# Solar Water Heating Installation Requirements

## Adapted by Energy Trust of Oregon

from The Bright Way to Heat Water™ technical requirements

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## Acknowledgments

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We would also like to thank The Bright Way to Heat Water™ program, established by the Eugene Water and Electric Board (EWEB) to promote the installation of energy-saving residential solar water and pool heating systems. The equipment specifications developed over the past 20 years by The Bright Way program have been integral in promoting the installation of durable, safe solar hot water systems in the Pacific Northwest.

## Revisions

Energy Trust updates the installation requirements annually. Many thanks to the industry members and inspectors that have invested their time to help keep this document current.

**Table 1. 2011 Revisions**

| Section | Revision |
|---|---|
| 2.2.5 | Revised to require stainless steel fasteners for all collector connections. |
| 2.7.2 | Revised minimum antifreeze temperature rating from 325 °F to 300 °F. |
| 2.9.1 | Revised to allow a minimum storage ratio of 1.0 gal/ft$^2$ for drainback systems and a load dependent requirement for commercial installations. |
| 2.9.5 | Eliminated requirement for anti-convective piping between tanks. |

# Table of Contents

# 1.0 Purpose

The following document outlines the minimum criteria for a solar water heating ("SWH") system ("System") installed by a Solar Water Heating Program trade ally under Energy Trust of Oregon's Solar Water Heating Program ("Program").

The purpose of these installation requirements is to help promote the performance and longevity of systems that receive Energy Trust incentive funding. Energy Trust reserves the right to require compliance with installation specifications that may differ from those of a manufacturer or exceed applicable codes. Any variations from the Program's installation requirements shall receive prior approval from Energy Trust.

# 2.0 Requirements for All Systems

## *2.1 General*

2.1.1 System shall be installed on real property in Oregon that receives electrical service directly from Portland General Electric or Pacific Power if the installation is displacing electric water heating or gas service from NW Natural or Cascade Natural Gas if the installation is displacing gas water heating.

2.1.2 The installation shall be of industry standard and workmanlike quality.

2.1.3 System should be optimized for annual performance without sacrificing good aesthetics. See ***Section 2.5: Solar Access.***

2.1.4 System design shall be documented with a schematic diagram that accurately describes all components installed, plumbing design, and relative location of valves and monitoring devices.

2.1.5 Equipment, materials, and installation shall comply with equipment manufacturers' specifications.

2.1.6 The system shall be properly permitted, inspected and in compliance with all relevant local building, plumbing, mechanical, and electrical codes.

2.1.7 System equipment installers shall be licensed according to the Oregon Building Codes Division and shall be working for a contractor that is licensed according to the Oregon Construction and Contractors Board.

2.1.8 Monitoring/maintenance instructions per Energy Trust specifications shall be plainly displayed. See ***Section 5.0: System Documentation***.

## *2.2 Materials*

2.2.1 Materials used outdoors shall be sunlight/UV-resistant and listed for outdoor locations.

2.2.2 Materials shall be designed to withstand the temperatures to which they are exposed.

2.2.3 Dissimilar metals that have galvanic action (such as aluminum and steel) shall be isolated from one another using industry standard practices (such as brass unions or nipples, non-conductive shims, washers, or other methods).

2.2.4 Aluminum shall not be placed in direct contact with concrete materials.

2.2.5 Only high-quality stainless steel fasteners shall be used to secure collectors. Stainless steel bolts shall be coated with an anti-seize lubricant to prevent galling and allow for removal during system maintenance or repair.

2.2.6 Structural members shall be either:

- Corrosion-resistant aluminum
- Hot-dip galvanized steel per ASTM A123 equivalent or better.
- Coated or painted steel (not allowed in marine environments)
- Stainless steel (recommended for marine environments)
- Outdoor rated pressure treated lumber or laminated beams:
  - Shall be installed using roofing flashing methods to prevent water pooling and UV exposure on top surface.
  - Shall not be installed in direct contact with roofing material, soil or where exposed to extended periods of pooled water.

## *2.3 Equipment and Installation*

2.3.1 All system components shall be new.

2.3.2 All solar collectors shall have OG-100 certification by the Solar Rating and Certification Corporation (SRCC).

2.3.3 All systems that serve the domestic water load in a single residence (home, apartment, or condo unit) shall be listed on Energy Trust's ***Eligible Residential Solar Water Heating Systems List*** and shall have SRCC OG-300 certification.

Energy Trust maintains a list of system models that have been reviewed by the Program and deemed eligible for incentives when installed in accordance with the requirements of this document and the ***Program Guide for Solar Water Heating Trade Allies.*** System models that are not on this list shall be submitted to the Program for review prior to the submission of an incentive application.

All residential systems shall comply with ***SRCC Document OG-300: Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems***[1].Energy Trust reserves the right to require compliance with installation specifications that may exceed SRCC's minimum standards.

***NOTE:*** Non-residential systems and systems that serve multiple residences are exempt from the ***Eligible Residential SWH Systems List*** and OG-300 requirements. See ***Section 4.0*** for additional requirements for custom-designed systems.

