for testing, regardless of the collector loop design heat transfer fluid

401.12.1.2 Selection. During the disassembly phase (401.20) of the testing protocol, 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 is permissible to destroy part of the collector (evacuated tubes, collector housing, etc.) to extract the heat pipes. However, when the heat 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.

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

401.12.1.4 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.

401.12.1.5 Temperature sensors. Two heat pipes shall have a temperature sensor attached to ensure an accurate and average temperature is measured. Each temperature sensor, shall have a maximum standard uncertainty of +/- 1 K and shall be mechanically and thermally attached to the outside of 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 specified in 401.14.3. The temperature indicated by these sensors shall be assumed to represent the temperature of the fluid inside the heat pipe.

> **Exception.** When the heat pipe 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 if a temperature sensor is placed inside one of the heat pipes. 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.

401.12.1.6 Test Conditions. All conditions in Table 401.14.1.6.1 shall be met.

Table 401.14.1.6.1

REQUIRED TEST CONDITIONS

TEST PARAMETER	REQUIRED VALUE
Tilt angle	The highest of 60^{o} or the manufacturer's highest recommended tilt angle
Freezing temperature	Negative 20 +/- 2^{o}C
Freezing time	The temperature sensor shall indicate the freezing temperature for at least 30 minutes per cycle
Thawing temperature	Positive 10 +/- 2^{o}C
Thawing time	The temperature sensor shall indicate the thawing temperature for at least 30 minutes per cycle
Number of cycles	20

401.12.1.6 Intermediate inspection. 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 or burst pipe) as a result of the freeze/thaw cycling in any of the test samples, the test shall be terminated.

401.12.1.7 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.

401.12.1.8 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 the procedure as defined in sections 401.14.1.1 through 401.14.1.8.

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

401.14 Thermal performance test. Thermal performance testing of solar thermal collectors shall be performed as specified in Sections 401.16.1 or 401.16.2.

[NOTE: The 6/5/2020 version of this document incorrectly included two new sentences that would have required all thermal performance tests to be conducted indoors. This language was submitted in a proposal that was disapproved by the technical committee, and therefore should not have been included in the Public Review document. The Public Review Draft has been corrected in this 6/26/2020 version and the language has been removed.]

401.14.1 Collectors containing no internal storage. Thermal performance testing of collectors that do not contain internal storage shall be performed as specified in ISO 9806, Section 20.

401.14.1.1 PVT Thermal performance testing. Thermal performance testing for PVTs shall be conducted with the electrical power generation components at maximum electrical power production (MPP) in accordance with Section 401.2.3.

401.14.2 Collectors containing storage. Additional testing shall be required for collectors containing storage because the mass of the storage precludes measurement of instantaneous efficiency. Such collectors include both integral collector storage designs and thermosiphon designs where the collection function cannot be separated from the storage function for testing. Such collectors shall be subjected to the applicable tests described in Sections 401.14.2.1 through 401.14.2.2

401.14.2.1 General testing procedures. Test objects shall be mounted in a manner that is similar to the intended usage. This requirement includes the use of such devices as reflectors and roof support structures. The hydraulic, thermal and optical characteristics shall be reproduced during the test.

401.14.2.1.1 Testing with fluid other than water. Where testing with a fluid other than water, fluid composition tests shall be performed to ensure that the specified fluid composition exists. At a minimum, a hygrometer test or its equivalent shall be performed and checked with the fluid specification before proceeding with the test.

401.14.2.1.2 Pre-heating heat exchanger. In any collector with a heat exchanger containing more than 2.5% by volume of the storage vessel volume, the heat exchanger shall be preheated to the same temperature as the rest of the collector for all tests. This heat exchanger shall not be directly purged at the end of the test. The energy within it shall be purged in the normal operating fashion.

401.14.2.1.3 Manufacturers recommended operating conditions. Performance testing shall not be performed in excess of manufacturers recommended operating conditions. Adjustment of test operating conditions is permissible to conform to the intent of the test. Flowrate should be specified by the manufacturer. When multiple sizes extrapolated from one test, the flowrate should be specified per unit gross area. Flow rate specification should be achievable in real - world installations.

401.14.2.1.4. Required instrumentation accuracy and resolution. Table 401.16.2.1.4 indicates the required assurances for the instrumentation used in the tests required in 401.14.2. The radiation measurements shall be performed with devices that meet the standards of the World Meteorological Organization for a first class pyranometer or pyrheliometer. The data resolution shall be not lower than the stated accuracy. The test lab shall ensure that data is checked for any offsets immediately prior to and at the conclusion of the test. Offsets shall be applied to the processed data and noted in the test report.

