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

PUBLIC REVIEW DRAFT #1

SOLAR THERMAL SYSTEM STANDARD

ICC 900/SRCC 300-201x

June 5, 2020

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

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 the minimum criteria for the design and installation of *solar thermal system*s. Furthermore, this standard describes the requirements and methodology for standardized *solar thermal system* design evaluation, including the analytical evaluation of its components.

SECTION 102
SCOPE

102.1 Scope. This standard shall apply to solar energy systems used in applications for heating, cooling, dehumidification and co-generation; generally referred to as *solar thermal systems*. This standard shall not apply to utility-scale power generation or loads provided with fluid heated by *solar thermal system*s.

104 REFERENCED DOCUMENTS

104.1 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 4 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.

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

202 DEFINED TERMS

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.

ACCESS (TO). That which enables a device, appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, door or similar obstruction [see also "Ready access (to)"].

ACTIVE SYSTEM. A *solar thermal system* using a pump to circulate fluid through any part of the system.

APPROVED. Acceptable to the code official or other authority having jurisdiction.

AUXILIARY HEATING EQUIPMENT. Equipment utilizing energy other than solar to supplement the output provided by the solar thermal system.

BACKFLOW. The flow of water or other fluids, mixtures or substances into the distribution pipes of a potable water supply from any source except the intended source.

CONTROLLER. Any device or part thereof that regulates the operation of the solar thermal system or component.

DAILY CLEARNESS INDEX (K_t). Ratio of the average radiation at the earth's surface to the average radiation available at the top of the atmosphere.

DESIGN LIFE. The intended useful operational life of a *solar thermal system* or component as defined by the Supplier.

DESIGN MAXIMUM NO-FLOW TEMPERATURE. The temperature below which a system component can return to normal operation following a *no-flow condition*.

DRAIN-BACK. *Solar thermal systems* in which the fluid in the solar collector loop is drained from the collector into a holding tank under prescribed circumstances.

DRAIN-DOWN. *Solar thermal systems* in which the fluid in the solar collector is drained from the system to an *approved* disposal area under prescribed circumstances.

DRAINAGE SLOPE. The designed continuous downward slope of installed piping or other components toward drain points.

FOOD GRADE FLUID. Potable water or a fluid containing additives listed in accordance with the Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Parts 174-186.

FREEZE TOLERANCE LIMIT. Minimum outdoor temperature at which a given solar thermal system can be operated without permanently damaging system components or performance, as specified by the Supplier.

HEAT EXCHANGER. A device that transfers heat from one medium to another.

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 backflow of heat transfer fluid between two separate fluid systems.

SINGLE WALL HEAT EXCHANGER. A *heat exchanger* design in which a single failure of any fluid barrier will cause a cross connection or permit backflow of heat transfer fluid between two separate fluid systems.

HEAT TRANSFER FLUID. The operating or thermal storage fluid in a *solar thermal system*, including water or other base, and additives at the concentration present under operating conditions used to move heat from one location to another.

INDIRECT SYSTEM. *Solar thermal system* in which the fluid in the solar collector loop circulates between the solar collector(s) and a heat exchanger and during normal operation such fluid is not drained from the system and is not supplied to the load.

IN-SERVICE CONDITIONS. The conditions to which a *solar thermal system* and its components will be exposed during operation.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

MANUAL. The total documentation package provided by the supplier to the purchaser that describes the general operation and maintenance procedures of the system.

NO-FLOW CONDITION. A condition where thermal energy is not transferred from the collector by means of flow of *heat transfer fluid*.

NON-FOOD GRADE. Any fluid that is not designated as a *food grade fluid.*

NONPOTABLE WATER. Water not safe for drinking, personal or culinary use.

POTABLE WATER. Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming to the bacteriological and chemical quality requirements of the Public Health Service Drinking Water Standards or the regulations of the public health authority having jurisdiction.

PHOTOVOLTAIC (PV) WATER HEATER- A system designed to convert energy contained within solar radiation using one or more photovoltaic modules and transfer it to water in the form of thermal energy.

PHOTOVOLTAIC (PV) SOLAR WATER HEATING COLLECTOR - A subsystem that converts solar radiation into electrical potential using one or more photovoltaic modules, used to power a water heater. Typically a combination of one or more PV modules, DC-AC inverters or DC-DC converters and other controls that are used to provide electrical input to one or more electrical heating elements.

PUMP STATION. A manufactured collection of components that moves fluid around and through a solar thermal system. It is permissible to include any of these components in a pump station: pump, piping and fittings, controller, valves, tank (expansion and/or storage), heat exchanger, and other components of the solar thermal system.

READY ACCESS (TO). That which enables a device, appliance or equipment to be directly reached, without requiring the removal or movement of any panel, door or similar obstruction and without the use of a portable ladder, step stool, or similar device [see “Access (to)”].

SOLAR THERMAL COLLECTOR. Components in a *solar thermal system* that collect and convert solar radiation to thermal energy.

SOLAR COLLECTOR LOOP. The portion of the *solar thermal system* that transports the *heat transfer fluid* in the form of gas or liquid through the *solar thermal collector*.

SOLAR THERMAL SYSTEM. A system that converts solar radiation to thermal energy for use in heating or cooling.

STAGNATION. A condition where no heat is removed from a collector or system by a heat transfer fluid and the gain from solar radiation is balanced by the heat loss.

STORAGE TANK. Unfired vessel designed to store fluid.

SUBSYSTEM. A separable, functional assembly of components.

SUPPLEMENTAL HEATING EQUIPMENT. Equipment utilizing energy other than solar to supplement the output provided by the solar thermal system.

THIRD-PARTY TESTED. Procedure by which an *approved* testing laboratory provides documentation that a product, material or system conforms to specified requirements.

TOXIC FLUIDS. Fluids that are poisonous or irritating in nature or composition.

WATER HAMMER. **A** pressure surge that occurs when fluid or other incompressible fluid flow is suddenly stopped in a pressurized piping system.

CHAPTER 3 SYSTEM REQUIREMENTS

301 ~~OVERALL~~ SYSTEM DESIGN ~~CRITERIA~~–

301.1 ~~Overall system~~ System design. The ~~overall system~~ design ~~criteria~~ of the *solar thermal system* shall comply with Sections 301.1.1 through 301.1.11.

301.1.1 Operating limits. Means shall be provided to protect all *solar thermal system* components within the design limits of temperature and pressure as specified by the manufacturer.

301.1.2 Solar system isolation. Isolation valves shall be provided with access and installed to allow solar storage tanks to be bypassed in the case of a multi-tank system, or to shut off the cold water supply to the solar tank in a one-tank system. The normal operating position shall be marked on a label affixed to each isolation valve.

301.1.3 Thermal expansion. The system design, components and subassemblies shall include provisions for the thermal contraction and expansion of *heat transfer fluids* and system components that will occur over the manufacturer(s) specified design temperature range.

> **Exception:** Thermal expansion control devices shall not be required in the drain-back section of *drain-back systems*.

301.1.4 *Auxiliary heating equipment*. ~~A backup system shall be provided such that the combined solar and back-up system will provide the same degree of reliability and performance as a conventional non-solar system. The backup system shall be sized to meet the design load without any solar contribution.~~ *Auxiliary heat*~~*ersing*~~ ~~*equipment*~~ shall be compatible with the solar thermal system heat output, temperatures, flow rates and *heat transfer fluid* types. *Auxiliary heating equipment* shall be *listed* and *labeled* by a recognized *third party listing agency*.

