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SRCC™ Standard 300-2014-07

MINIMUM STANDARDS FOR SOLAR THERMAL SYSTEMS

July 15, 2014

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SRCC Standard 300-2014-07
Minimum Standards for Solar Water Heating Systems

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Foreword

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

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

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

Background

SRCC is recognized by the Solar Industry as the Standards Development Body for Solar Collectors and Solar Thermal Systems. SRCC™ Standard 300 has been adopted by federal and state authorities and recognized as a requirement for product certification in the tax code.

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

The draft as a result of the Standard Development Effort was first adopted in 1989 and has undergone several revisions since. Advocates who made major contributions to this national Solar Thermal System Standard - SRCC™ Standard 300 were DOE, NREL, ISCC/IREC, FSEC, and SEIA.

References to Solar Rating & Certification Corporation appear in requirements in the Energy Policy Act of 2005; commonly referred to as the “2005 Energy Bill” for determining eligibility of certified solar water heating systems for federal tax incentives.

Foreword and Background: The Foreword and Background sections are included with this document for information purposes only, and are not part of the “SRCC™ Standard 300 - MINIMUM STANDARD FOR SOLAR THERMAL SYSTEMS.

1.0 PURPOSE

The purpose of this standard for solar thermal systems is to ensure product safety, reliability and performance by giving suppliers the opportunity to submit their SWH system designs to an open-ended review in which standard practices and field experiences can be brought to suppliers' attention in order that they may produce the best possible products.

This standard sets forth the minimum criteria for the design of a solar thermal systems. Furthermore this standard describes the requirements and methodology for standardized solar thermal system design evaluation, including the analytical evaluation of its components. Resulting data serves as the basis for comparing solar systems.

2.0 SCOPE

This standard applies to solar thermal systems that provide hot water, space heating, cooling, and pool heating for residential, commercial and industrial applications. It is not intended for utility-scale power generation. The standard does not address the equipment associated with the load that is provided with heated fluid.

3.0 REQUIREMENTS

The design and analytical evaluation of components which comprise the solar thermal system, i.e., collectors, controls, sensors, fluids, heat exchangers, inverters, pumps, plumbing, piping and tanks, shall meet or exceed the minimum standards established in this document.

All components used in the fabrication of solar thermal systems shall conform to manufacturer's specifications, instructions and the requirements of this standard.

For active systems, the solar collectors shall have been tested according to SRCC Standard 100, "Minimum Standards for Solar Thermal Collectors". Passive (ICS, self-pumping, thermosiphon, and PV water heating) collectors and solar system components not addressed in Standard 100 shall be tested according to SRCC TM-1, "Solar Water Heating Component Test and Analysis Protocol ", or a similar test procedure as specified in 6.1.2.1 of this document.

4.0 DEFINITIONS AND REFERENCES

4.1 Definitions

Acidic/Caustic Fluids – A fluid is considered to be acidic if its pH is less than 6.7 and caustic if its pH is greater than 7.3.

Active System – A solar water heating system utilizing a pump to circulate fluid through any part of the system.

Auxiliary Heating Equipment - Equipment utilizing energy other than solar to supplement the output provided by the solar energy system.

Backflow - The reversal of the normal direction of fluid flow.

Controller - Any device which regulates the operation of the solar water heating system.

Design Life - The intended useful operation life of the system as defined by the Supplier.

Double Wall Heat Exchanger - A heat exchanger design in which a single failure of any fluid barrier will not cause a cross connection or permit back siphonage of heat transfer fluid into the potable water system. Any barrier which fails shall allow the discharge of exchanger fluid and/or potable water to the atmosphere at a location visible to the operator or owner.

Drain-Back - Refers to systems in which the fluid in the solar collector loop is drained from the collector into a holding tank under prescribed circumstances.

Drain-Down - Refers to systems in which the fluid in the solar collector is drained from the system under prescribed circumstances.

Drainage Slope - The designed continuous downward slope of installed piping or other components toward drain points.

Indirect - Refers to systems in which the fluid in the solar collector loop circulates between the solar collector(s) and a heat exchanger and is not drained from the system, nor is it supplied to the load, during normal operation.

Indoor Tank - A tank which is not directly exposed to weather conditions.

In-Service Conditions - The conditions to which a SWH system and its components will be exposed.

Manual - The total documentation package to be provided by the supplier to the purchaser which describes the general operation and maintenance procedures of the system. The manual will include a parts list, a system diagram, a description of major components, and other features required by this document.

May - Action indicated is allowed.

No-Flow Condition - The condition obtained when the heat transfer fluid is not flowing through the collector array due to shutdown or malfunction.

Nonpotable Water - Water containing impurities in amounts sufficient to cause disease or harmful physiological effects when taken internally by humans or domesticated animals.

Non-Toxic Fluids – fluids and additives to the heat transfer fluid which are listed in the Code of Federal Regulations, Title 21, Food and Drugs; Chapter 1, Food and Drug Administration; Part 182, Substances Generally Recognized as Safe; Part 184, Direct Food Substances Affirmed as Generally Recognized As Safe (GRAS).

Potable Water - Water free from impurities in amounts sufficient to cause disease or harmful physiological effects when taken internally by humans or domesticated animals.

PV Water Heating Collector – The portion of a PV water heating system consisting of the PV module(s), the inverter/converter(s), and the heating element(s).

PV Water Heating System – A PV water heating collector, a storage tank, and the balance of system components necessary to meet the requirements of this standard.

Shall - The criterion is required to comply with the standard.

Should - Recommended, but not required.

Significant Deterioration - Deterioration that results either in the creation of a hazard or a debilitating decrease in performance.

Solar Collector Loop - The portion of the solar system which transports the heat transfer fluid in form of heated gas or liquid through the collector.