Table 401.14.2.1.4
INSTRUMENTATION ACCURACIES

VALUE TO BE MEASURED	ACCURACY SI UNITS (±)	ACCURACY IP UNITS (±)
Temperature	0.1˚C (0.1˚C)	0.2˚F (0.2˚F)
Temperature Difference	0.1 K (0.1 K)	0.2 R (0.2 R)
Mass	1%	1%
Fossil Fuel Usage	1%	1%
Air Flow	1%	1%
Liquid Flow	1% measured mass value	1% measured mass value

401.14.2.1.5 Minimum Data Time Step. Data shall be sampled with at a maximum interval of fifteen-seconds. This data shall be averaged and reported at a maximum rate of 5 minutes for long-term tests having a duration longer than 1 day or 0.5 minutes for short-term tests. Because of the interaction with the transient system simulation software, which uses a fixed time step, data for all collected channels shall be reported in fixed time steps. Note that any test using an energy purge shall be measured with the highest data resolution available at the laboratory.

401.14.2.1.6 Instrument Calibration. Calibration of instrumentation used in the testing setup shall be traceable to a national standard and be performed at least annually.

401.14.2.1.7. Required Experimental Data. The data specified in Sections 401.14.2.8.1 through 401.14.2.8.3 is required.

401.14.2.1.7.1 Required Numerical Data. The minimum real time data to be collected for the tests shall consist of the following in metric units. Data channels shall be reported on a regular time interval. Channels not used in a particular test shall be populated with a value not found elsewhere in the data for that channel. The test lab shall review for and address any missing or erroneous data. This data reduction shall occur prior to submission for modeling.

401.14.2.1.7.1.1 Data gaps or corrections. Gaps or corrections for critical data shall not last longer than 10 minutes during non-purge periods. During purge periods, critical data shall not be missing or erroneous. The missing or adjusted data shall be filled in using proxy measurements or interpolation to existing data and highlighted in the data set and noted in the test report.

401.14.2.1.7.1.2 Log requirements. A log indicating the timing of the draw, purge, and irradiation start and stop times shall be included. Other data including site elevation, longitude, latitude, and test sample orientation shall be supplied. Any data sets that do not meet these minimum requirements shall be excluded from the analysis. Required data includes:

1. Data collection time, both local and solar, and date and day of year (*dd-mm-yyyy*)
    2. Inlet temperature(s) (ºC)
    3. Outlet temperature(s) (ºC)
    4. Ambient temperature (i.e. “Outside”, if applicable) (ºC)
    5. Environmental temperature (i.e. “Inside”, if applicable) (ºC)
    6. Flow Rate(s) (kg/hr)
    7. Fluid heat capacities(s) (kJ/kg- ºC)
    8. Wind velocity (m/s)
    9. Auxiliary energy usage (if applicable) kJ
    10. Radiation measurements (kJ/m^2)
        a. Total surface
        b. Total horizontal
        c. Horizontal diffuse
        d. Horizontal infrared, integral collector storage and unglazed collectors only

401.14.2.1.7.2 Required Physical Data. Easily accessible significant characteristics of the component or collector shall be measured and reported in consistent sets of units, including:

- Diameters, lengths and widths, internal and external.
- Lengths, internal and external, and spacing of tubes and fins.
- Heights, internal and external, minimum and maximum water levels shall be denoted.
- Thickness, such as insulation, tank shell, tank vessel, and fins.
- Volumes at ambient air temperature of the tank and any integral heat exchangers.
- A diagram indicating geometry including vessel, shell, and any protrusions such as heat exchangers and plumbing connections.
- Materials used for vessel, including insulation, shell, tank liner, and heat exchangers.
- Piping lengths and orientations.
- Slope of components.

401.14.2.1.7.3 Additional required documentation. The following documentation shall be provided:

- Equipment model number(s)
- Description of the test method(s) and any deviations from the standard method.
- Photographs of any applicable equipment.

401.14.2.1.8 Laboratory process. The testing and analytical work shall consist of these steps:

1. The test lab shall determine physical parameters from the tests
2. The test lab shall collect extended test data from warm up tests
3. The test lab shall prepare the data in the format requested by the certification body.
4. The certification body shall create a model using transient system simulation software.