301.1.5 Thermosiphon prevention. Means shall be provided to control energy losses from thermal storage tanks and supplemental heating equipment caused by thermosiphonage.

301.1.6 Fluid system sizing. Pumps, piping, fans, ducts and other components shall be sized to carry the heat transfer fluid at design flow rates over the *design life* without operational impairment, erosion and corrosion.

301.1.7 Pressure drop and vibration. The maximum pressure drop and vibrations of *solar thermal system*s shall be limited to levels that will not exceed the manufacturer's design specifications or adversely impact system performance and longevity.

301.1.8 Vacuum-induced pressure protection. Components of the solar energy system shall be protected against the maximum vacuum that could occur within the system.

301.1.9 Thermal shock protection. The system shall be able to withstand sudden changes in temperature.

301.1.10 Protection from ultraviolet radiation. ~~Ultraviolet radiation shall not alter beyond design specifications the performance of any~~ Solar thermal system components ~~or~~ subcomponents, and materials used that are exposed to ultraviolet radiation shall not be adversely affected or impaired beyond design specifications ~~of the *solar thermal system*~~ during their *design life*.

301.1.11 Airborne pollutants. *Solar thermal system* 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 pollutants to the extent that their function will be impaired beyond design specifications during their *design life*.

301.2 Collectors. Solar thermal ~~C~~collectors and PV solar water heating collectors shall comply with Sections 301.2.1 through 301.2.2.

301.2.1 Solar thermal collectors. ~~The~~ Solar thermal collectors~~)~~ shall be listed and labeled to ~~relevant sections of~~ ICC 901/SRCC 100.

301.2.2 PV Solar water heating collectors. PV solar water heating collector components shall be listed and labeled in accordance with the requirements of Section 303.2.

301.3 Water heating equipment and *storage tanks*. Water heating equipment and storage tanks shall comply with Sections 301.3.1 through 301.3.3 shall comply with the plumbing code and mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code and International Mechanical Code.

301.3.1 General. *Storage tanks* and water heating equipment shall comply with the requirements of this section. Tanks that are not separable from the collector shall comply with ICC 901/SRCC 100.

301.3.1.1 Protection from damage. *Storage tanks* and water heating equipment shall not be installed in a location where subject to mechanical damage unless protected by *approved* barriers.

301.3.1.2 Antisiphon devices. A cold water “dip” tube with a hole at the top or a vacuum relief valve installed in the cold water supply line above the top of the heater or tank or other *approved* means shall be provided to prevent siphoning of any storage water heater or tank.

301.3.1.3 Vacuum relief valve. Bottom fed water heaters and bottom fed *storage tanks* connected to water heaters shall be provided with a vacuum relief valve. Vacuum relief valves shall comply with ANSI Z21.22/CSA 4.4.

301.3.1.4 Outdoor installation. *Storage tanks* and heating equipment installed in outdoor locations shall be designed for outdoor installation.

301.3.2 *Storage tanks*. *Storage tanks* shall comply with Sections 301.3.2.1 through 301.3.2.3.

301.3.2.1 Storage tanks shall be listed and labeled by a recognized third-party listing agency.

301.3.2.1.1 Pressurized ~~hot water~~ storage tanks. Pressurized ~~hot water~~ storage tanks shall comply with *ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, or Section X* as applicable.

301.3.2.2 Insulation. *Storage tanks* shall be insulated to an R-value of not less than R-12.5 (h • ft^2 • ºF)/Btu (R-2.2m^2 • K/W).

301.3.2.3 Separable tanks installed outside. Where solar thermal systems use collectors with separable tanks installed outdoors, the separable tanks shall be tested in accordance with Section 301.3.2.3.1. Upon completion of testing there shall not be degradation of any of the tank components or retention of water anywhere inside the tank jacket unintended by design.

301.3.2.3.1 Separable tank environmental test procedure. Solar collector(s) and tank(s) shall be installed in accordance with the system manufacturer's installation procedures. This assembly shall be subjected to the qualification tests in ICC 901/SRCC 100 Sections 401.3, 401.4, 401.7, 401.8, 401.9, and 401.19. Following these tests, 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:

(a) Solar collectors and separable solar thermal tank shall be exposed to solar radiation outdoors for a period of 24 hours where the daily clearness index is equal to or greater than 0.7 for the duration of the test.

(b) Solar collectors and separable solar thermal tank shall be exposed under a solar simulator with an irradiance equal to or greater than 800 W/m^2 at an ambient air temperature greater than or equal to 77ºF (25ºC).

301.2.4 Nonpressurized storage tanks. Nonpressurized storage tanks shall be listed and labeled by a recognized third party listing agency.

301.3.2.~~4~~ 5 Non-pressurized tank venting. Non-pressurized tanks shall be vented to atmospheric pressure by means of open vents or vacuum relief valves. ~~with a total venting cross-sectional area of no less than 12 square inches~~. Open ~~V~~vents and vacuum relief valves ~~to~~ shall be sized ~~adequately~~ to ensure that the pressure in the tank does not exceed atmospheric pressure during heat cycling, within design parameters. ~~The reservoir~~ Reservoir vents shall not be connected to, or combined with, any other vents. Open ~~V~~vents shall extend vertically not less than 6 inches above the reservoir fluid level. Open ~~V~~vents shall be protected from contamination by means of an approved cap or U-bend installed with the opening directed downward. Open ~~V~~vents ~~openings~~ shall be protected against the entrance of vermin and insects. Screen materials shall be compatible with contacting system components and shall not accelerate corrosion of system components. Vacuum relief valves shall comply with ANSI Z21.22/CSA 4.4.

301.3.3.2.3 Waterproofing. Unsheltered *storage tanks* shall be waterproofed to prevent water intrusion and damage.

301.3.3 Water heating equipment. Water heaters shall be listed and labeled to one of the standards listed in Table 301.3.3.

TABLE 301.3.3
WATER HEATING EQUIPMENT

WATER HEATING EQUIPMENT	STANDARD
Electric water heaters	UL 174; UL 1453; UL 499
Oil-fired water heaters	UL 732
Solid-fuel-fired water heaters	UL 2523
Gas-fired water heaters	ANSI Z21.10.1/CSA 4.1; Z21.10.3/CSA 4.3

301.3.3.1 Shutdown. A means for disconnecting an electric hot water supply system from its energy supply shall be provided in accordance with NFPA 70. A separate valve shall comply with the mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Mechanical Code or the International Fuel Gas Code and shall be provided to shut off the fuel supply to all other types of hot water supply systems.

301.4 Expansion tanks design criteria. Where expansion tanks are used to provide thermal expansion control in accordance with Section 301.1.3, expansion tanks used in a collector loop shall be sized to allow for compensation of pressure and volume increase caused by accumulation of thermal energy during operating, stagnation, and no-flow conditions, in accordance with Section 301.4.1.Thermal expansion tank components shall be compatible with the heat transfer fluid and rated for the fluid temperature and pressure at design conditions.

301.4.1 Expansion tank sizing. The required expansion tank volume shall demonstrate consideration of all of the following:

1. Total system volume shall be calculated for as-built conditions.
2. Calculation of total volume that can evaporate and turn to steam, including collectors and associated piping experiencing similar conditions for the heat transfer fluid contained therein.
3. Static pressure height calculated from the highest point in the collector loop to the location of the pressure relief device.
4. An additional 10 % safety factor shall be used.
5. If the calculated size is greater than a readily available expansion tank the next greater size shall be specified.
6. Expansion tanks used in single-phase systems shall be sized in accordance with the mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Mechanical Code.