2.3.4 The system shall incorporate freeze and overheat protection strategies that:

- Require no manual operations on the part of the building occupant.
- Result in no lost electrical or gas energy due to re-circulation of heated water during cold winter conditions.
- Result in no lost electrical or gas energy due to drain of heated water.
- Limit possible high water temperature in the solar storage tank to no more than 180°F.
- Possess demonstrated or theoretical reliability in weather conditions common to climates of the Pacific Northwest.

2.3.5 Monitoring devices shall be installed in an easily visible location.

[1] http://www.solar-rating.org/standards/standards.htm

2.3.6 Any building insulation (attic, floor, wall) disturbed due to system installation shall be restored to previous condition.

To preserve pre-existing building insulation levels, Contractor shall re-fluff, add to, replace, or re-attach in a workmanlike manner, any existing insulation and its support that was disturbed during system installation. It is recommended the contractor document any pre-existing damage not due to the solar installation.

2.3.7 All penetrations to building shell shall be sealed and fire resistance maintained.

To prevent intrusion by insects or vermin, all penetrations to building shell (walls, etc.) resulting from the installation of the solar system shall be permanently sealed with appropriate water and pest-proof materials. Any penetrations through fire-rated assemblies shall not reduce the fire resistance required by local codes and standards.

2.3.8 All components, including solar storage and backup tanks, shall be located to allow access and adequately protected.

To facilitate servicing and/or replacement of System components, the installation shall be configured to provide adequate access to all parts; components and controls of the system, including solar storage and backup tanks. “Adequate” access means not having to remove permanently affixed building components in order to service or replace system equipment, and not having to remove tanks in order to service system equipment.

The installation shall also be configured to provide adequate protection of all system components from potential damage due to occupant traffic or activity.

2.3.9 The solar storage and backup tanks and related components (excluding collectors and integral passive systems) shall be located in an enclosed tempered space.

To protect the system from freezing conditions, the solar storage tank, backup tanks, and related components (excluding collectors and integral passive systems) shall be located in a totally enclosed, tempered and weatherproof space. It is recommended this space be insulated. A “tempered” space can be one of the following:

- An interior heated space.
- A fully enclosed, weatherproof space that is consistently warmed (tempered) in the winter to above freezing temperatures due to 1) A common wall with, and a door opening into, a heated space and/or 2) A consistent source of supplemental heat (such as a water heater, freezer, portable heater, etc.) sufficient to maintain the space above 32°F during periods of winter design dry bulb temperatures for the location.
- A detached fully enclosed exterior space with adequate supplemental heat.
- A fully enclosed basement located under a heated living space, with a concrete floor and below grade walls, and not subject to outdoor ambient air flow.
- A fully enclosed and insulated structure located in a vented crawl space under the insulated floor of a heated living space. The structure shall have R-11 minimum insulated framed walls extending from grade level to the insulated floor above, and a hinged, positively latched and insulated access door sized to allow full access for monitoring system performance and servicing system components.
- A fully enclosed outdoor shed that is attached to a common wall with a heated space. The shed shall have weatherproof, R-19 minimum insulated walls and roof, concrete floor, or wood floor insulated to R-19, and a hinged, positively latched, insulated, and weather stripped access door sized to allow full access for monitoring system performance and servicing system components.

2.3.10 Potable water supplied to the solar storage tank shall meet the following minimum quality standards:

- Less than 1000 ppm total dissolved solids
- Less than 500 ppm total hardness
- Less than 400 ppm total alkalinity

The potable water supplied to the system shall meet minimum water quality standards to maximize the operational life of the solar storage tank and other solar system components.

2.3.11 Incoming supply line pressure to the system shall not exceed 80 psi, and pressure reducing valve (if required) shall be properly located.

To avoid potentially damaging pressure build up from high potable water temperatures in the system, and resulting unwarranted discharge of temperature and pressure relief valves, the incoming supply line pressure to the system shall not exceed 80 psi. If the incoming supply line pressure to the system exceeds 80 psi, a pressure reducing valve shall be installed and set to 80 psi or less to control the inlet pressure. The pressure-reducing valve shall be located on the incoming water supply line upstream of all plumbing and components associated with the solar and back-up water heating system.

2.3.12 If a pressure reducing valve, check valve, and/or back flow preventer is/are on potable supply line to the system, a properly sized, located, and charged expansion tank shall be installed.

To avoid potentially damaging pressure build up from the thermal expansion of the potable water in the system, and resulting unwarranted discharge of temperature and pressure relief valves, if a pressure reducing valve, check valve, and/or back flow preventer exist on the cold water supply line to the system, a properly sized expansion tank shall be installed on the potable water piping in the system.