Solar Thermal – Solar systems that provide energy for liquid heating, space heating, space cooling, pool heating, and process heating for residential, commercial, and industrial applications.

Subsystem - A separable, functional assembly of components.

Supplemental Heating Equipment - Equipment utilizing energy other than solar to supplement the output provided by the solar energy system.

SWH - Solar water heating.

System – (Also referred to as Solar Water Heating System, or SWH System or Solar Water Heater) - A unit or package of components designed to provide solar heated water to residential-type loads.

Toxic Fluids - Fluids which are poisonous or irritating in nature or composition.

Water Hammer - The hammering noises and severe shock that occurs in pressurized water supply systems when flow is halted abruptly.

4.2 References

The following documents are referenced in Standard 300. The current edition shall be used when a specific edition is not referenced.

AHRI Directory of Certified Product Performance, http://www.ahridirectory.org/ahridirectory/pages/home.aspx

ANSI Z21.10.1-2011/CSA 4.1-2011 Gas Water Heaters Volume 1, Storage Water Heaters With Input Ratings of 75,000 Btu Per Hour or Less

ANSI Z21.10.3-2004/CSA 4.3-2004 Gas Water Heaters - Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous.

ASME Boiler and Pressure Vessel Code, Division 1, Section VIII, "Rules for Construction of Pressure Vessels"

ASME Boiler and Pressure Vessel Code, Section X, "Fiber-Reinforced Plastic Pressure Vessels"

ASTM D750-12, "Standard Practice for Rubber Deterioration Using Artificial Weathering Apparatus "

ASTM D471-12a, "Standard Test Method for Rubber Property—Effect of Liquids"

ASTM D1149-07(2012), "Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment"

Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Part 182, "Substances Generally Recognized as Safe;" Part 184, "Direct Food Substances Affirmed as Generally Recognized as Safe"

HUD Minimum Property Standard 4930.2

National Electrical Code (NFPA 70®)

National Fire Protection Association (NFPA) No. 30, "Flammable and Combustible Liquid Code"

National Roofing Contractors Association

National Sanitation Foundation Standard 61 "Drinking Water System Components - Health Effects"

SRCC Standard 100, "Test Methods and Minimum Standards for Certifying Solar Collectors"

SRCC Document TM-1, “SDHW System and Component Test Protocols”

TRNSYS: A Transient System Simulation Program, Solar Energy Laboratory, University of Wisconsin – Madison, Madison, WI, July 1994

UL 1703, Standard for Flat-Plate Photovoltaic Modules and Panels

UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

U.S. Department of Energy test for water heaters (Federal Register volume 55 number 201 page 42161 – 42177, October 17, 1990)

5.0 Blank

6.0 EVALUATION CRITERIA

6.1 Design Criteria

6.1.1 Overall System Design Criteria

6.1.1.1 Operating Limits

Means shall be provided to protect the SWH system within the design limits of temperature and pressure.

6.1.1.2 Solar System Isolation

Isolation/bypass valves shall be installed to allow the system owner to bypass the solar storage tank in the case of a two-tank system, or to shut off the cold water supply to the solar tank in a one-tank system. All isolation valves shall be labeled with their normal operating position indicated. In PV water heaters, isolation shall be accomplished with electrical disconnects.

6.1.1.3 Thermal Expansion

The system design, components and subassemblies shall include adequate provisions for the thermal contraction and expansion of heat transfer fluids, thermal storage fluids and system components that will occur over the design temperature range.

6.1.1.4 Auxiliary Water Heating Equipment

A backup system shall be provided such that the combined system will provide the same degree of reliability and performance as a conventional system.

Auxiliary (non-solar) water heating equipment shall be compatible with the solar system heat output, temperatures, flow rates and fluid types. Auxiliary equipment, including all modifications made during installation of the solar system, shall be listed and labeled by a recognized third party listing agency.

6.1.1.5 Thermosiphon Prevention

Means shall be provided to prevent undesired escape of thermal energy from storage through thermosiphoning action.

6.1.1.6 Fluid System Sizing

Pumps, piping, fans, ducts and other components shall be sized to carry the heat transfer fluid at design flow rates without significant operational impairment, erosion or corrosion.

This standard shall be applied for residential ratings using a 4.9 meter (16 ft.) head and 7.6 meter (25 ft) pipe runs to and from the collector array.

In the fabrication of a solar water heating system the pressure drop and vibrations shall be limited to levels not to exceed the manufacturer's design specifications or adversely impact system performance and longevity.

6.1.1.7 Electrical System Sizing

Wiring and disconnects shall comply with NFPA 70 and the requirements of the Authority Having Jurisdiction at the installation site.

6.1.1.8 Vacuum-Induced Pressure Protection

All components of the solar energy system shall be protected against the maximum vacuum which could occur within the system.

6.1.1.9 Thermal Shock Protection

The system shall be able to withstand any thermal shock caused by an electric power failure or intentional or accidental shutdown.

6.1.1.10 Different Metallic Materials

All metals used in the solar system which come into contact with water or the heat transfer fluid shall be in accordance with Tables S-515-2.3.2 or S-515-2.3.3 of HUD Minimum Property Standard 4930.2. Documentation shall be provided to demonstrate that material usages not covered in these tables meet the intent of S-515-1.4 and S-515-7.4

6.1.1.11 Airborne Pollutants

Solar components and materials that are exposed to airborne pollutants such as ozone, salt spray, SO_2 or NO_x shall not be adversely affected by these factors to the extent that their function will be significantly impaired during their design life.

6.1.1.12 Effects Of Decomposition Products

Chemical decomposition products that are expelled from solar components under in-service conditions shall not cause the degradation of solar components or building elements to the extent that would significantly impair their ability to perform their intended function over their design life.