301.5 Heat exchanger design criteria. *Heat exchangers* shall comply with Sections 301.5.1 through 301.5.2.

301.5.1 Double-wall heat exchangers. *Double wall heat exchangers* shall be required. *Double-wall heat exchanger* design shall be such that any failure of a barrier will allow the discharge of *heat transfer fluid* or potable water to the atmosphere. The discharge shall be readily observable and in accordance with Section 305.1.3.

Exception. *Single wall heat exchangers* shall be permitted when in compliance with both of the following:

1. Fluids containing only components that are food grade are used in the system.

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

301.5.2 Shutoff valves. Shutoff valves shall be installed on the supply and return side of each *heat exchanger*.

Exception: Shutoff valves shall not be required where *heat exchangers* are integral with *water heating equipment*; or are a component of a manufacturer's *water heating equipment* and *heat exchanger* packaged units that are capable of being isolated from the *solar thermal system* by the supply and return valves required by Section 301.5.2.

301.6 *Controller subsystem* design criteria. Controller subsystems for *solar thermal systems* shall comply with Sections 301.6.1 through 301.6.5.

301.6.1 General. *Controller subsystems* shall facilitate installation, startup, operation, shutdown and maintenance of the solar thermal system. The *controller subsystem* shall include provisions for bypass, adjustment and override as established in a design evaluation in accordance with the requirements of this standard. Safety controls shall not have provision for bypass or override. Operational controls and means of disconnect and their function shall be labeled and readily accessible in accordance with the NFPA 70. 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.

301.6.2 Sensors. Sensors shall be installed in accordance with the *controller subsystem* design.

301.7 Thermostatic mixing valve. Where hot water is supplied to a potable hot water distribution system for domestic use, a master thermostatic mixing valve complying with ASSE 1017 shall be provided to reduce water temperature to defined limits.

~~**Exemption**: Systems designed by the manufacturer to operate with actively controlled storage temperatures of less than or equal to 120°F~~

301.7.1 Thermostatic mixing valve location. The thermostatic mixing valve shall be placed upstream of *auxiliary heating equipment* not rated for solar storage temperatures.

301.8 Plumbing and piping design criteria. Plumbing and piping shall comply with Sections 301.7.1 through 301.7.7. Piping shall be installed in accordance with the plumbing code and mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code and International Mechanical Code.

301.8.1 Protection of piping. Exterior piping insulation shall be protected from ultraviolet radiation and moisture damage and shall be for outdoor use. The exterior of piping shall be protected from corrosion and degradation.

301.8.2 Potable piping materials and standards. Water distribution pipe shall comply with Section 303.1.5 and at least one of the standards listed in Table 301.8.2. Hot water distribution pipe and tubing shall have a pressure rating of not less than 100 psi (690 kPa) at 180ºF (82ºC).

301.8.3 Non-potable piping materials standards. Piping for non-potable fluids shall conform to the standards listed in Table 301.8.3.

TABLE 301.8.2
POTABLE WATER PIPE

MATERIAL	STANDARD
Brass pipe	ASTM B 43
Chlorinated polyvinyl chloride (CPVC) plastic	ASTM D 2846; ASTM F 441; ASTM F 442; CSA
Copper or copper-alloy pipe	ASTM B 42; ASTM B 302
Copper or copper-alloy tubing (Type K, WK,	ASTM B 75; ASTM B 88; ASTM B 251; ASTM B
Cross-linked polyethylene (PEX) plastic	ASTM F 876; ASTM F 877; CSA B137.5
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe	ASTM F 1281; ASTM F 2262; CSA B137.10~~M~~
Cross-linked polyethylene/aluminum/high-density polyethylene	ASTM F 1986
Ductile iron pipe	AWWA C151/A21.51; AWWA C115/A21.15
Galvanized steel pipe	ASTM A 53
Polyethylene/aluminum/polyethylene (PE-	ASTM F 1282
Polyethylene of raised temperature (PE-RT)	ASTM F 2769
Polypropylene (PP) plastic pipe or tubing	ASTM F 2389; CSA B137.11
Stainless steel pipe (Type 304/304L)	ASTM A 312; ASTM A 778
Stainless steel pipe (Type 316/316L)	ASTM A 312; ASTM A 778

TABLE 301.8.3
NON-POTABLE WATER PIPE

MATERIAL	STANDARD
Acrylonitrile butadiene styrene (ABS) plastic	ASTM D 1527; ASTM D 2282
Brass pipe	ASTM B 43
Brass tubing	ASTM B 135
Copper or copper-alloy pipe	ASTM B 42; ASTM B 302
Copper or copper-alloy tube (Type K, L or M)	ASTM B 75; ASTM B 88; ASTM B251
Chlorinated polyvinyl chloride (CPVC) plastic pipe	ASTM D 2846; ASTM F 441; ASTM F 442
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure	ASTM F 1281; ~~CSA CAN/~~CSA-B-137.10
Cross-linked polyethylene (PEX) tubing	ASTM F 876; ASTM F 877
Ductile iron pipe	AWWA C151/A21.51; AWWA C115/A21.15
Flexible stainless steel pipe	ASME A112.18.6/CSA B125.6; ISO 10380
Hoses containing rubber	ASTM D750; ASTM D471; ASTM D1149
Lead pipe	FS WW-P-325B
Polybutylene (PB) plastic pipe and tubing	ASTM D 3309
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F 1282; CSA B137.9
Polyethylene (PE) pipe, tubing and fittings (for ground source heat pump loop systems)	ASTM D 2513; ASTM D 3035; ASTM D 2683; ASTM F 1055; ASTM D 2837; ASTM D 3350; ASTM D 1693
Polypropylene (PP) plastic pipe	ASTM F 2389
Polyvinyl chloride (PVC) plastic pipe	ASTM D 1785; ASTM D 2241
Raised temperature polyethylene (PE-RT)	ASTM F 2623; ASTM F 2769
Steel pipe	ASTM A 53; ASTM A 106
Steel tubing	ASTM A 254
Stainless steel pipe (Type 304/304L)	ASTM A 312; ASTM A 778
Stainless steel pipe (Type 316/316L)	ASTM A 312; ASTM A 778

301.8.4 Potable pipe fittings. Pipe fittings shall conform to the respective pipe standards or to the standards listed in Table 301.8.4 and Section 303.1.5.

301.8.5 Non-potable pipe fittings. Pipe fittings shall conform to the respective pipe standards or to the standards listed in Table 301.8.5.