The expansion tank shall be sized according to the expansion tank manufacturer's recommendations or ASHRAE calculations, using the following steps:

- Measure the incoming potable water supply pressure.
- Measure incoming water temperature, and decide on maximum system design temperature.
- Calculate the total volume of potable water in the solar storage and back-up tanks and interconnecting water lines.
- Use a manufacturer's calculation tool or ASHRAE guidelines to properly size the expansion tank. Many manufacturers' websites have tank sizing calculators.

The expansion tank shall be installed according to manufacturer's recommendations, with the following considerations:

- The air charge pressure in the expansion tank shall be adjusted to match the inlet water supply pressure.
- The tank shall be located after any pressure-reducing valve, check valve, or backflow preventer in the cold water supply line in a location that will receive thermal expansion created in the solar storage and back-up water heater tanks.

2.3.13 If hot water re-circulation system exists, return piping is plumbed to a standalone backup water heater or a separate heater dedicated to the circulation loop, not to the solar storage tank.

A hot water re-circulation system plumbed to the solar storage tank can significantly reduce the performance of a solar water heating system by introducing hot return water that can

raise the temperature of the stored water and cause temperature destratification in the tank. Therefore, if a hot water re-circ system exists, it shall be plumbed to a tank-style or tankless backup heater, separate and discrete from the solar storage tank. The solar storage shall be used solely for the collection of solar energy. Solar storage tanks with backup capacity at the top and solar storage at the bottom (i.e., single, "combination" style tanks) shall not be plumbed to a hot water re-circulation system.

## *2.4 Collector Mounting*

2.4.1 If roof-mounted, the roofing material shall have at least 10 years of useful life remaining to ensure the roof will not need repair or replacement early in the system's operational life. If in question, evidence of this requirement may be met by providing either a copy of a recent roof inspection or a receipt showing the date of the most recent roof replacement.

2.4.2 If roof-mounted, the roof system shall be capable of handling additional load of the system. Augmentation of the structure may be required by building codes.

2.4.3 Collectors and mounting systems shall be designed and installed to meet local wind, snow and seismic loads.

2.4.4 If roof-mounted, collectors shall be raised off the roof surface a minimum of 1½ inches or properly flashed to the roof.

2.4.5 All roof penetrations shall be made watertight using roofing industry-standard methods of flashing that protect the warranty of the roof. Sealant compounds used shall be appropriate for the roofing material and application and shall not be the sole method of waterproofing.

2.4.6 All mounting equipment shall be installed according to manufacturer specification.

## *2.5 Solar Access*

2.5.1 Solar resource shall be measured with an Energy Trust sun chart or approved shading analysis tool from the point on the collector(s) where shading is most significant. Details on using sun charts and a list of approved shading analysis tools are available on the Energy Trust Solar Trade Ally Forms & Resources web page[2].

2.5.2 Total Solar Resource Fraction ("TSRF") shall be 75% or greater at all points on the collector(s). See ***Program Guide for Solar Water Heating Trade Allies*** for TSRF calculation.

2.5.3 Photovoltaic powered systems shall have the module mounted within six feet of at the same tilt and orientation as the thermal collector(s). TSRF at PV module shall be equal to or greater than the highest TSRF at any portion of the thermal collector(s) it serves.

2.5.4 It is recommended that the system be installed in an aesthetic manner that blends in with the building architecture. Small trade-offs in system performance due to sub-optimal tilt and orientation can greatly enhance the aesthetics of the installation and thereby increase long-term public support for solar.

2 http://energytrust.org/trade-ally/programs/solar/resources/

## *2.6 Plumbing*

2.6.1 There shall be no leaks in the system plumbing.

2.6.2 All piping in the collector loop shall be copper or stainless steel. All potable water piping shall be copper, stainless steel, or cross-linked polyethylene. All fittings shall be either copper or brass. Cross-linked polyethylene piping connections shall be made with compression fittings.

To ensure there is no failure in the piping and fittings due to high operating temperature or pressure, all pipes in the collector loop shall be copper or stainless steel and all fittings either copper or brass. To ensure highest possible reliability, connections in or to cross-linked polyethylene piping shall be made with only brass or copper compression fittings. Cross-linked polyethylene piping is rated to only 180ºF and therefore is not acceptable for collector loop piping in active systems. Galvanized fittings or nipples, or PVC, CPVC, or polybutylene pipe shall NOT be used for any plumbing in the system.

***NOTE:*** For non-residential and multifamily systems using rigid metal plumbing, expansion joints shall be installed as necessary to allow for expansion and contraction.

2.6.3 Heat exchanger shall be copper, high-quality stainless steel, or cupronickel.

To ensure there is no failure in the heat exchanger due to high operating temperature or, pressure, the heat exchanger shall be made of copper, high-quality stainless steel, or cupronickel.