401.14.2.1.9 Data Processing Methods. These tests shall provide data for computer modeling of collectors and or collector components. The method of modeling shall depend upon the test and available transient system simulation software models. The certification body will provide direction for new and innovative collector tests that are not explicitly covered in this test method.

401.14.2.1.9.1 Use of real-time data. The calculation of temperature dependent densities and heat capacities shall be performed using real-time data by the test lab. Data reduction shall include the filtering out of any erroneous data. The delivered energy value shall be used where matching net delivered energy with the transient system simulation software. It is permissible to not adjust this value if the simulation software accounts for energy changes caused by different starting and ending temperatures and losses from the collector during the purge period. Data should not be utilized for determining the performance of a collector until the test has achieved a steady‐state result for 15 minutes. Steady‐state is determined by a stabilized outlet temperature for a given inlet temperature and environmental condition.

401.14.2.1.9.2 Data consistency. All data shall be consistent with the test conditions. When the pyranometer and pyrheliometer are not covered by the collector cover, the visual radiation shall be set to zero and the sky infrared radiation shall be adjusted to an equivalent sky radiation to account for the covering of the collector during the purge period. Any adjustments shall be noted in the test report.

401.14.2.1.9.3 Processing for component model calibration using transient system simulation software. Upon receipt of the processed data, the certification body shall create a series of computer models using transient system simulation software. One model shall be created for each test. This model is called the "audit" model. Each of the audit models is then fit to the test data as indicated in items 1 through 4:

1. Collector heat loss shall be determined as follows:
   1.1 When both capacitance and heat loss tests are performed, the results from the heat loss test and capacitance tests shall be iterated upon until a final value of collector loss rate is determined. The loss value shall be used directly in the model. No other explicit fit is required at this point.
   1.2 When only the heat loss test is performed, the results are used to calibrate a transient system simulation software computer model. The loss value shall be used directly in the model. No other explicit fit is required at this point.

2. Parameters for heat exchangers integral to a collector shall be used directly in the model. No other explicit calibration is required

at this point. The calibration is done by minimizing the chi-squared value for all data sets.

3. The data from each of the individual data points in the warm-up tests shall be used to calibrate a transient system simulation software computer model using the FR_{TA} and FR_{UL} isothermal initial conditions. A calibration routine shall be used to compare the observed net, solar or auxiliary energy deliveries to the observed data points (one per test). The calibration is done by minimizing the chi-squared value for all data sets.

   For integral collector storage collectors, the F_RUL adjustment is actually a UA_{loss} adjustment since there is no F_RUL data point. (Note that the ICS night time loss test shall be calibrated as part of the data set). The net result of this process is two points ($F_R\tau\alpha$ and F_RUL) that are used in the transient system simulation software model.

4. When the collector is initially stratified due to the presence of an auxiliary heater, a separate set of tests and calibrations shall be done. This is required when a heater is located within the storage vessel of a thermosiphon collector.

401.14.2.2 Specific testing procedures. Collectors containing internal storage shall be tested using the procedures described in ISO 9459-4, Annex C, with the following clarifications:

1. During the collector purge described in ISO 9459-4, Section B.2, a bypass loop shall be used to pre-condition the inlet water to the specified temperature before introducing water to the test article. Unless otherwise specified, the purge temperature shall be the same temperature as the charge temperature in order to minimize internal energy change in the collector.
2. During the heat loss test described in ISO 9459-4, Section B.4.1, any source of heating, including resistance heaters and/or solar radiation, shall be shut off or blocked. All pumps shall be shut off for the duration of the test.
3. During the heat loss test described in ISO 9459-4, Section B.4.1, when internal temperature probes are used, the test shall continue until both of the following are satisfied:
   3.1 The collector temperature drops at least 3°C.
   3.2 The differential between the average collector temperature and the average environmental temperature changes by at least 3°C.
4. During the warm-up tests described in ISO 9459-4, Section C.3, the temperature in the collector at the beginning of a low-temperature test shall be close to ambient temperature.
5. During the warm-up tests described in ISO 9459-4, Section C.3, wind at a speed between 1 and 3 m/s shall be required when testing collectors with integral storage tanks and/or unglazed collectors.

401.15 Collector incident angle modifier. The incident angle modifiers of the collector shall be determined for each test specimen in accordance with ISO 9806, Section 27. 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.

401.15.1 Concentrating collectors. Concentrating solar collector testing shall include all operational conditions in which the collector is designed to operate. Incident angle modifiers shall be found for the maximum acceptance angle and all intermediate angles as needed to properly characterize the optical behavior of the collector. Unless manufacturer stipulates otherwise, the maximum acceptance angle to be tested shall be at least 60°.