TABLE 301.8.4
POTABLE PIPE FITTINGS

MATERIAL	STANDARD
Acrylonitrile butadiene styrene (ABS) plastic	ASTM D 2468
Cast-iron	ASME B16.4; ASME B16.12

Chlorinated polyvinyl chloride (CPVC) plastic	ASSE 1061; ASTM D 2846; ASTM F 437; ASTM F 438; ASTM F 439; CSA B137.6
Copper or copper alloy	ASSE 1061; ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.23; ASME B16.26; ASME B16.29
Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE)	ASTM F 1986
Fittings for cross-linked polyethylene (PEX) plastic tubing	ASSE 1061, ASTM F 877; ASTM F 1807; ASTM F 1960; ASTM F 2080; ASTM F 2098, ASTM F 2159; ASTM F 2434; ASTM F 2735; CSA B137.5
Fittings for polyethylene of raised temperature (PE-RT) plastic tubing	ASTM F 1807; ASTM F 2098; ASTM F 2159; ASTM F 2735
Gray iron and ductile iron	AWWA C110/A21.10; AWWA C153/A21.53
Insert fittings for polyethylene/aluminum/polyethylene (PE-AL-PE) and cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX)	ASTM F 1974; ASTM F1281; ASTM F1282; CSA B137.9; CSA B137.10M
Malleable iron	ASME B16.3
Metal (brass) insert fittings for polyethylene/aluminum/polyethylene (PE-AL-PE) and cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX)	ASTM F 1974
Polyethylene (PE) plastic pipe	ASTM D 2609; ASTM D 2683; ASTM D 3261; ASTM F 1055; CSA B137.1
Polypropylene (PP) plastic pipe or tubing	ASTM F 2389; CSA B137.11
Polyvinyl chloride (PVC) plastic	ASTM D 2464; ASTM D 2466; ASTM D 2467; CSA B137.2; CSA B137.3
Stainless steel (Type 304/304L)	ASTM A 312; ASTM A 778
Stainless steel (Type 316/316L)	ASTM A 312; ASTM A 778
Steel	ASME B16.9; ASME B16.11; ASME B16.28

TABLE 301.8.5
NON-POTABLE PIPE FITTINGS

MATERIAL	STANDARD

Brass	ASTM F 1974
Bronze	ASME B16.24
Copper and copper alloys	ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.23; ASME B16.26; ASME B16.29
Ductile iron and gray iron	ANSI/AWWA C110/A21.10
Ductile iron	ANSI/AWWA C153/A21.53
Gray iron	ASTM A 126
Malleable iron	ASME B16.3
PEX fittings	ASTM F 877; ASTM F 1807; ASTM F 2159
Plastic	ASTM D 2466; ASTM D 2467; ASTM D 2468; ASTM F 438; ASTM F 439; ASTM F 877; ASTM F 2389; ASTM F 2735
Steel	ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A 420

301.8.6 Joints and Connections. Joints and connections shall be of an *approved* type. Joints and connections shall be listed for the pressure of the hydronic system. Joints between different piping materials shall be made with *approved* adapter fittings.

301.8.7 Protection from foreign substances. The system shall be protected to prevent contamination by foreign substances that could impair the flow, quality, and safety of the system.

301.8.8 Insulation. Insulation shall be used on all solar system fluid piping and ducts and the final 1.5 meters (5.0 feet) of metallic cold water supply pipe leading into the system, or the length of piping that is exposed if less than 1.5 meters. Insulation shall have a value of R-0.46 ^{o}K m^2/W (R-2.6 ^{o}F-ft^2-hr /Btu) or greater.

> **Exception:** Non-metallic pipe and fittings approved for outdoor use that are exposed to solar radiation commensurate with the solar collector and contributes to the collection of energy.

301.8.9 Water shut-off. The *solar thermal system* shall have valves to provide for shut-off from the service water supply without interrupting cold water service to the remaining portion of the water distribution system.

301.8.10 Service connections. Connections shall be provided with access for filling, draining and flushing liquid systems.

301.8.11 Filters. Where filters are used in solar thermal systems, they shall be provided with *access* so that they can be cleaned or replaced without cutting or altering the solar thermal piping system or requiring the removal of adjacent equipment or other piping.

The maintenance instructions shall be provided in the applicable installation, operation or maintenance section of the system manual provided by the manufacturer.

301.8.12 Piping systems. The piping system shall be provided with isolation valves that can be closed for the purpose of bypassing the *solar thermal system* thereby permitting operation of the *auxiliary heating equipment* when the *solar thermal system* is inoperative or being serviced.

303.8.13 Entrapped air. Means shall be provided for air and gas removal from the piping system. Open loop circulating systems using potable water as the *heat transfer fluid* shall use an automatic means of air removal. Closed loop systems shall use manual or automatic means of air removal.

> **Exception**: Where allowed by system design, including but not limited to integral collector storage, direct thermosiphon, or drain-back systems.

302
RELIABILITY AND DURABLILITY

302.1 General. *Solar thermal system*s shall comply with Sections 302.1.1 through 302.1.13.

302.1.1 Stagnation. The system 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 system.

302.1.2 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.

302.1.3 Operation conditions. Solar thermal system components shall be capable of operating within manufacturer(s) specified pressure and temperature ranges and shall be capable of withstanding environmental extremes anticipated in actual service without reducing the *design life* of the system.

302.1.4 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.

302.1.5 Freeze protection. Protection from freezing temperatures shall be provided for all system components subject to damage. The supplier shall specify a *freeze tolerance limit* for each system. Solar thermal systems shall comply with Section 302.1.5.1 through 302.1.5.3.

> **Exception**: Systems installed in a location that has no record of an ambient temperature below 5°C (41°F) shall be exempted from the requirements of this paragraph, except the specification of a freeze tolerance limit.

302.1.5.1 Water exposed to freezing temperatures. For solar systems where water is exposed to freezing temperatures a minimum of two freeze protection mechanisms shall be provided on each system. Manual intervention in accordance with 302.5.2 shall be considered as one mechanism. Other acceptable mechanisms include but are not limited to thermal mass (protection, but protection is limited to the thermal capacitance of the system), automatic draining, closed-loop recirculation (with uninterruptible power supply).

302.1.5.2 Manual intervention freeze protection. For solar thermal systems that rely on manual intervention for freeze protection, not less than one freeze protection mechanism shall be provided to protect components from freeze damage under all conditions, including in the event of power failure. Acceptable manual intervention actions include but are not limited to:

1. Draining: 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.

~~2. Valve position adjustments: Valves must be labeled in accordance with 302.1.5.3.~~

~~**302.1.5.3 LABELLING**. A conspicuously placed label shall be attached to the system explaining how the system is protected from freezing and what actions are required to prevent freeze damage, and further leakage if rupture occurs. For systems that rely on manual intervention for freeze protection, this label shall indicate the *freeze tolerance limit* below which manual intervention is required and the procedure to be followed.~~

302.1.6 Protection from leaks. Piping in a solar water heating system shall pass a leak test in accordance with the plumbing code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code, for direct systems or the mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the *International Mechanical Code,* for indirect systems.

302.1.7 Fluid compatibility. Fluids in contact with *solar thermal system* materials shall not corrode or otherwise adversely affect system materials to the extent that their function will be impaired beyond design specifications during the system *design life*.

302.1.8 Deterioration of fluids. Fluids shall not freeze, give rise to precipitation or otherwise lose their homogeneity, boil or develop 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 the *heat transfer fluid design life*.

Exception: When the system design allows for these conditions.

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

302.1.10 Buried components. Solar thermal system components and materials that are intended to be buried in soils shall be protected from degradation under in-service conditions to ensure that their function is not impaired during the system *design life.*

302.1.11 Deterioration protection. Gaskets, sealants, and coupling hoses shall not be adversely affected by contact with fluids or the environment to an extent that will impair beyond design specifications their ability to function during the system *design life*.

302.1.12 Water hammer. Where an incompressible liquid is used as the *heat 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.

302.1.13 Sound and vibration control. Piping and associated fittings shall be designed to carry the *heat transfer fluid* at design flow rates without degradation during the system *design life*. Components involving moving parts, shall be balanced or mounted in such a manner that they do not induce vibration that could cause damage during the system *design life*.

303
SAFETY CRITERIA

303.1 General. *Solar thermal system*s shall comply with Sections 303.1.1 through 303.1.13.

303.1.2 System failure prevention. The system shall be designed so that, in the event of a power failure or a failure of any of the system components, the temperatures, pressures, or other conditions developed in the *solar thermal system* will not damage the system, or the building, or endanger its occupants.