***EXCEPTION:*** When used in a pressurized antifreeze system with a properly stabilized heat exchange fluid (see ***Section 2.7.2***), the heat exchanger may be carbon steel coated with enamel or glass. For systems with this type of heat exchanger, a label shall be installed on the storage tank or pump station with the following language, or equivalent:

**Warning: this system contains components that are susceptible to corrosion. Maintenance of the heat transfer fluid in the collector loop is critical to prevent degradation of the equipment. Contact [company] at [phone number] for service. Next service due: [blank to enter date]**

***NOTE:*** Vented, double wall heat exchangers provide customers with additional protection from potable water contamination should the heat exchanger fail. The vent will reveal fluid leakage upon failure of the heat exchanger wall(s) indicating the need for replacement. Single wall heat exchangers are allowed, but require additional precautions to protect the customer and meet code. See additional requirements for systems with single wall heat exchangers in ***Section 2.7.2*****,** ***Section 3.1.6*****, and** ***Section 3.4***.

2.6.4 Potable plumbing in unheated overhead spaces shall be continuous cross-linked polyethylene type piping with no connections.

Due to the freeze risk, potable plumbing run through unheated overhead spaces shall be cross-linked polyethylene (PEX). PEX has a limited ability to expand during freeze conditions without breaking. However, PEX connections cannot expand and will leak after exposure to freezing or repeated wide temperature swings. Therefore, to avoid possible fluid leaks that could cause damage if piping connections were located in attics or other unheated overhead spaces, the PEX piping shall be continuous with no connections within the unheated overhead space.

2.6.5 Piping runs shall be adequately and appropriately supported.

To ensure correct system operation, and to preserve the integrity of joint seals, piping runs shall be well supported using appropriate materials. Follow the minimum support spacing requirements in Table 2, below.

**Table 2. Maximum support spacing by piping material**

| Pipe Type | Run Type | Maximum Spacing |
|---|---|---|
| Rigid or Flex Copper | Horizontal | 6 feet |
| | Vertical | 6 feet |
| PEX or Flex Stainless Steel | Horizontal | 32 inches |
| | Vertical | 4 feet |

2.6.6 High temperature rated closed cell elastomeric foam or factory-jacketed molded fibrous glass pipe insulation with a minimum ¾-inch wall thickness shall be installed on all pipes in the system. R-12 minimum insulation shall be installed on potable water piping exposed to outdoor temperature or in unheated spaces.

To minimize heat loss and risk of fluid freezing, pipe insulation with a minimum ¾-inch wall thickness shall be installed on all pipes in the system. R-12 minimum insulation shall be installed on any potable water piping exposed to outdoor temperatures or in unheated spaces over current or planned finished living areas. To avoid degradation of the insulation due to solar system operating temperatures, the insulation material shall have minimum temperature ratings according to Table 3, below. In situations where high stagnation temperatures are expected, higher temperature ratings on the insulation are encouraged.

**Table 3. Minimum temperature ratings for insulation**

| Piping Type | Minimum Temperature Rating Requirement |
|---|---|
| Active systems collector loop | 220ºF |
| Passive systems hot return | 220ºF |
| Non-residential system | Sufficient for actual operating conditions. |
| All other piping | 180ºF |

***EXCEPTION:*** Line sets that have continuous factory-installed insulation may have minimum 5/8-inch insulation. Insulation shall be high-temperature rated closed cell elastomeric foam. A specification sheet shall be included in the customer manual. Sections of plumbing that are not pre-insulated shall meet the requirements above.

2.6.7 Pipe insulation shall be properly sized to fit pipe and continuously closed and sealed using a manufacturer-approved method of attaching and sealing.

2.6.8 Pipe insulation exposed to the outside shall be adequately protected.

To prevent ultraviolet (UV) deterioration and damage of pipe insulation, all pipe insulation located outside the building shell and exposed to sunlight and weather shall be protected using one or more of the following methods:

Elastomeric Foam or Fibrous Glass

- Continuously enclosed in UV inhibited ABS, PVC, or aluminum pipe or jacketing, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied so they will shed water and shall be sealed completely.

- Continuously enclosed in a wood or metal chase painted to match house exterior (for exterior wall applications.)

Additional options for Elastomeric Foam

- Continuously wrapped in an overlapping manner with adhesive backed aluminum foil tape and painted with an aluminum adhesive paint either dark brown or other customer-approved color to match house exterior.
- Continuously wrapped in an overlapping manner with an adhesive backed UV-inhibited tape.
- Painted with two coats of elastomeric paint compatible with insulation type to match building exterior (ONLY applicable for under eave or other outside locations not exposed to direct sunlight.)

2.6.9 Underground piping shall be fully enclosed with appropriately waterproofed R-6 insulation designed for underground application.

To minimize heat loss, all underground plumbing shall be insulated with a minimum R-6 insulation that has been appropriately water proofed or rated for direct burial. Water contact with the piping increases the heat loss by 15 times. The insulation must be specifically designed for underground application, or insulation not approved for direct burial shall include a waterproofing system to encase the insulation.

2.6.10 If underground piping is used for potable water, it shall be continuous cross-linked polyethylene with no connections along the lengths to be buried. If underground piping is used for non-potable water in a collector loop, it shall be Type L copper. Both shall be properly installed.