6.1.2 Collector Design Criteria

6.1.2.1 Collectors

Thermal collector component(s) shall be tested in accordance with either SRCC Standard 100, “Test Methods and Minimum Standards for Certifying Solar Collectors,” SRCC TM-1, “SDHW System and Component Test Protocols,” SRCC Standard 600, “Minimum Standard for Solar Thermal Concentrating Collecgtors,” or a similar test procedure provided that the alternate test procedure includes the durability tests specified in Section 5 of SRCC Standard 100 and the collector component of the system meets the collector standards specified in Section 6 of SRCC Standard 100.

Collectors to be used in separable thermosiphon systems shall have measured test data for the pressure drop across the collector.

Solar photovoltaic module(s) shall be listed and labeled in accordance with UL 1703. The inverter/converter(s) in a PV water heating collector shall be listed and labeled in accordance with UL 1741.

6.1.2.2 Protection From Ultraviolet Radiation

Ultraviolet radiation shall not significantly alter the performance of any component or subcomponent of the system.

6.1.2.3 Blank

6.1.2.4 Collector Flow Rate/Distribution

In multiple thermal collector arrays, the instantaneous flow rate variations between collectors shall not exceed 10% of the array average flow.

When an array of collectors is connected by manifolds to form a parallel flow configuration, provision shall be incorporated in the manifold and/or collectors to maintain the proper design flow rate of the heat transfer fluid through each collector.

In PV water heaters, the PV modules shall be interconnected to meet the requirements of the inverter/converter and NFPA 70.

6.1.2.5 Blank

6.1.2.6 Blank

6.1.2.7 Collector Circulation Control

The collector subsystem control shall be designed to be compatible with control requirements of the system.

6.1.3 Tank and Heat Exchanger Design Criteria

6.1.3.1 Tank Design Requirements

Both pressurized and non-pressurized tanks shall meet the requirements set forth in applicable national standards.

Non-pressurized tanks shall be vented to atmospheric pressure.

Non-Fiberglass hot water storage tanks shall comply with ASME Boiler and Pressure Vessel Code, Division 1, Section VIII, “Rules for Construction of Pressure Vessels” unless they fall into one of the classes of vessels exempted in Part U-1(c).

Fiber-reinforced plastic pressure vessels shall comply with ASME Boiler and Pressure Vessel Code, Section X, “Fiber-Reinforced Plastic Pressure Vessels” unless they fall into one of the classes of vessels exempted in Part RG-121.

Gas water heaters shall comply with ANSI Z21.10.1-2011/CSA 4.1-2011 ‘Gas Water Heaters Volume 1, Storage Water Heaters With Input Ratings of 75,000 Btu Per Hour or

Less' or ANSI Z21.10.3-2011/CSA 4.3-2011 'Gas Water Heaters - Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous'.

Tanks containing one or more electric heating elements shall be listed to UL 174 or UL 1453 by a recognized listing agency.

Tank(s) designed to be installed outdoors shall be subjected to the qualification tests in SRCC Standard 100, "Test Methods and Minimum Standards for Certifying Solar Collectors," Sections 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, and 5.12 or an equivalent test procedure. During these tests, if solar collectors are intended to be connected to the tank (eg. as in a thermosiphon system), the solar collector(s) shall be installed in accordance with the system manufacturer's normal installation procedures. Following the tests specified above, if solar collectors are intended to be connected to the tank, the tank and the collectors shall be filled with the heat transfer fluid(s) specified in the installation manual and allowed to operate as they would in a typical installation while being exposed to one of these conditions:

- Outdoors: one day with the daily clearness index (K_t) is equal to or greater than 0.7, where:

  $$K_t = \frac{average\ radiation\ at\ the\ earth's\ surface}{average\ radiation\ available\ at\ the\ top\ of\ the\ atmosphere}$$

- Under a solar simulator: eight hours with the irradiance greater than 800 W/m^2 and the ambient air temperature greater than 25^{o}C.

After all of these tests have been completed, there shall be no severe deformation of any of the tank components or excessive retention of water anywhere inside the tank jacket.

6.1.3.2 Tank Insulation

Except where required by system design or constrained by safety considerations tank insulation shall have a minimum of R-2.1 ^{o}K-m^2/W (R-12 ^{o}F-ft^2-hr/Btu). An exterior insulation blanket may be used to satisfy this requirement.

6.1.3.3 Waterproofing

Underground and above ground unsheltered storage tanks shall be waterproofed to prevent water seepage.

6.1.3.4 Expansion Tanks

The expansion tank in a collector loop shall be sized to allow for adequate compensation of pressure and volume increase due to accumulation of thermal energy in the form of heat during operating conditions. Operating conditions include stagnation under no flow conditions at the solar collector.

The required expansion tank volume shall be established using the following conditions:

a) Total system volume shall be calculated for as-built conditions.

b) Calculation of total collector volume that can evaporate and turn to steam, including associated piping experiencing similar conditions for the heat transfer fluid contained therein.

c) Static pressure height calculated from the highest point in the collector loop to the location of the pressure relief device. Typically the highest point will experience the hottest temperature in a collector loop.

d) An additional 10 % safety factor shall be used.

e) If the calculated size is greater than a readily available expansion tank the next greater size shall be specified.

The tank components shall be compatible with the heat transfer fluid and rated for the fluid temperature and pressure at design vaporization.

6.1.3.5 Blank

6.1.3.6 Heat Exchanger

When toxic fluids are used as the heat transfer fluid, a double wall heat exchanger shall be used. The heat exchanger design shall be such that any failure of a barrier material shall allow the discharge of exchanger fluid and/or potable water to the atmosphere. The discharge location shall be visible to the operator or owner of the system and be located so that no hazards are created by such discharge.