401.15.1.1 Biaxial incident and single angle modifiers testing. Biaxial incident angle modifiers testing and reporting shall be conducted on all non-tracking concentrating collectors as covered by this standard and any single axis tracking collector where reflectors and/or receivers move independently of each other.

401.15.1.2 Drawings. The manufacturer shall submit a drawing showing the optical normal, transverse plane and longitudinal plane.

401.16 Pressure drop test. Where conducted, ~~The~~ the pressure drop across the collector shall be measured as specified in ISO 9806, Section 28.~~,~~

401.17 Rain penetration test. Where conducted, ~~A~~the rain penetration test shall be performed ~~on glazed collectors~~ as specified in ISO 9806, Section 14.

401.18 Mechanical load test. The ability of the collector to withstand loading by wind or snow shall be determined as specified in ISO 9806, Section 16.

401.19 Impact resistance test. The ability of the collector to withstand impact shall be determined as specified in ISO 9806, Section 16. Where reflectors and are separated, both elements shall be subjected to impact, unless specified below. The optical elements of the collector shall withstand impacts without adverse effect on operation or performance.

Exceptions: ~~**302.1.1 Tempered glass.**~~ Impact resistance testing shall not be required in the following cases:

1. Where the outer cover is ~~flat, and~~ constructed of flat glass, ~~glass, the glass shall be~~ tempered in accordance with ASTM C1048, ~~or equivalent~~. ~~Testing in accordance with this section shall not be required when tempered glass is used.~~

2. No PVT collector assembly utilizing a PV module tested in accordance with the Impact Test specified in UL 1703, or Module Breakage Test in UL 61730 shall be required to undergo Impact Resistance Testing as specified in ISO 9806. For PVT collectors where the solar thermal components are not subject to direct solar irradiance (i.e. completely obscured by the PV module), impact resistance testing to ISO 9806, Section 16 shall not be required.

401.20 Fire testing for PVT assemblies. PVT assemblies shall be tested in accordance with UL 1703 Section 31 or UL 61730 Section 10.17. The fire classification for the PVT assembly shall be identified with a fire classification in accordance with UL 1703 or UL 61730.

401.21 PV Module Substitution in PVTs. A different photovoltaic module may be substituted for the module used in the tested PVT assembly without retesting where the following conditions are met:

- Replacement module's area is within +/-10% of the tested module's area and the maximum power (Pmax) of the modules are within +/- 20% at STC.

OR

- Ratio of the maximum power (Pmax) at STC and gross area of the replacement and tested PV modules is within +/-10%

AND

- The fire classification of the substituted PV module, determined in accordance with UL 1703 or UL 61730 shall be the same as or greater than that of the original PV module used for testing of the PVT assembly.

401.~~20~~ 22 Disassembly and final inspection. ~~After the completion of testing, test specimens shall be disassembled and inspected in accordance with Section 306. Any visible damage, deformation, discoloration or flaw shall be recorded.~~

After completing the test sequence outlined in Section 401, the collector shall be disassembled, its subassemblies visually inspected, and their condition noted as specified in ISO 9806, Section 1~~8~~7, to determine final collector condition and actual or potential points of failure that can lead to impairment of function or abnormally short collector life. The format specified in ISO 9806 Annex A.15, "Final inspection results," shall be used to report conditions observed. Components and inspection criteria shall be in accordance with Table ~~306~~401.19.1.

Test specimens and their components shall not exhibit conditions capable of producing premature failure including, but not limited to the items listed in Table ~~306~~401.~~1~~20.2.

TABLE 401.20.1

COMPONENT INSPECTION CRITERIA

Collector Component	Inspection Criteria
Collector box/fasteners	Cracking, warping, corrosion, rain~~-~~ and penetration
Mountings/structure	Strength and safety

Seals/gaskets	Cracking, adhesion, and elasticity
Cover/reflector	Cracking, crazing, buckling, delamination, warping, and outgassing
Absorber coating	Cracking, crazing, and blistering
Absorber tubes and headers	Deformation, corrosion, leakage, and loss of bonding
Absorber mountings	Deformation and corrosion
Insulation	Water retention, outgassing, and degradation