To ensure a long-lived installation, buried piping shall be of the appropriate type and properly installed. Trenches and backfill shall be free of sharp objects that could come in contact with and puncture the water proofing membrane, insulation, or pipe. Underground piping shall be below local frost line per local code.

To avoid possibility of fluid leaks that would be difficult to detect and repair, cross-linked polyethylene piping in an underground application shall be continuous with no connections along the lengths to be buried.

## *2.7 Heat Transfer Fluid*

2.7.1 Heat transfer fluid shall be appropriate for the system type and components used.

Heat transfer fluid shall be chemically compatible with the components used in the collector loop.

If the collector fluid drains back into a tempered space, antifreeze will typically not be required and distilled or deionized water should be used to maximize heat transfer and lower pumping energy consumption.

In a pressurized antifreeze system, a passive system, or a drainback system where the reservoir is exposed to external temperatures, antifreeze solution is the primary means of freeze protection and shall be selected and mixed to provide sufficient protection.

***NOTE:*** Antifreeze solutions may become corrosive over time if not properly maintained. Maintenance instructions shall be provided as described in ***Section 5.2*** and ***Section 5.3***

2.7.2 If used, antifreeze solution shall be inhibited propylene glycol mixed with distilled or deionized water. Antifreeze solution shall be rated for usage up to 300 °F (149 °C) or higher.

To minimize the health hazard should the heat transfer fluid come in contact with potable water; the heat transfer fluid shall be a solution of inhibited propylene glycol mixed with distilled or deionized water. As an alternative, glycerin antifreeze may be used if the product is reviewed and pre-approved by the Program.

To protect system components from corrosion caused by premature chemical breakdown of the heat transfer solution due to high collector stagnation temperatures, the solution shall include corrosion inhibiters and be rated for usage up to 300 °F (149 °C) or higher.

***NOTE:*** For systems that include a single wall heat exchanger to meet the requirements of SRCC OG-300 and Oregon Plumbing Specialty Code (OPSC) Alternative Method #08-05, any additives to the heat exchange fluid—including corrosion inhibiters—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," and Part 184, "Direct Food Substances Affirmed as Generally Recognized as Safe." Heat transfer solutions that are known to meet this requirement and are rated to 325 °F are listed in an appendix to the Eligible Residential Solar Water Heating system list.

2.7.3 If used, antifreeze solution shall be properly mixed to promote both heat transfer and freeze protection capabilities.

In an active antifreeze or thermosiphon system, the propylene glycol shall be mixed with distilled or deionized water to withstand the lowest expected local temperature as required by the manufacturer. Because mixtures with higher percentages of propylene glycol can withstand higher temperatures, solutions of up to 50% heat transfer fluid may be used to extend fluid life. As a tradeoff, a higher propylene glycol to water ratio will lower the heat transfer efficiency of the solution and reduce the hydraulic performance of the pump.

2.7.4 If antifreeze solution is not used, heat transfer fluid shall be distilled or deionized water with a suitable corrosion inhibitor.

In a drainback system to prevent scaling build up, distilled or deionized water and a corrosion inhibitor that is chemically compatible with the collector loop components shall be used in the collector loop. Note that while all piping is required (per ***Section 2.6.2***) to be copper or stainless steel, the collector loop may contain components that are more susceptible to corrosion (e.g., a cast iron pump).

***EXCEPTION:*** Corrosion inhibitor shall not be required in cases where all components in the collector loop are nonreactive (e.g., plastic flow meter) or made of copper, stainless steel, or a metal that is less susceptible to corrosion (more noble).

2.7.5 If antifreeze or a corrosion inhibitor is used in collector loop, fill valve shall have a label indicating that additives to the heat transfer fluid are being used.

A separate valve tag of one of the qualities described in ***Section 5.1.1*** shall be attached to the collector loop fill and drain valves which reads:

**Caution: Non-potable fluid. Do Not Drink.**

## *2.8 Backup Water Heater*

2.8.1 Solar water heater shall serve primary water heater(s).

The SWH system shall pre-heat water for the water heater(s) that supply the largest percentage of the hot water load at the residence or non-residential building.

2.8.2 Backup heater shall be either:

- Electric with minimum tank capacity of 40 gallons and both thermostats set to 120ºF (or not to exceed 140º F).
- Gas with minimum tank capacity of 40 gallons and thermostat set to 120ºF (or not to exceed 140ºF).
- Tankless gas water heater with a variable firing rate thermostatically controlled based on water temperature and not flow rate. Thermostat shall be set to 120ºF (or not to exceed 140ºF).

Tank-type water heaters shall have a minimum of 40 gallons of backup water heating to ensure customer has adequate service hot water capacity. An energized top portion of a single tank may be used if solar storage requirement is achieved by the non-energized bottom portion of the single tank. For example, a single 120 gallon solar tank with a single energized electric element at the top of the tank meets this requirement by providing approximately 40 gallons of backup heated water over 80 gallons of solar storage volume.

***EXCEPTION:*** Backup heaters for non-residential solar water heaters, either in-line boilers or tanks, shall be selected, sized, and otherwise engineered as appropriate for the end use.