A single wall heat exchanger shall be deemed acceptable when in compliance with both of the following:

1. The heat transfer fluid is taken from a potable water source or is distilled water suitable for domestic use. Any additives shall be listed in the Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Part 182, “Substances Generally Recognized as Safe,” Part 184, “Direct Food Substances Affirmed as Generally Recognized as Safe.”

2. The maximum operating pressure of the non-potable heat transfer fluid within the heat exchanger shall be less than the normal minimum operating pressure of the potable water system.

6.1.4 Blank

6.1.5 Pumps and Controls Design Criteria

6.1.5.1 Sensor locations

The solar storage tank sensor, when used, shall be installed in a location to approach the temperature of the coldest fluid in the solar storage tank.

The collector sensor, when used, shall be installed in a location to approach the hottest temperature of the solar collector.

6.1.5.2 Control System Override

The control subsystem shall include provisions for bypass, adjustment or override controls as established in a design evaluation in accordance with the requirements set forth in this standard. The control subsystem shall facilitate installation, startup, operation, shutdown and maintenance of the system. Safety controls shall not have provision for bypass or override. All switches and their function shall be labeled and easily accessible.

6.1.5.3 Wiring Identification

Control circuit wiring and terminals shall be identified in accordance with Chapter 2 of the National Electrical Code.

6.1.5.4 Wiring Temperature Rating

All wiring used in a solar water heating system shall comply with NFPA 70.

6.1.5.5 Control Lines and Sensors

All wires and connections, sensors, pneumatic lines, hydraulic lines or other means for transmitting sensor outputs to control devices shall be sufficiently protected from degradation or from introducing false signals as a result of environmental or system operating conditions.6.1.5.6 Temperature Control

The system shall be equipped with a means for automatically limiting the temperature of the hot water at the fixtures to a selectable temperature. The range of selectability shall be at least 10^{o}C (18^{o}F) and the valve shall achieve a set point of 48.9 ^{o}C (120 ^{o}F).

6.1.5.7 PV Power Inverters and ConvertersInverters and power controllers/converters used in PV water heaters shall be listed and labeled to UL 1741.

6.1.6 Plumbing and Piping Design Criteria

6.1.6.1 Protection From Foreign Substances

The solar collector loop shall be protected to prevent contamination by foreign substances that could impair the flow and quality of the heat transfer fluid beyond acceptable limits.

6.1.6.2 Blank

6.1.6.3 Insulation

All interconnecting hot water piping and the final 1.5 meters (5.0 feet) of metallic cold water supply pipe leading to the system, or the length of piping which is accessible if less than 1.5 meters, shall be insulated with R-0.46 ^{o}K m^{2}/W (R-2.6 ^{o}F-ft^{2}-hr /Btu) or greater insulation.

All exterior piping insulation shall be protected from ultraviolet radiation and moisture damage.

6.1.6.4 Blank

6.1.6.5 Water Shut-Off

The SWH system shall have valves to provide for shut-off from the service water supply without interrupting normal cold water service to the residence.

6.1.6.6 Service Connections

Suitable connections shall be provided at readily accessible locations for filling, draining and flushing liquid systems.

6.1.6.7 Filters

Filters are not required. If Filters are , used in the solar water heating system, they shall be designed and located so that they can be cleaned or replaced with minimum disruption to the system and adjacent equipment. The maintenance instructions shall be provided in the applicable installation, operation or maintenance section of the system manual provided by the manufacturer. 6.1.6.8 Blank

6.1.6.9 Blank

6.1.6.10 Coupling Hoses

Coupling hoses shall be tested in accordance with the current version of ASTM D750, ASTM D471, and ASTM D1149.

6.1.6.11 Piping System

The piping system shall be provided with valves which can be closed for the purpose of isolating the solar hot water supply system from the auxiliary water heater, thereby permitting operation of the auxiliary water heater when the solar hot water system is inoperative or being serviced.

6.2 Reliability and Durability Criteria

6.2.1 Stagnation

The system shall be able to withstand prolonged periods of stagnation (high solar flux, no hot water demand) without significant system deterioration and with no maintenance. This includes conditions during loss of electric power to the system.

6.2.2 Solar Degradation

Components or materials exposed to sunlight shall not be affected by exposure to sunlight to an extent that will deteriorate their function beyond design specifications during their design life.

6.2.3 Operation Conditions

Collectors, tanks, pumps, valves, regulating orifices, pressure regulators, heat exchangers, inverters/converters, piping, hoses and other components shall be capable of operating within design pressures, design electrical current/voltage, and design temperature ranges, and withstanding environmental extremes anticipated in actual service without significantly reducing system design life.

6.2.4 Incompatible Materials

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

6.2.5 Freeze Protection

Protection from freeze damage under the most severe environmental conditions that can be expected in actual use shall be provided for all system components containing heat transfer liquids. The Supplier of each system shall specify the limit ("Freeze Tolerance Limit") to the system's tolerance of freezing weather conditions. Systems installed in a location which has no record of an ambient air temperature below $5^{o}C$ ($41^{o}F$) may be exempted from the requirements of this paragraph except the specification of a freeze tolerance limit.

For systems that rely on manual intervention for freeze protection, the Supplier shall specify the system's freeze tolerance limit based on exposure for 18 hours to a constant atmospheric temperature. The Certification Body will evaluate the system design to determine the reasonableness of the specified limit.

For solar systems where the collector fluid is water, a minimum of two freeze protection mechanisms shall be provided on each system. Manual intervention (draining, changing valve positions, etc.) is suitable as one mechanism. At least one freeze protection mechanism, in addition to manual intervention, shall be designed to protect components from freeze damage, even in the event of power failure. The thermal mass of a system can be considered to be a limited form of freeze protection.