303.1.3 High temperature control. Means shall be provided to limit the temperatures of the components to values not to exceed high temperature limits specified by the supplier. Pressure/temperature relief valves shall not be used for this purpose.

303.1.4 Protection against auto-ignition of combustibles. Combustible materials used in solar equipment shall have a self-ignition temperature of 650 F or greater where tested in accordance with ASTM D1929 at the maximum thickness intended for use. Plastic materials shall conform to Class CC1 or CC2 when tested in accordance with ASTM D635 at the thickness intended for use.~~Combustible materials used in solar equipment shall not be exposed to temperatures that could cause ignition.~~

303.1.5 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.

303.1.6 Fluid safety. Heat transfer fluids used within *solar thermal systems* shall comply with Section 303.1.6.1-303.1.6.5.

303.1.6.1 Food grade fluid additives. Any *food grade fluid* used as a heat transfer fluid containing additives shall be third party tested by an approved agency to the appropriate section of the *Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Parts 174-186*.

303.1.6.2 Combustible and flammable fluids. The storage, piping and handling of combustible and flammable fluids shall conform to the requirements of the *International Fire Code*.

303.1.6.3 Flash point. The flash point of a heat transfer fluid shall exceed by 28°C (50°F), or more, the design maximum no-flow temperature to be reached by the fluid in the collector. The flash point shall be determined in accordance with the *International Fire Code*. In systems using a gaseous heat transfer fluid, a flammable gas shall not be used.

303.1.6.4 Toxicity. The use of *toxic fluids* shall comply with the *Title 15 of the Federal Hazardous Substances Act,* Chapter 60 of the *International Fire Code*, and the requirements of the local jurisdiction.

~~**303.1.6.5 Fluid safety labeling.** *Solar thermal systems* shall be provided with labels indicating heat transfer fluid classes used as defined in Section 202. Labels shall identify the drain and fill valves in the *solar thermal system*. Each label shall identify the fluid in that loop. The location of fluid handling instructions shall be referenced. Labeling shall categorize the heat transfer fluid with one of the following: "Potable Water", "Food Grade", "Non-Food Grade", or "Toxic". Labeling shall also be provided that reads as follows: "Fluid could be discharged at high temperature or pressure or both. Fluids shall not be used that would change the original classification of this system. Unauthorized alterations to this system could result in a health hazard or hazardous condition."~~

~~**303.1.6.6 Heat exchanger labeling.** Heat exchangers shall be labelled to indicate the heat exchanger type as follows:~~

~~1. "Single-wall without leak protection"~~
~~2. "Double-wall with no leak protection"~~
~~3. "Double-wall with leak protection"~~

303.1.8 Backflow. Means shall be provided to prevent the backflow of non-potable fluids, solids or gases into the potable water system through cross-connections or any other piping connections to the system.

303.1.9 Pressure relief. Each portion of the system where excessive pressures can develop shall be protected by a pressure relief device. Means of rendering a pressure relief device ineffective shall not be allowed under this standard. A section shall not be isolated from a pressure relief device. Automatic pressure relief devices shall be designed to open at or below the maximum design pressure of the system device that has the lowest pressure rating.

303.1.10 Occupant protection. System subassemblies and components that are exposed to the public and are maintained at elevated temperatures shall be insulated to maintain exposed surface temperatures below 49°C (120°F) during operation, or they shall be isolated.

303.2 Electrical safety. *Solar thermal systems* containing electrical components and wiring shall be designed and installed in accordance with NFPA 70 or CSA C22.1, as applicable.

303.2.1 Protection of electrical components. Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the device and NFPA 70.

303.2.2 Wiring and Connections. Electrical wiring shall be sized and installed in accordance with NFPA 70 and manufacturer's instructions. Wiring shall be approved for the temperature, voltage and applicable service conditions. Wiring subjected to direct sunlight shall be rated for the application or shall be protected by an approved method.

303.2.2.1 Wiring identification. Control circuit wiring and terminals shall be identified in accordance with the NFPA 70.

303.2.2.2 PVT wiring. Wiring associated with photovoltaic modules used for electrical power generation within a photovoltaic-thermal hybrid shall comply with UL 1703.

303.2.4 Component listings. Electrically powered components over 24 volts used within systems shall be listed and labeled to standards referenced by NFPA 70 or CSA C22.1. Electrically powered components over 24 volts shall also be listed and labeled to one or more of the standards specified in Table 303.2.4, as applicable.

TABLE 303.2.4

ELECTRICAL COMPONENT REFERENCE STANDARDS

ELECTRICAL COMPONENT	STANDARD
Differential Controllers	CSA E60730-1, EN 60730-2-9, UL 60730-1, UL 873
Pumps	CSA 22.2, No. 108, UL 778,
Photovoltaic Modules	UL 1703, IEC 61215, or IEC 61646
Inverters and Power Conditioners	UL 1741
Metal-Sheathed Heating Elements	UL 1030
Wiring Connectors	UL 1977

Solar Trackers	UL 3703

304
OPERATION AND SERVICING CRITERIA

304.1 General. *Solar thermal system*s shall comply with Sections 304.1.1 through 304.1.6.

304.1.1 Operating indicators. *Solar thermal system*s shall include means for an observer to readily determine that the system is operating properly.

304.1.2 Tanks. Tanks shall be labeled to indicate the maximum operating pressure and temperature.

304.1.3 Waste disposal. Where fluid is automatically discharged in systems using a *toxic heat transfer fluid,* a means shall be provided for the catchment and removal of these fluids in accordance with *Title 15 of the Federal Hazardous Substances Act,* Chapter 60 of the *International Fire Code*, and the requirements of the local jurisdiction.

304.1.4 Dirt retention and staining. Solar systems and collectors shall be accessible for periodic cleaning if conditions are such that self-cleaning by rain will not keep the collectors operating efficiently.

304.1.5 Maintenance and servicing. Access to individual components of the system that require periodic examination, adjustment, service or maintenance shall be provided in accordance with the plumbing code and mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code and International Mechanical Code.

304.1.6 Permanent maintenance accessories. Permanent maintenance accessories shall be provided, including but not limited to hose bibbs and drains necessary for maintenance of the system. Where accessories are in contact with potable water, they shall be protected against backflow in accordance with Section 303.1.8.

305
INSTALLATION CRITERIA

305.1 General. *Solar thermal system*s shall comply with Sections 305.1.1 through 305.1.19.

305.1.1 Penetrations of floor/ceiling assemblies and fire-resistance-rated assemblies. Penetrations of floor/ceiling assemblies and assemblies required to have a fire-resistance rating shall be protected in accordance with the *International Building Code*.

305.1.2 *Auxiliary heating equipment*. Interconnection of the *auxiliary heating equipment* to the solar energy system shall be made in a manner that will not result in temperatures or pressures beyond design specifications in the auxiliary heating equipment or bypassing of safety devices in the auxiliary heating equipment.

305.1.3 Component placement. Components of a solar water heating system that during operating conditions will cause effects to increase or decrease humidity, temperature or thermal radiation beyond acceptable levels for building materials shall be identified in the installation, operation and maintenance manuals with required clearances to prevent such effects. The location of components used in the *solar thermal system* design shall facilitate installation, startup, operation, shutdown and maintenance of the system.

305.1.4 Access. The location of solar components shall not impair access~~ibility~~ needed to maintain and protect the building or site.

305.1.5 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 vermin. Required roof penetrations shall be made in accordance with the International Building Code.