2.8.3 Anti-convective piping with sweat fittings or brass unions shall be installed at hot water outlet and cold water inlet.

Anti-convective plumbing loops or traps connected with sweat fittings or brass unions shall be installed to inhibit hot water migration through the piping system. These loops or traps shall be 10 times the pipe diameter and have a minimum 8-inch vertical drop to constitute an effective convective heat barrier. These loops or traps shall be located within close proximity to the tank. Heat trap nipples alone are not reliable in stopping heat migration, and will not meet this specification. The use of flexible copper pipe connectors with threaded fittings shall be permitted only if gaskets meet high temperature specifications of the system.

2.8.4 Closed cell or factory-jacketed molded fibrous glass pipe insulation with a minimum ¾-inch wall thickness shall be installed on all exposed hot water pipes and first 5 feet of exposed cold-water inlet piping.

All exposed hot water pipes and the first 5 feet of exposed cold water inlet piping connected to backup water heater shall be insulated per ***Section 2.6.6*** to reduce heat loss through the piping

2.8.5 If backup tank is replaced, it shall be replaced with either:

- Electric tank water heater with energy factor of 0.93 (or higher) if less than 60 gal or 0.91 (or higher) if 60 gal or more.
- Gas tank water heater of forced convection type with electronic ignition and energy factor of 0.63 (or higher).
- Tankless gas water heater with a variable firing rate thermostatically controlled based on inlet water temperature and not flow rate. Heater shall be rated to accept water temperatures up to 180˚F.

These requirements minimize standby heat losses and improve overall system performance.

2.8.6 If backup water heater is replaced or moved, and located over wood framed floor, drip pan with pipe routed to drain or outside shall be installed.

To avoid possible structural damage should the backup water heater leak, if backup water heater is replaced or moved as part of the solar water heater installation, and is located over a wood framed floor (in heated or unheated space), a drip pan with attached drain pipe routed to a positive drain or outside the structure shall be installed per local building code.

2.8.7 If backup water heater is replaced or moved, and installed on concrete floor, an R-10 bottom pad shall be installed.

Typically the rated insulation value on water heater tanks does not apply to the tank bottom because the steel tank supports under the tank itself form a direct heat conduit to the outside metal jacket. To reduce heat loss, a tank installed on a concrete floor shall be placed on an R-10 bottom pad of high density foam designed for use under water heaters.

## *2.9 Solar Storage Tank*

2.9.1 The ratio of solar storage tank capacity per square foot of net collector area shall be a minimum of:

- 1.0 gallons of storage capacity per square foot of collector area for all drainback systems.
- 1.25 gallons of storage capacity per square foot of collector area for all other typical installations.

Commercial systems shall meet these requirements or shall be engineered for the specific hot water load and schedule at the site.

To ensure adequate system fluid heat collection efficiency, a minimum solar storage tank capacity per$ft^2$ of collector net area shall be provided. Where possible, additional storage should be used to maximize system performance (ideally, 1.75 gal/$ft^2$).

2.9.2 Electric power shall not be connected to a roof-mounted tank or the solar tank (except for wiring to upper element on non-roof-mounted, single tank systems).

To provide the maximum capability of the system to capture solar heat, electric power shall not be connected to a roof-mounted tank or the solar tank, except for wiring to an upper element on non-roof-mounted, single tank systems.

2.9.3 If solar storage tank is located in space where water leakage could cause structural damage, drip pan with pipe routed to drain or outside shall be installed.

To avoid possible damage should the tank leak, a drip pan with attached drain pipe routed to a positive drain or outside the structure shall be installed per local building code if the solar storage tank is located in space where water leakage could cause structural damage (e.g., inside the home, on top of wood flooring).

2.9.4 If located on a concrete floor, an R-10 bottom pad shall be installed under solar storage tank.

Typically the rated insulation value on water heater tanks does not apply to the tank bottom because the steel tank supports under the tank itself form a direct heat conduit to the outside metal jacket. To reduce heat loss, a tank installed on a concrete floor shall be on placed on R-10 bottom pad of high density foam designed for use under water heaters.

2.9.5 If tank includes a sacrificial anode rod, means for changing the anode shall be provided.

To maximize solar storage tank longevity, the solar storage tank shall be installed to facilitate the periodic servicing and replacement of the tank's sacrificial anode rod.

## *2.10 Valves*

2.10.1 Fully ported isolation valves shall be installed, enabling bypass of solar system.

To ensure the system can be isolated from the backup water heater in an emergency or for servicing or component replacement, valves shall be installed to enable bypass of the entire

solar system. Isolation valves shall be fully ported to allow unrestricted water flow through the solar system under normal operation. Brass ball valves are recommended.

2.10.2 Temperature actuated tempering valve(s) shall be installed and shall be:

- ASSE Standard 1017 listed.
- On the downstream side of backup water heater(s), if tank-type or tankless and fully compatible with solar input temperatures. See ***Section 2.10.3*** for requirements for tankless backup heaters that are not rated for 180°F input temperatures.
- Set no higher than 140°F in residential systems. Temperatures in non-residential systems shall be appropriate to their use.