A system in which components and/or piping are subject to damage by freezing shall have the proper fittings, pipe slope and collector design to allow for manual gravity draining and air filling of the affected components and piping. Pipe slope for gravity draining shall have a minimum 2 cm vertical drop for each meter of horizontal length (1/4 inch per foot). This also applies to any header pipes or absorber plate riser tubes internal to the collector.

At the time of installation, a conspicuously placed label shall be attached to the system explaining how the system is protected from freezing and what actions are required by the homeowner to prevent freeze damage, and further leakage if rupture occurs. For systems which rely on manual intervention for freeze protection, this label shall indicate the minimum ambient temperature conditions (Freeze Tolerance Limit) below which owner actions are required and the procedure to be followed.

6.2.6 Protection From Leaks

All potable water sections of a solar water heating system shall pass a leak test in accordance with code requirements and local authorities having jurisdiction All non-potable sections of a solar water heating system shall be tested for leaks in accordance with the supplier's instructions.

6.2.7 Fluid Compatibility

Fluids in contact with SWH system materials shall not corrode or otherwise adversely affect system materials to the extent that their function will be significantly impaired during the design life.

6.2.8 Deterioration Of Fluids

Except when allowed by the system design, fluids shall not freeze, give rise to excessive precipitation or otherwise lose their homogeneity, boil or develop excessive vapor pressure, change absorptivity, or change pH, viscosity or thermal properties beyond design ranges when exposed to their maximum and minimum service temperatures and pressures during their design life.

6.2.9 Thermal Storage System

Materials comprising the thermal storage system shall not cause corrosive wear which would result in premature failure or degradation in performance greater than that specified within the system.

6.2.10 Buried Components

Solar components and materials that are intended to be buried in soils shall be protected from degradation under in-service conditions to insure that their function shall not be impaired.

6.2.11 Deterioration Protection

Gaskets, sealants, and coupling hoses shall not be adversely affected by contact with fluids or the environment to an extent that will significantly impair their ability to function (See 6.1.6.10).

6.2.12 Water Hammer

When a liquid is used as the transfer fluid and quick-closing valves are employed in the design, the piping system shall be able to control or withstand the effects of water hammer.

6.2.13 Sound And Vibration Control

Piping and associated fittings shall be designed to carry the heat transfer fluid at design flow rates without excessive noise or vibrations which could be annoying or induce mechanical stress levels high enough to cause damage.

Pumps and compressors, or other components involving moving parts, shall be balanced or mounted in such a manner that they do not induce excessive noise or vibration that could be annoying or cause damage.

6.3 Safety Criteria

6.3.1 Relief Valve Discharge

The discharge from relief valves shall be directed to avoid injury.

6.3.2 Protection of Electrical Components

Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the device and with the provisions of Article 240, Chapter 2 of the National Electrical Code.

6.3.3 Blank

6.3.4 System Failure Prevention

The system shall be so designed that, in the event of a power failure or a failure of any of the system components, the temperatures or pressures developed in the SWH system shall not damage the system, or the building, or endanger its occupants.

6.3.5 High Temperature Control

Means shall be provided to limit temperatures to a value not to exceed all component suppliers' specified high temperature limits. The pressure/temperature relief valve shall not be used for this purpose under normal operating conditions.

In a PV water heater, the heating element(s) must have thermostatic and high limit control.

6.3.6 Protection Against Auto-Ignition Of Combustibles

Combustible materials used in solar equipment shall not be exposed to elevated temperatures which could cause ignition.

6.3.7 Fluid Safety Labeling

Labels shall mark all drain and fill valves in the SWH system. Each label shall identify the fluid in that loop. The location of fluid handling instructions shall be referenced. The label shall list the heat exchanger type as defined here:

- Single wall with no leak protection (SW): A heat exchanger that provides single-wall separation between the potable water and the heat transfer fluid.
- Double wall with no leak protection (DW): A heat exchanger that has two separate, distinct walls separating the potable water and the heat transfer fluid.
- Double wall with leak protection (DWP): A heat exchanger that has two separate, distinct walls separating the potable water and the heat transfer fluid, plus a pathway to the outside of the heat exchanger such that fluid leaking through either wall will be visible.

and the heat transfer fluid class as defined here:

- Potable water (PW): Water that meets local drinking water standards.
- Food grade (FG): A fluid that contains only non-toxic additives as defined in Section 4.1 of this document. All components are GRAS.
- Non-food grade (NFG): A fluid that contains components that are not GRAS.

- Toxic (T): A fluid that contains components that toxic as defined in Section 4.1 of this document.

The label shall include a warning that fluid may be discharged at high temperature and/or pressure. The label shall contain the following warning:

> "No other fluid shall be used that would change the original classification of this system. Unauthorized alterations to this system could result in a hazardous health condition."

6.3.8 Contamination Of Potable Water

Materials which come in direct contact with potable water shall not adversely affect the taste, odor or physical quality and appearance of the water and shall meet National Sanitation Foundation Standard 61.

6.3.9 Entrapped Air

Suitable means for air or gas removal from all high points in the piping system and any other location where air is most likely to accumulate shall be provided. The method of removal shall be appropriate for the system type as follows:

- Automatic for open loop (direct) circulating systems using potable water as the heat transfer fluid,
- Manual or automatic for closed loop (indirect) systems,
- Not required for integral collector storage (ICS) and direct thermosiphon systems.

6.3.10 Backflow

Means shall be provided to prevent backflow of non-potable fluids into the potable water system.

6.3.11 Blank

6.3.12 Toxicity

The use of toxic fluids shall comply with Title 15, Federal Hazardous Substances Act, or its equivalent, and the requirements of the health authority having jurisdiction.