TABLE 401.20.2

PREMATURE FAILURE CONDITIONS

Severe deformation[1] of the absorber
Severe deformation[1] of the fluid flow passages.
Loss of bonding between fluid flow passages and absorber plate.
Leakage from fluid flow passages or connections.
Loss of mounting integrity.
Severe corrosion[1] or other deterioration caused by chemical action.
Crazing, cracking, blistering or flaking of the absorber coating or concentrating optical element surfaces.
Excessive retention of water anywhere in the collector.
Swelling, severe outgassing or other detrimental changes in the collector insulation that could adversely affect collector performance.
Cracking, loss of elasticity, or loss of adhesion of gaskets and sealants.
Leakage or damage to hoses used inside the collector enclosure, or leakage from mechanical connections.
Cracking, crazing, permanent warping or buckling of the cover plate.
Cracking or warping of the collector enclosure materials.
Notes: 1. Deformation or corrosion shall be considered severe if it impairs the function of the collector or there is evidence that it will progress.

401.2~~1~~3 Reporting. Test results shall be reported in accordance with ISO 9806, Appendix A.

401.2~~1~~3.1 Gross area. Gross area of the collector shall be determined as defined in ISO 9488.

> **Exception:** The gross area of the PVT shall be determined utilizing the full projected area of the PV module and solar thermal collector assembly. Gross area shall not include junction boxes or microinverters projecting beyond the projected area of the PVT assembly.

CHAPTER 5 LABELLING AND MANUALS

501 GENERAL

501.1 General. Solar thermal collectors shall be provided with labeling and documentation to facilitate installation, inspection, operation and maintenance.

502 LABELING

502.1 General. Solar thermal collectors shall include an indelible label containing information as established in this section at a minimum. Information shall be provided in a clearly readable size and format. Labels shall be permanently affixed to collectors in a location that will visible after the collector is installed.

502.1.2 Site-Built Collectors. Where collectors are assembled at the location of installation, a permanent label shall be applied to the collector in a location visible after the collector is installed.

502.3 Label Content. The label shall include the following information at a minimum:

2. Model name and/or number
3. Year of manufacture or serial number
4. Certification number and third-party certification agency
5. Maximum operating pressure
6. Dry weight
7. Fluid volume
8. Compatible heat transfer fluids
9. Standard stagnation temperature

503 MANUAL

503.1 General. One or more manuals shall be provided with each *solar thermal collector*. The manual(s) shall describe procedures for installation, operation and maintenance in accordance this section and shall include the following general information:

2. Manufacturer's name and address
3. Model name and/or number
4. Certification number and third-party certification agency
5. Maximum operating pressure
6. Operating flow rate range.
7. *Freeze tolerance limit*
8. Maximum and minimum recommended operating temperature.
9. Standard stagnation temperature
10. Pressure drop.
11. Dry weight
12. Fluid volume
13. Compatible heat transfer fluids
14. Dimensions
15. Parts list.
16. Limitations on the applicability, use, type of application, and locations where the collector may be used.
17. Warning against health and safety hazards that could arise in the operation and maintenance of the system and shall fully describe the precautions that must be taken to avoid these hazards.

18. Description of any warranty for the collector and the method for obtaining warranty coverage.

503.2 Installation instructions. Installation instructions shall prescribe installation in accordance with the building code, plumbing code, mechanical code, fire code and electrical code adopted by the authority having jurisdictions, or in the absence of such codes, shall prescribe installation in accordance with the *International Building* Code, *International Plumbing Code, International Mechanical Code, International Fire Code, and National Electrical Code (NFPA 70).* They shall also include the following information:

1. Transport, storage and handling of the collector
2. Manufacturer's approved mounting hardware and instructions for mounting on applicable roofing types to account for local loading conditions.
3. Tilt angle selection with maximum and minimum values
4. Requirements for interconnection with a solar thermal system and other collectors, including appropriate pipe type, fittings, sizing, insulation and associated tools.
5. Requirements for any field-installed components including but not limited to freeze valves, pressure relief valves, vacuum relief valves, sensors and wiring.
6. Lightning protection.
7. Methods for filling the collector with heat transfer fluids, including safe handling of fluids.

503.3 Operation instructions. The manual shall include instructions for the operation of the collector along with maintenance practices. Any parts that may be subject to periodic inspection, repair or replacement shall be identified.

CHAPTER 6 REFERENCED STANDARDS

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title. The application of the referenced standards shall be as specified in Section 103.1.