To help ensure hot water distribution outlets in the residence are not capable of delivering scalding water, tempering valve(s) shall be (1) installed on the downstream side of the backup tank-type water heater(s), (2) temperature actuated and listed as meeting ASSE (American Society of Sanitation Engineering) Standard 1017, and (3) adjusted no higher than 140°F. The valve(s) shall be installed after anti-convective plumbing below the top of the backup water heater as defined in ***Section 2.8.3***. This will prolong the valve's life by protecting valve components from constant exposure to high water temperatures. This will also avoid hot water migration through the tempering valve and into the cold water feed line, which could compromise the effectiveness of the valve. It is recommended the valve(s) be plumbed with brass unions on either side to allow future repair or replacement. Exercising the valves during servicing avoids potential freeze-up of the valve.

2.10.3 If an existing backup water heater is tankless and not rated to accept temperatures up to 180°F,the tempering valve shall be installed downstream of solar storage, and a thermometer and label installed.

This section does not apply to new or replaced tankless backup heaters, which shall be rated to accept temperatures up to 180°F (see ***Section 2.8.5)***.

If an existing backup water heater is an allowed tankless type (see ***Section 0***) that has inlet water temperature limitations below 180°F, the tempering valve shall be installed downstream of the solar storage tank, before the tankless heater, and be set to the maximum temperature allowed by the tankless heater manufacturer in order to protect the heater. The valve shall be installed after anti-convective plumbing below the top of the solar storage tank, as defined in ***Section 2.8.3***.

Because the tempering valve could fail, preventing solar preheated water from passing through to the household, a thermometer shall be installed downstream of the tempering valve to allow detection of water temperatures below its set point, indicating a failed tempering valve. The thermometer shall have a tag with label attached that meets the standards in ***Section*** *Error! Reference source not found.* and displays a clear warning that if the thermometer reads below the set point for the tempering valve, the tempering valve must be replaced.

Required language for temperature gauge after tempering valve:

**TEMPERING VALVE TEMPERATURE GAUGE**

- Measures temperature of water after passing through tempering valve.
- At end of sunny day, while running hot water, read both solar storage and tempering valve temperatures. If solar storage temperature is greater than 120°F, and tempering valve exit temperature is less than the set point for the tempering valve (usually 120°F), the solar system is nonfunctional and it is critical to **replace the tempering valve**.

2.10.4 Check valves shall be installed on both hot and cold inlets to the tempering valve(s).

To prevent unintended water migration through the tempering valve, a check valve shall be installed on both the hot and cold inlets to the tempering valve.

2.10.5 If there is a domestic hot water recirculation system for the house, the return water from this system shall be piped to both tempering valve inlets. An aquastat shall be installed to control the on/off operation of the re-circ system circulator and set 5 to 10 degrees lower than the mixed water outlet temperature.

The purpose of a recirculation system on domestic hot water piping is to maintain a minimum temperature in the piping, thus making tempered water immediately available to the user. The cooler return water must be piped to a water heater (to be reheated) and to the cold piping to the valve, to allow the valve to regulate. An aquastat shall be used to control the on/off operation of the circulator. The aquastat shall be set 5°F to 10°F lower than the mixed water outlet temperature of the tempering valve. The circulator cannot be allowed to run continuously because bypass through the mixing valve will eventually compromise the valve and allow the temperature in the piping to climb to that of the hot water heater during no draw periods.

To promote energy efficiency, the re-circ pump should also be controlled by a time clock or other activation switch to limit the operation of the system to times when the facilities are likely to be occupied.

2.10.6 Temperature & pressure relief valve shall be installed on solar storage tank.

To ensure safe relief of the solar preheated water in the event of overheating, a 210°F and 150psi valve shall be installed per local plumbing code requirements.

***NOTE:*** For non-residential systems, the temperature and pressure relief valves shall be engineered and specified appropriate to the capabilities of the system components.

2.10.7 Valves shall be supplied for filling, flushing, and draining collector loop and potable water piping.

To enable scheduled service and any needed repairs to the collector loop and potable piping, all valves as designated by the system manufacturer, SRCC OG-300 specifications and/or the SWH Program shall be supplied for filling, flushing, and draining the collector loop and potable water piping.

# 3.0 Requirements for Specific System Types

## *3.1 Passive Thermosiphon Systems*

3.1.1 Roof-mounted solar storage tanks systems shall have adequate structural support per manufacturer's specifications.

To maintain the integrity of the system and prevent damage to the dwelling’s roof or roof framing, the roof-mounted solar storage shall be adequately supported per manufacturer’s specifications and/or local building code requirements.

3.1.2 The potable water inlet and outlet piping on roof-mounted tanks shall be type L copper or brass and shall be piped to directly above the roof jack, where the connection to non-metal piping is made.