305.1.6 Water damage. Collectors and supports shall be installed in such a manner that water flowing off the collector surface will not damage the building or cause erosion of the roof beyond design specifications.

305.1.6.1 Required pan. Where a *storage tank*-type water heater or a hot water *storage tank* is installed in a location where water leakage from the tank will cause damage, the tank shall be installed in a galvanized steel pan having a material thickness of not less than 0.0236 inch (0.6010mm) (No. 24 gage), or other pans approved for such use.

305.1.6.2 Pan size and drain. The pan shall be not less than 11/2 inches (38 mm) in depth and shall be of sufficient size and shape to receive all dripping or condensate from the tank or water heater. The pan shall be drained by an indirect waste pipe having a diameter of not less than 3/4 inch (19 mm). Piping for safety pan drains shall be of those materials listed in Table 301.7.3 or Table 301.7.4.

305.1.6.3 Pan drain termination. The pan drain shall extend full-size and terminate over a suitably located indirect waste receptor or floor drain or extend to the exterior of the building and terminate not less than 6 inches (152 mm) and not more than 24 inches (610 mm) above the adjacent ground surface.

305.1.7 Relief valve discharge. Solar energy system components containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with a pressure and temperature relief valve. Each section of the system in which excessive pressures are capable of developing shall have a relief device located so that a section cannot be isolated from a relief device. Relief valves shall comply with the requirements of Section 305.1.7.1 and discharge in accordance with Section 305.1.7.2.

Exception: Solar energy system collector loops containing pressurized fluids, and separated from a domestic water source by an approved heat exchanger, shall be protected against pressures exceeding design limitations with a pressure relief valve.

305.1.7.1 Safety and safety relief valves. Safety and safety relief valves shall be listed and labeled, and shall have a minimum rated capacity for the equipment or appliances served.

305.1.7.2 Discharge pipes. Safety and relief valve discharge pipes shall be of rigid pipe that is approved for the temperature of the system. The discharge pipe shall be the same diameter as the safety or relief valve outlet. Safety and relief valves shall not discharge so as to be a hazard, a potential cause of damage or otherwise a nuisance. Relief valves in partially filled collector loops capable of producing steam shall be discharged to the outside of the structure. Where a relief valve discharges inside a structure or to the drainage system, the installation shall conform to the plumbing code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code. Where a solar system component requiring a relief valve is located outside the structure the termination shall be not more than 6 inches (152 mm) above a splash block, a secured surface material or catchment method to prevent damage.

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

305.1.8.1 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.

305.1.9 Penetration of structural members. Where penetrations are required in structural members to accommodate passage of solar components, such modified structural members shall comply with the plumbing code and mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code and International Mechanical Code, as applicable.

305.1.10 Protection from thermal deterioration. Building materials adjacent to solar equipment shall not be exposed to elevated temperatures that could accelerate their deterioration.

305.1.11 Tilt and azimuth. Collectors shall be installed on a mount capable of maintaining tilt and azimuth to design conditions.

305.1.12 Shading of collector. The location and orientation of collectors shall be such that they are not shaded by external obstructions or each other more than the specified period allowed in the design.

305.1.13 Pipe and component supports. Piping shall be installed and supported in accordance with the plumbing code and mechanical code adopted by the authority having jurisdiction, or in the absence of such code, the International Plumbing Code and International Mechanical Code. Hangers shall provide support and maintain slope of pipes. Hangers or supports for insulated pipes and components shall be designed to not compress or damage the insulation material. Hangers shall not cause galvanic corrosion of the hanger or the pipe.

305.1.15 Underground piping. Underground piping material shall conform to sections 301.7.2 or 301.7.3. Underground piping subject to vehicular traffic shall be installed to withstand the additional loading applied by such traffic. The trenches and backfill shall be free of sharp objects in contact with the pipe.

305.1.16 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, and other factors that have the potential to adversely affect accuracy.

305.1.17 Emergency egress and access. The design and installation of systems shall not impair egress of the building occupants.

305.1.18 Rain and snow on collector. The location, orientation, and position of collectors relative to nearby objects and surfaces shall be such that water run-off from the collector surface is not impeded and excessive build-up of snow on lower portions of the collector glazing is not permitted to occur.

305.1.19 Lightning protection. Lightning protection shall be provided for collectors in accordance with NFPA 780.

307 Pump Stations

307.1 General. The performance of a *pump station* that is comprised of multiple components can be evaluated separately from a complete solar thermal system if the performance of the individual pump station components working together as one is known. Pump stations shall comply with Sections 307.2 through 307.21.2.

307.2 Controller. The pump station controller shall comply with Section 301.6.

307.3 Wiring identification. Pump station wiring shall comply with Section 301.6.3.

307.4 Protection of electrical components. Electrical components in a pump station shall comply with Section 303.1.1.

307.5 Pump station failure. The pump station shall comply with Section 303.1.2. The pump station shall remain in a secure state and keep the freezing and overheating protection mechanisms operable when tested in accordance with Sections 307.5.1 through 307.5.3.

307.5.1 Operating conditions. Pumps shall be tested under operating conditions for the duration of the test.

307.5.2 Failure mode. Failure of the temperature sensors shall be simulated by short circuiting all sensors and opening the circuit one sensor at a time and then simultaneously together.

307.5.3 Operation verification. Operation state or mode of the station shall be verified.

307.6 Piping and fittings. Piping shall comply with Section 301.8.2 and 301.8.3. Fittings shall comply with 301.8.4 and 301.8.5.

307.7 Service connections. Pump station service connections shall comply with Section 301.8.10.

307.8 Solar system isolation. Isolation valves that can be closed for the purpose of isolating the *solar thermal system* shall be listed and labeled by a recognized third-party listing agency.

307.9 Fluid system sizing. Pumps, piping, fans, ducts and other components shall comply with Section 301.1.6.

307.10 Pressure drop and vibration. Pump stations shall comply with Section 301.1.7. Except for the higher startup flow rate needed in a *drain-back* system to establish a siphon, 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 *solar thermal system*.

307.11 Contamination of potable water. Pump stations shall comply with Section 303.1.5.

307.12 Fluid compatibility. Pump stations shall comply with Section 302.1.7.

307.13 Pressure Integrity Test. The pressure integrity test shall be conducted in accordance with the following procedure. The piping components pass the test where observable pressure change has not occurred.

1. The pressure gauge shall be attached to the exit port of the pump station and the outlet shall be sealed.

2. The supply side shall be filled with unheated water.

3. The test pressure shall be 1110 kPa Gauge (160 PSIG).

4. Hydraulic pressure shall be applied to the inlet port until the gauge indicates the test pressure has been reached.

5. The inlet pressure port shall be closed and the pressure is monitored for 15 minutes.

6. The final pressure shall be recorded.

307.14 Thermostatic mixing valve. Thermostatic mixing valves in pump stations shall comply with Section 301.7.

307.14.1 Thermostatic mixing valve location. The location of all thermostatic mixing valves in a pump station shall comply with Section 301.7.1.

307.15 Components. Temperature and pressure control valves and devices used in pump stations shall be listed and labeled by recognized third party listing agencies.

307.16 High temperature control. High temperature control in pump stations shall comply with Section 303.1.3.

307.16.1 Temperature limiting system test. Temperature limiting system testing shall comply with the following procedure. The system passes the test when the pump station disables any heat input device when the maximum temperature limit is exceeded.

1. Pumps shall be tested under operating conditions for the duration of the test.
2. The pump station shall be connected to a suitable heating source that can supply the target temperature.