6.3.13 Combustible Liquids

The storage, piping and handling of combustible liquids shall conform to the requirements of the National Fire Protection Association (NFPA) No. 30, "Flammable and Combustible Liquid Code."

6.3.14 Liquid Flash Point

The flash point of a heat transfer fluid shall exceed by 28^{o}C (50^{o}F), or more, the design maximum no-flow temperature to be reached by the fluid in the collector. The flash point shall be determined by the methods described in National Fire Protection Association (NFPA) No. 30, "Flammable and Combustible Liquid Code." In systems using a gaseous heat transfer fluid; a flammable gas shall not be used.

6.3.15 Blank

6.3.16 Pressure Relief

Each portion of the system where excessive pressures can develop shall be protected by a pressure relief device. No means of rendering a pressure relief device ineffective shall be allowed under this standard, specifically to ensure that no section can be valved off or otherwise isolated from a pressure relief device. Automatic pressure relief devices shall be designed to open at not more than maximum design pressure of the system device having the lowest pressure rating.

6.3.17 Heated Components

System subassemblies which are exposed to public traffic and are maintained at elevated temperatures shall either be insulated sufficiently to keep exposed surface temperatures below 60^{o}C (140^{o}F) during operation, or they shall be suitably isolated. Any other exposed areas that are maintained at hazardous temperatures shall be identified with appropriate warnings.

6.4 Operation and Servicing Criteria

6.4.1 Operating Indicators

The SWH systems shall include means for an observer to determine readily that the system is operating properly and providing solar heated water.

6.4.2 Blank

6.4.3 Tanks

Tanks shall be used within the temperature limitations established by the tank supplier. Tanks shall be labeled to show the maximum operating pressure and temperature.

6.4.4 Waste Disposal

Systems utilizing a toxic heat transfer fluid or thermal storage fluid shall provide for the catchments and harmless removal of these fluids from vents where fluid may be automatically discharged.

6.4.5 Dirt Retention And Staining

Solar systems and collectors shall be accessible for periodic cleaning if conditions are such that self-cleaning by rain is not sufficient to keep the collectors operating efficiently.

6.4.6 Maintenance And Servicing

All individual components of the system which may require periodic examination, adjustment, service and/or maintenance shall be easily and safely accessible by the owner and in accordance with the codes in force at the installation site.

6.4.7 Permanent Maintenance Accessories

Permanent maintenance accessories such as hose bibs, drains and electrical disconnects necessary for maintenance of the system shall be provided.

6.4.8 Blank

6.5 Installation Criteria

6.5.1 Firestopping

The SWH system components shall be assembled such that firestopping shall be possible at time of installation, if required by local codes and ordinances.

6.5.2 Auxiliary System

Interconnection of the auxiliary system to the solar energy system shall be made in a manner which will not result in excessive temperature or pressure in the auxiliary system or bypassing of safety devices of the auxiliary system.

Installation of the solar system shall not invalidate any certification or listing of the auxiliary system.

6.5.3 Space Use

The location of components used in the solar water heating system design shall allow for the fulfillment of the requirements stated in 6.1.5.2 in regards to facilitating installation, startup, operation, shutdown and maintenance of the system.

Components of a solar water heating system that during operating conditions will cause effects to increase or reduce humidity, temperature or thermal radiation beyond acceptable levels to building materials shall be identified in the installation, operation and maintenance manuals with proper specifications as to clearance requirements to prevent of such effects.

6.5.4 Accessibility

The location of the solar components should not impair accessibility needed to maintain the building or site.

6.5.5 Building Penetrations

Penetrations of the building through which piping or wiring is passed shall not reduce or impair the function of the enclosure. Penetrations through walls or other surfaces shall not allow intrusion by insects and/or vermin. Required roof penetrations shall be made in accordance with applicable codes and also by practices recommended by the National Roofing Contractors Association.

6.5.6 Water Damage

Collectors and support shall be installed in such a manner that water flowing off the collector surface will not damage the building or cause premature erosion of the roof. Water tanks located in or above the living space shall be installed on a drip pan with a drain line to a waste line or outside or have other means to safely remove any excess liquid. The discharge from temperature relief valves shall be directed to avoid damage.

6.5.7 Blank

6.5.8 Structural Supports

Neither wind loading (including uplift) nor the additional weight of filled collectors and/or tanks shall exceed the live or dead load ratings of the building, roof, roof anchorage, foundation or soil. Collector supports shall not impose undue stresses on the collectors. The design load shall be as specified by the codes in force at the installation site and shall include an additional load due to snow accumulation for applicable locations.

6.5.9 Expansion And Contraction Of Supports

Structural supports shall be selected and installed in such a manner that thermal expansion of the collector and piping will not cause damage to the collector structural frame or the building.

6.5.10 Penetration Of Structural Members

When penetrations are required in structural members to accompany passage of solar components, those modified structural members shall comply with local building codes.

6.5.11 Protection From Thermal Deterioration

Building materials adjacent to solar equipment shall not be exposed to elevated temperatures which could accelerate their deterioration. Many non-metal roofing materials will soften in the temperature range of 60 - 80^{o}C (140-180^{o}F) and begin to degrade above this temperature.

6.5.12 Tilt And Azimuth

The collector shall be installed on a mount capable of maintaining tilt and azimuth to design conditions.

6.5.13 Shading Of Collector

The location and orientation of the collector shall be such that it is not shaded by external obstructions or mutual shadowing more than the specified period allowed in the design.

6.5.14 Pipe And Component Supports

Hangers shall provide adequate support and correct pitch of pipes. Hangers or supports for insulated pipes or components shall be designed to avoid compressing or damaging the insulation material. Hangers shall not cause galvanic corrosion between the hanger and the pipe.