ASME B1.20.1-2019 “Pipe Threads, General Purpose (inch)”

ASME B1.20.7-1991 “Hose Coupling Screw Threads (inch)”

ASSE 1061-2015 “Performance Requirements for Push Fit Fittings”

ASTM C1048-2012e1 “Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass”

ASTM C1549-2016 “Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer”

ASTM D635-2018 “Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position”

ASTM D1929-2020 “Standard Test Method for Determining Ignition Temperature of Plastics”

ASTM D2843-2019 “Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics”

ASTM E84-2020 “Standard Test Method for Surface Burning Characteristics of Building Materials”

CSA C22.1-2018 “Canadian Electrical Code, Part I”

ICC 900/SRCC 300 – 202# Solar Thermal Systems

IBC—21 International Building Code®

IFC—21 International Fire Code®

IFGC—21 International Fuel Gas Code®

IMC-21 International Mechanical Code®

IPC—21 International Plumbing Code®

IRC-21 International Residential Code®

ISO 9459-4-2013 “Solar heating — Domestic water heating systems — Part 4: System performance characterization by means of component tests and computer simulation”

ISO 9488-1999 “Solar Energy – Vocabulary”

ISO 9806-~~2013~~ 2017 “Solar energy — Solar thermal collectors — Test methods”

NFPA 70-2020 “National Electric Code”

NSF 61-2013 “Drinking Water System Components – Health Effects”

NSF 372-2011 “Drinking Water System Components – Lead Content”

UL 723-2018 “Standard for Test for Surface Burning Characteristics of Building Materials”

UL 1703-02 “—Flat-Plate Photovoltaic Modules and Panels-with Revisions through November 2014”

UL 61730-1 2017 “Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction”

UL 61730-2 2017 “Photovoltaic (PV) Module Safety Qualification – Part 2: Requirements for Testing”

[END PUBLIC REVIEW DRAFT]

ICC STANDARDS - PUBLIC COMMENT FORM

PLEASE SEE INSTRUCTIONS (SUBMITTAL RULES OF PROCEDURES). ALL SUBMITTALS MUST BE IN COMPLIANCE WITH THESE PROCEDURES.

CLOSING DATE: All Comments Must Be Received by the Announced Closing Date

1) Indicate the format in which you would like to receive your Public Comments Report (PCR):

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2) PLEASE TYPE OR PRINT CLEARLY: FORMS WILL BE RETURNED if they contain unreadable information.

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4) Indicate appropriate ICC Standard associated with this Public Proposal – Please use Acronym:
(See bottom of this form or the instructions for list of Names and Acronyms for the ICC Standards) ______________

5) Indicate the Standard Proposal Number that is being addressed by this Public Comment (if applicable): ___________

6) Revision to: ☐ **Section** ______________ ☐ **Table** ______________ ☐ **Figure** ______________

7) COMMENT **Revise as follows (check BOX and state proposed change):**

☐ **Revise as follows:** ☐ **Add new text as follows** ☐ **Delete and substitute as follows:** ☐ **Delete without Substitution:**

Show the proposed NEW or REVISED or DELETED TEXT in legislative format: ~~Line through text to be deleted.~~ Underline text to be added.

☐ COMMENT Continued (Attach additional sheets as necessary)

8) SUPPORTING INFORMATION (State purpose and reason, and provide substantiation to support proposed change):

☐ SUPPORTING INFORMATION Continued (Attach additional sheets as necessary)

PLEASE USE SEPARATE FORM FOR EACH COMMENT

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e-mail: kaittaniemi@iccsafe.org **Phone**: (888) 422-7233 x4205 **Fax**: (708) 799-0320

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Name of ICC Standard: The following acronyms should be used when designating the name of a Standard.

Acronym	ICC Standard Name
IS-BLE	Standard on Bleachers, Folding and Telescopic Seating, and Grandstands
IS-RHW	Standard for Residential Construction in High Wind Regions
IS-IEDC	Landscape Irrigation Sprinkler and Emitter Standard
IS-LOG	Standard on Design, Construction and Performance of Log Structures
IS-STM	Standard on Design, Construction and Performance of Storm Shelters
A117.1	Standard on Accessible and Usable Buildings and Facilities
IS-STSC	Solar Thermal Collector Standard
IS-STSC	Solar Thermal Systems Standard
IS-PHSC	Pool Solar Heating and Cooling Standard
IS-RCSPI	Rainwater Harvesting Systems
IS-FPI	Standard for Spray-Applied Polyurethane Foam Plastic Insulation
IS-OSMC	Standard for Off-Site Construction: Planning, Design, Fabrication and Assembly
IS-OSMC	Standard for Off-Site Construction: Inspection and Regulatory Compliance