3. The heating source output temperature shall be set not less than 5°C (10°F) above the maximum temperature limit specified by manufacturer.

4. The pump station shall be observed during testing.

307.17 Expansion tanks. Expansion tanks in pump stations shall comply with Section 301.4.

301.18 Heat exchangers. Heat exchangers in pump stations shall comply with Section 301.5.

307.19 Reliability and durability. Pump stations shall comply with Section 302 of this standard, as applicable.

307.20 Combustible materials. Combustible materials used in pump stations shall comply with Section 303.1.4.

307.21 Labeling and manuals. ~~Pump stations shall be labeled with the manufacturer's contact information or trademark, a model name or number, the recommended working fluids, the maximum working temperature and pressure and the recommended flow rates~~

307.21.1 Labels. Warning lights, switches and controls in pump stations 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.~~

307.21.2 Manuals and instructions. Pump stations operation, maintenance, and installation instructions manuals from the manufacturer shall be supplied or made available. Manufacturer's contact information shall be included within these documents.

CHAPTER 4 LABELLING, MARKING AND DOCUMENTATION

401 GENERAL

401.1 General. Solar water heating systems shall be provided with marking, labeling and documentation to facilitate installation, inspection, operation and maintenance.

402 MARKING AND LABELING

402.1 General. The solar water heating system shall include one or more indelible labels containing system information as established in this section.

402.2 Label Location. Where a system incorporates a storage tank, the label shall be permanently affixed to the tank in a location that is not obscured by piping or insulation. Where systems do not include a dedicated solar storage tank, the label shall be affixed to the auxiliary water heater. For PV water heaters, the label may also be affixed to the inverter.

402.3 Units. Energy values shall be provided in both Imperial and SI units.

402.4 Label Content. The information specified in this section shall be provided 1 to 2 labels in a clearly readable size and format. Where two labels are utilized, they shall be affixed in proximity of each other. The label(s) shall include the following information:

1. Manufacturer's name
2. Model number
3. System listing number and third-party certification agency
4. Collector listing number, third-party certification agency, and quantity
5. Heat transfer fluid and concentration range
6. Storage tank volume
7. Expansion tank volume
8. Relief valve specification and setpoint
9. Maximum water supply pressure
10. Maximum solar loop pressure
11. Flow rate range (where a flow meter is installed)
12. Backup energy rating. For electrical, include phase/volts/amps. For gas, include minimum pressure.
13. Installation date field (to be entered by the installer in the field).

402.5 Electrical Diagram. A master wiring diagram with system electrical requirements, including but not limited to electrical phase, voltage and maximum current, shall be affixed to the system. The diagram may be included in the label specified in 402.4 or affixed separately.

402.6 Mechanical Diagram. A mechanical diagram showing all major system components and connections shall be affixed to the system. The diagram may be included in the label specified in 402.4 or affixed separately.

403 MANUALS

403.1 General. *Solar thermal system*s shall comply with Sections 403.1.1 through 403.1.8.

403.1.1 Provision for manuals. A manual or manuals shall be provided with each *solar thermal 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 in accordance with Section 403.1.1.1 through Section 403.1.1.3.

403.1.1.1 Installation instructions. The manuals shall include an explanation of the physical and functional requirements of the system and its components and the general procedures for their proper installation. The instructions shall describe the interconnection requirements of the various subsystems and components and their interface requirements with the building and the site. Installation instructions shall prescribe installation complying with the building code, plumbing code, mechanical code, ~~and~~ fire code and electrical code adopted by the authority having jurisdictions, or in the absence of such codes, shall comply with the *International Building* Code, *International Plumbing Code, International Mechanical Code,* ~~and~~ *International Fire Code, and National Electrical Code (NFPA 70)*.

403.1.1.2 Operation instructions. The manual shall:

1. Clearly describe the operation of the *solar thermal system*, explaining the function of each subsystem and component. Include a system diagram showing the components and their relationships in the typical installed system and list the system manufacturer's design flow range in each collector bank.

2. Describe major components in a separate section or by enclosing descriptive material furnished by the supplier of the components.

3. Describe procedures for system start-up, routine maintenance and special conditional operations such as drain-down.

4. Specify fill weights, pressure ratings and temperature ratings for servicing and routine maintenance of the system.

5. Specify temperature, pressure and flow conditions expected at various access points to allow simple operational checks and troubleshooting.

6. Include instructions for isolating different sections of the system in emergency situations and shall include instructions for leaving the system unattended and unused for long periods of time.

7. Indicate the *freeze tolerance limit* and freezing control measures and include the statement: “Freeze tolerance limits are based upon an assumed set of environmental conditions.” Where 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 provided: “Extended periods of cold weather, including ambient air temperatures above the specified limit, might 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.”

8. Be provided at the installation site

403.1.1.3 Maintenance plan. The manual shall include a comprehensive plan for maintaining the specified performance of the *solar thermal system* over the *design life* of the 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 provide projections for component replacement.

403.1.2 Fluid quality. The manual shall identify *heat transfer fluid(s)* used in the *solar thermal 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 or additives for water used in the system. Procedures shall be described for maintaining the heat transfer fluid's chemical composition at levels to prevent beyond design specifications deposits on the heat transfer surfaces, corrosion of the heat transfer surfaces and loss of freeze resistance. Recommended inspection and test intervals for the heat transfer fluid shall be provided.

403.1.3 Service and replacement parts. The manual shall include a parts list with 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 the make and model of all options 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 flow conditions expected at system monitoring points to allow simple operational checks. The number and piping connection arrangement of the solar collectors shall be included. The manual shall include contact information for not less than one company in close geographic proximity to the purchaser that offers service for the system.

403.1.4 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 must be taken to avoid these hazards.

403.1.5 Warranty coverage. The manual shall provide a full description of the warranty coverage on the system. The manual shall describe what actions the purchaser must undertake to obtain warranty coverage.

CHAPTER 5 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 and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 104.1.

ANSI Z21.10.1/CSA 4.1-~~2013~~ 2017 Gas Water Heaters Volume 1, Storage Water Heaters With Input Ratings of 75,000 Btu Per Hour or Less

ANSI Z21.10.3/CSA 4.3-~~2013~~ 2017 Gas Water Heaters - Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous.

ANSI Z21.22/CSA 4.4-1999(R2003)~~2015~~ "Relief Valves for Hot Water Supply Systems"

~~ASME Boiler and Pressure Vessel Code 2013, Division 1, Section VIII, "Rules for Construction of Pressure Vessels"~~

~~ASME Boiler and Pressure Vessel Code 2013, Section X, "Fiber-Reinforced Plastic Pressure Vessels"~~

BPVC-2019 ASME Boiler and Pressure Vessel Code -07 Edition

ASME A112.4.1–2009 (R2019) "Water Heater Relief Valve Drain Tubes"

ASME A112.18.6/CSA B125.6-202109 "Flexible Water Connectors"

ASSE 1017-2009 "Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems

ASTM A53-20182 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless"

ASTM A106-~~2013~~ 2018 "Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service"

ASTM A254-~~2012~~ 2010(2018) "~~Standard~~ Specification for Copper ~~-~~Brazed Steel Tubing"

ASTM A312-~~2014~~ 2017 "Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes"

ASTM A778-201609 "~~Standard~~ Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products"

ASTM B42-~~2010~~ 2015a "~~Standard~~ Specification for Seamless Copper Pipe, Standard Sizes"

ASTM B43-~~2010~~ 2015 "~~Standard~~ Specification for Seamless Red Brass Pipe, Standard Sizes"