6.5.15 Pitch Or Angle Of Piping Installation

When water is used in sections of the solar collector loop exposed to freezing, piping shall be sloped to drain with a drainage slope of no less than 2 cm vertical drop for each meter of horizontal length (1/4 inch per foot).

6.5.16 Blank

6.5.17 Underground Piping

Underground piping subject to vehicular traffic shall be installed to withstand the additional loading applied by this traffic. The trenches and backfill shall be free of sharp objects in contact with the pipe.

6.5.18 Control Sensor Installation

Control sensors and the means for transmitting sensor outputs to control devices shall be protected from environmental influence such as wind, moisture, temperature, ultraviolet radiation, or other factors which may alter their intended sensing function.

6.5.19 Penetrations Through Fire-Rated Assemblies

Penetrations through fire-rated assemblies etc. shall not reduce the building's fire resistance required by local codes, ordinances and applicable standards.

6.5.20 Emergency Egress And Access

The design and installation of systems shall not impair emergency movement of the building occupants.

6.5.21 Rain and Snow on Collector

The location, orientation, and position of the collector relative to nearby objects and surfaces shall be such that water run-off from the collector surface is not impeded nor is excessive build-up of snow on lower portions of the collector glazing permitted to occur.

6.6 Manual Criteria

6.6.1 Provision For Manuals

A manual or manuals shall be provided with each SWH system. The manual shall contain the name and address of the system supplier, the system model name or number, and shall describe the operation of the system and its components and the procedures for installation, operation and maintenance. The manual(s) provided to the system owner shall contain, at a minimum, the information described below in 6.6.3 through 6.6.8.

6.6.2 Installation Instructions

The manual(s) shall include an explanation of physical and functional requirements of the system and its components and the general procedures for their proper installation. The instructions shall describe the interconnection requirement of the various subsystems and components and their interface requirements with the building and the site. The instructions shall be available at the installation site or from normally accessible sources.

The installation instructions shall state that the installation shall comply with NFPA 70 and the requirements of the Authority Having Jurisdiction at the installation site.

6.6.3 Operation Instructions

The manual shall:

- clearly describe the operation of the SWH system, explaining the function of each subsystem and component.
- include a system diagram showing the components and their relationships in the typical installed system.
- describe major components in a separate section or by enclosing descriptive material furnished by the supplier of the components.describe procedures for system start-up, routine maintenance and special conditional operations such as drain-down.
- specify fill weights, pressure ratings and temperature ratings for servicing and routine maintenance of the system.
- specify temperature, pressure and flow conditions expected at various access points to allow simple operational checks and troubleshooting.
- include instructions for isolating different sections of the system in emergency situations
- include instructions for leaving the system unattended and unused for long periods of time.
- indicate the minimum ambient temperature above which the system is designed not to be damaged due to freezing (Freeze Tolerance Limit).
- for thermal systems shall include the statement:

  "Freeze tolerance limits are based upon an assumed set of environmental conditions."

If the freezing point of the fluid in an exposed part of the system is above the freeze tolerance limit specified for the system, the following statement shall be added to the one above:

> "Extended periods of cold weather, including ambient air temperatures above the specified limit, may cause freezing in exposed parts of the system. It is the owner's responsibility to protect the system in accordance with the Supplier's instructions if the air temperature is anticipated to approach the specified freeze tolerance limit."

6.6.4 Maintenance Plan

The manual shall include a comprehensive plan for maintaining the specified performance of the SWH system.

The plan shall include a schedule and description of procedures for ordinary and preventive maintenance including cleaning of collector exterior surfaces. The manual shall describe minor repairs and give the projections for equipment replacement.

6.6.5 Fluid Quality

The manual shall identify the fluid(s) used in the SWH system and state whether or not the fluid(s) are toxic or hazardous. Proper procedures for handling, safe disposal, and first aid shall be provided for each non-water fluid. A technical data sheet shall be provided for each non-water fluid used in the system.

Procedures shall be described for maintaining the heat transfer fluid's chemical composition at levels adequate to prevent unacceptable deposits on the heat transfer

surfaces, corrosion of the heat transfer surfaces or loss of freeze resistance. Recommended inspection and test intervals for the heat transfer fluid shall be provided.

6.6.6 Service And Replacement Parts

The manual shall include a parts list giving a sufficient description of each part for ordering a replacement. Parts, components and equipment required for service, repair or replacement shall be commercially available or available from the system or subsystem supplier.

The manual shall list on the same page of both the installation and operation manuals all options (make and model) for the following components: solar collector, solar storage tank, pump, piping material, controller, heat exchanger, and heat transfer fluid. This page shall also include temperature, pressure, and/or flow conditions expected at system access points to allow simple operational checks.

The manual shall include the name and address of at least one company in close geographic proximity to the purchaser that offers service on the system. An 800 telephone number maintained by the supplier that a consumer can call to get in contact with a local service agent will satisfy this requirement.

6.6.7 Hazards

The manual shall provide warning against health and safety hazards that could arise in the operation and maintenance of the system and shall fully describe the precautions that shall be taken to avoid these hazards. For collector(s) that are not grounded via the plumbing components, a warning label shall be affixed to the system and the manual shall reference NFPA 70® in regards to lightning protection.

6.6.8 Warranty Coverage

The manual shall provide a full description of the warranty coverage on the system. In addition, the manual shall describe what actions the purchaser shall undertake to obtain warranty coverage.

7.0 Blank

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Appendix A

Method for Evaluating Pump Stations in Solar Water Heating Systems
The performance of a pump station which is comprised of multiple components can be evaluated separately if the performance of the individual components working together as one is known. The pump station may include but is not limited to the following components: pump, piping and fittings, controller, valves, tank and heat exchanger.