ASTM B75-2011 "~~Standard~~ Specification for Seamless Copper Tube"

ASTM B88-~~2009~~ 2016 "~~Standard~~ Specification for Seamless Copper Water Tube"

ASTM B135-~~2010~~ 2017 "~~Standard~~ Specification for Seamless Brass Tube"

ASTM B251-~~2010~~ 2017 "~~Standard~~ Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube"

ASTM B302-~~2012~~ 2017 "~~Standard~~ Specification for Threadless Copper Pipe, Standard Sizes"

ASTM B447-2012 "~~Standard~~ Specification for Welded Copper Tube"

ASTM B75-2011 "~~Standard~~ Specification for Seamless Copper Tube"

ASTM B302-~~2012~~ 2017 "~~Standard~~ Specification for Threadless Copper Pipe, Standard Sizes"

ASTM B251-~~2010~~ 2017 "~~Standard~~ Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube"

ASTM D471-2012a "Standard Test Method for Rubber Property—Effect of Liquids"

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

ASTM D750-2012 "Standard Practice for Rubber Deterioration Using Artificial Weathering Apparatus"

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

ASTM D1527-1999 (2005) "Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80"

ASTM D1693-~~2013~~ 2015 "~~Standard~~ Test Method for Environmental Stress-Cracking of Ethylene Plastics"

ASTM D1785-~~2012~~ 2015E1 "~~Standard~~ Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120"

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

ASTM D2282-1999(2005) “Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe (SDR-PR)”

ASTM D2241-201509 “Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)”

ASTM D2513-2014 “Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings”

ASTM D2683-2014 “Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing”

ASTM D2837-2013E1” Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products”

ASTM D2846-2009 2017BE1 “Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems”

~~ASTM D2683-2010e3 “Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing”~~

~~ASTM D2837-2013E1” Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products”~~

ASTM D3035-2014 2015 “Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter”

ASTM D3309-1996a(2002) “Specification for Polybutylene (PB) Hot and Cold Water Distribution Systems”

ASTM D3350-2012e1 “Standard Specification for Polyethylene Plastics Pipe and Fittings Materials”

ASTM F441-2013 2015 “Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80”

ASTM F442-2013 2015 “Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR–PR)”

ASTM F876-2013a 2018A “Standard Specification for Crosslinked Polyethylene (PEX) Tubing”

ASTM F877-2011a 2018A “Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems”

ASTM F1055-~~2013~~ 2016A "~~Standard~~ Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing"

ASTM F1281-~~2011~~ 2017 "~~Standard~~ Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe"

ASTM F1282-~~2010~~ 2017 "~~Standard~~ Specification for Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe"

ASTM F1986-2001(2011) "~~Standard~~ Specification for Multilayer Pipe Type 2, Compression Fittings, and Compression Joints for Hot and Cold Drinking-Water Systems"

ASTM F2262-~~2011~~ 2009 "~~Standard~~ Specification for Multilayer Pipe Type 2, Compression Fittings, and Compression Joints for Hot and Cold Drinking-Water Systems"

ASTM F2389-~~2010~~ 2017A "~~Standard~~ Specification for Pressure-rated Polypropylene (PP) Piping Systems"

ASTM F2623-~~2008~~ 2014 "~~Standard~~ Specification for Polyethylene of Raised Temperature (PE-RT) SDR 9 Tubing"

ASTM F2769-~~2010~~ 2018 "~~Standard Specification for~~ Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems"

AWWA C115/A21.15-201~~4~~7 "Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges"

AWWA C151/A21.51-2015~~09~~ "Ductile-Iron Pipe, Centrifugally Cast"

Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Parts 174-186

CSA B137.1-2017 "Polyethylene (PE) Pipe, Tubing and Fittings for Cold-water Pressure Services"

CSA B137.2-2017 "Polyvinylchloride (PVC) Injection-moulded Gasketed Fittings for Pressure Applications"

CSA B137.3-2017 "Rigid Poly (Vinyl Chloride) (PVC) Pipe for Pressure Applications"

CSA B137.5-2017 "Cross-linked polyethylene (PEX) tubing systems for pressure applications"

CSA B137.6-2017 " Chlorinated polyvinylchloride (CPVC) pipe, tubing, and fittings for hot- and cold-water distribution systems"

CSA B137.9-~~2009~~ 2017 "Polyethylene/aluminum/polyethylene (PE-AL-PE) composite pressure-pipe systems"

CSA B137.10-~~2009~~ 2017 "Cross-linked polyethylene/aluminum/crosslinked polyethylene (PEX-AL-PEX) composite pressure-pipe systems"

CSA B137.11-~~2009~~ 2017 " Polypropylene (PP-R) pipe and fittings for pressure applications"

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

CSA E60730-1-2015 "Automatic electrical controls – Part 1: General requirements"

FS WW-P-325B-1976 "Pipe Bends, Traps, Caps and Plugs; Lead (for Industrial Pressure and Soil and Waste Applications)"

EN 60730-2-9-2016 "Automatic electrical controls – Part 1: General requirements"

ISO 10380-2012 "Pipework – Corrugated Metal Hoses and Hose Assemblies"

FDA Title 21 Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Parts 174–186 (revised as of April 1, 2015)

FDA Title 15 Federal Hazardous Substances Act~~, Title 15~~

ICC 901/SRCC Standard 100-202#, "Test Methods and Minimum Standards for Certifying Solar Collectors"

IEC 61215-2016 "Terrestrial photovoltaic (PV) modules - Design qualification and type approval"

IEC 61646-2008 "Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval"

IBC—21 International Building Code®~~International Building Code 2012~~

IFC—21 International Fire Code®~~International Fire Code 2012~~

IFGC—21 International Fuel Gas Code®

IMC-21 International Mechanical Code® ~~2012~~

IPC—21 International Plumbing Code®~~International Plumbing Code 2012~~

NFPA 30-2012, "Flammable and Combustible Liquid Code"

NFPA 70-~~2014~~2020, "National Electrical Code"

NFPA 780-~~2014~~2020, "~~National Electrical Code~~Standard for the Installation of Lightning Protection"

NSF 61-2013 "Drinking Water System Components – Health Effects"

NSF 372-2011 "Drinking Water System Components – Lead Content"

UL 174-2012 "Standard for Household Electric Storage Tank Water Heaters"

UL 499-~~2013~~ 2014 "Electric Heating Appliances—with revisions through February 2017"~~Standard for Electric Heating Appliances"~~

UL 732-~~2013~~ 2018 "~~Standard for~~ Oil-Fired Storage Tank Water Heaters"

UL 778-2014 "Standard for Motor-Operated Water Pumps"

UL 873-2012 "Standard for Safety Temperature-Indicating and Regulating Equipment

UL 1030-2015 "Standard for Sheathed Heating Elements"

UL 1453-2016~~1~~ "~~Standard for~~ Electric Booster and Commercial Storage Tank Water Heaters"

UL 1703-2002 "Standard for Flat-Plate Photovoltaic Modules and Panels with Revisions through November 2014"

UL 1741-2010 "Standard for Inverters, Converters, Controllers and Interconnection System Equipment Use with Distributed Energy Resources

UL 2523-2009~~2013~~ "Standard for Oil-Fired Storage Tank Water Heaters – with revisions through March 2018"

UL 3703-2015 "Standard for Solar Trackers"

UL 60730-1-2009 "Automatic Electrical Controls for Household and Similar Use - Part 1: General Requirements"

[END PUBLIC REVIEW DRAFT]

ICC STANDARDS - PUBLIC COMMENT FORM

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7)

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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
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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