A.1 Pump and Control Design Criteria

A.1.1 Control System Override

The pump station control shall include such provision for bypass, adjustment or override controls as are required to facilitate installation, startup, operation, shutdown and maintenance. Safety controls shall not have provision for bypass or override. All switches and their function shall be labeled and easily accessible. The pump station control shall be designed to be compatible with control requirements of the SWH system.

A.1.2 Wiring Identification, Pumps and Electrical Components

Control circuit wiring and terminals shall be identified in accordance with Chapter 2 of the National Electrical Code. Pumps and electrical components shall have appropriate approvals from recognized third party listing agencies.

A.1.3 Control Lines and Sensors

All wires and connections, sensors, pneumatic lines, hydraulic lines or other means for transmitting sensor outputs to control devices shall be sufficiently protected from degradation or from introducing false signals as a result of environmental or system operating conditions.

A.1.4 Protection of Electrical Components

Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the pump station and with the provisions of Article 240, Chapter 2 of the National Electrical Code.

A.1.5 Pump Station Failure Prevention

The pump station control shall be so designed that, in the event of a power failure or a failure of any of the station components, the temperatures or pressures developed in the SWH system shall not damage the SWH system, or the building, or endanger its occupants.

Test Method:

a. All pumps, etc. shall be tested under operating conditions for the duration of the test.
b. Fail the temperature sensors by short circuiting the system and opening the circuit one sensor at a time and then simultaneously together.
c. Verify the operation state or mode of the station.

Analysis Method:

The result of this test is “pass” if short circuiting the system or open circuiting of the sensors separately or simultaneously together leaves the system frozen and the overheating protection mechanism operable.

A.2 Plumbed Component Design Criteria

A.2.1 Pipe and Fittings

Pipe and fittings shall have appropriate approvals from recognized third party listing agencies.

A.2.2 Valves

Suitable connections shall be provided at readily accessible locations for filling, draining and flushing liquid systems. Valves which can be closed for the purpose of isolating the SWH system shall have appropriate approvals from recognized third party listing agencies.

A.2.3 Fluid System Sizing

Plumbed components shall be sized to carry the heat transfer fluid at design flow rates without significant operational impairment, erosion or corrosion.

In the design of plumbed components pressure drop and vibrations shall be limited to levels not to exceed the manufacturer’s design specifications or adversely impact system performance and longevity.

The instantaneous flow rate within the pump station shall not exceed 10% of average flow to maintain the proper design flow rate of the heat transfer fluid through the SWH system. Exception is allowed for the higher startup flow rate needed in a drainback system to establish a siphon.

A.2.4 Contamination of Potable Water

Components which come in direct contact with potable water shall not adversely affect the taste, odor or physical quality and appearance of the water and shall meet the standards of the National Sanitation Foundation Standard 61.

A.2.5 Compatibility with Heat Transfer Fluids

Components which come in direct contact with the heat transfer fluid shall not be adversely affected by the heat transfer fluid within the operating pressure and temperature ranges.

A.2.6 Pressure Integrity Test

Test Method:

a. A pressure gauge is attached to the exit port of the pump station and the outlet is sealed.
b. The supply side is filled with unheated water.
c. The test pressure shall be 1110 kPa Gauge (160 PSIG).

d. Hydraulic pressure is applied to the inlet port until the gauge indicates the test pressure has been reached.
e. The inlet pressure port is then closed and the pressure is monitored for 15 minutes.
f. The final pressure is recorded.

Analysis Method:

The result of this test is “pass” if no observable pressure change has occurred.

A.3 Temperature and Pressure Criteria

A.3.1 Temperature Control

The pump station shall be equipped with a means for automatically limiting the temperature of the hot water to the fixtures to a selectable temperature. The range of selectability shall be at least 10°C (18°F) and shall include a set point of 48.9°C (120°F).

A.3.2 Components

Temperature and pressure control valves or devices shall have appropriate approvals from recognized third party listing agencies. Means shall be provided to limit temperatures and pressures to a value not to exceed all component suppliers’ specified high temperature and pressure limits. The pressure/temperature relief valve shall not be used for this purpose under normal operating conditions.

A.3.3 Temperature Limiting System Test

a. All pumps, etc. shall be tested under operating conditions for the duration of the test.
b. The pump station shall be connected to a suitable heating source which can supply the target temperature.
c. The heating source output temperature shall be set no less than 5°C (10°F) above the maximum temperature limit specified by Supplier.
c. Observe the pump station.

Analysis Method:

The result of this test is “pass” if the pump station disables any heat input device when the maximum temperature limit is exceeded.

A.4 Tank and Heat Exchanger Design Criteria (As applicable)

Tanks and heat exchangers shall be evaluated in accordance with Section 6.1.3 of this standard. Test data shall be available in accordance with Section 9.0 or 10.0 of SRCC TM-1 as applicable.

These requirements are only required if the tank or heat exchanger has not undergone similar testing by another evaluation authority.

A.5 Reliability and Durability Criteria

The pump station shall be evaluated in accordance with Section 6.2 of this standard as applicable.

Combustible materials used in the pump station shall not be exposed to elevated temperatures which could cause ignition. Such materials not used exterior to a building shall have a flame spread of not more than 25 and a smoke developed rating of not more than 50.

A.6 Labeling and Manuals (As applicable)

Pump station shall be labeled with the Supplier's name or trademark, model name and/or number, recommended working fluids, maximum working temperature and pressure and recommended flow rate(s).

All warning lights, switches and controls shall be clearly identified. Where the pump station includes electrical components, the station shall be labeled with the electrical rating in volts, amperes and motor phase.

Any operation, maintenance, and installation instructions manuals from the manufacturer shall be supplied or made available to the public with the pump station. Supplier's contact information shall be included within these documents.