To keep the very hottest collector water from affecting the non-metal pipe causing damage or bursting, the potable water inlet and outlet piping on roof-mounted tanks shall be type L copper or brass and piped to directly above the roof jack, where the connection to non-metal piping can be made.

3.1.3 Check valve shall be installed in the cold water supply line before the cold water expansion valve for thermosiphon.

To prevent emptying of the collector/solar storage tank should the cold water supply be interrupted, a check valve (or equivalent) shall be installed in the cold water supply line to the collector/solar storage tank for thermosiphon. The check valve shall be installed on the upstream side of the cold water expansion valve.

3.1.4 A thermometer shall be installed between solar storage and backup water heater tank in the inlet piping to and near the top of the backup tank.

To monitor the temperature of the solar pre-heated water, a thermometer shall be installed between the solar storage tank and the backup water heater in the inlet piping to and near the top of the backup tank in an easily visible location.

3.1.5 Temperature and pressure relief valve on solar tank shall be piped to drain per Oregon Plumbing Specialty Code (OPSC).

To minimize risk of scalding water coming in contact with persons, pets, or landscaping, the temperature and pressure relief valve on the roof-mounted solar tank shall be plumbed to ground, drain or gutter per manufacturer's specifications.

3.1.6 If system uses glycol solution in a closed loop single wall heat exchanger, the potable water supply pressure for the building shall be 40 psi or greater.

To meet the requirements of OPSC Alternative Method #08-05, the operating pressure within a single wall heat exchanger shall be less than the operating pressure of the potable water system. The minimum required potable water pressure for the Energy Trust program is 40 psi.

## *3.2 All Active Systems*

3.2.1 Collector loop plumbing shall be thoroughly flushed and pressure tested prior to charging with collector fluid and system startup.

To ensure system operation is not jeopardized by any debris or impurities that may have entered the collector loop piping as system components were plumbed, and to ensure the collector loop piping will not leak when charged and system is operating, the piping shall be thoroughly flushed with clean water, and fully pressure tested prior to charging with collector fluid and system startup. It is recommended to pressure test at 100 psi for 24 hours.

3.2.2 Fluid shall have an adequate flow rate and circulate in proper direction.

To ensure the heated fluid from the collectors is transferred to the solar storage tank, the fluid shall flow from the top of the collectors to the solar tank and with a flow rate appropriate to the size of the system according to manufacturers' specifications. For forced circulation systems, the typical recommended range of flow rates is 0.015 – 0.04 gallons per minute (gpm) per sq. ft. of collector area. Table 4, below, shows examples of typical flow rates based on system size.

**Table 4.Typical flow rates for example collector areas**

| Gross Collector Area | Flow Rates |
|---|---|
| 40 $ft^2$ | 0.5 – 2 gpm |
| 64 $ft^2$ | 1 – 3 gpm |
| 80 $ft^2$ | 2 – 4 gpm |

PV powered system have variable flow rates, with a typical range of 0.2-2.5 gpm. Maximum flow rates in full sun conditions are typically 1.5-2.5 gpm.

3.2.3 Circulation pump shall be installed with shaft oriented horizontally.

To ensure the pump shaft is continuously immersed in and lubricated with collector fluid, which will help prolong pump life, the circulation pump shall be installed with the shaft oriented horizontally.

3.2.4 System shall be designed to allow for isolation of the circulation pump.

To enable servicing and/or replacement if needed, isolation unions, ball valves, check valves, or pumps with built in isolation features shall be installed.

***EXCEPTION:*** For non-residential systems, system design shall be such that all components requiring maintenance and/or removal may be similarly isolated and removed (e.g., valves, unions, etc).

3.2.5 Controller shall have correct settings and be mounted within 6 ft. of solar storage tank, hard-wired or plugged into nearest outlet, with wiring securely attached.

To ensure correct system operation, the differential controller shall turn the circulation pump on at a 10-15 degree differential between the solar storage tank and the collectors and it shall turn the circulation pump off at a 4 to 6 degree differential. The controller shall also have a maximum 180 degree high limit setting and the controller sensors shall be pre-tested for accuracy. To allow for monitoring and diagnostic servicing of the system, the controller shall be mounted within 6 ft. of the solar storage tank, hard-wired or plugged into nearest outlet (twist locks are acceptable) with the wiring securely attached to parts of the system or adjacent walls or ceiling.

***EXCEPTION:*** For non-residential systems, the controller may be located at a location convenient to the facility operator.

3.2.6 If PV powered system, the PV module shall be connected to the DC pump with wiring of appropriate gauge and type, and shall be installed through a dedicated roof jack with exterior conduit.

To minimize line loss and ensure adequate power is delivered and maintained from the photovoltaic module, the wiring connecting the PV module and the DC pump shall be of an appropriate gauge to meet code requirements and assure less than 2% voltage drop, be ultraviolet resistant, and routed through a separate roof jack with exterior electrical conduit. The conduit, current carrying conductors and equipment ground shall be installed as required by the Oregon Electrical Specialty Code (OESC).

3.2.7 If PV powered system, a DC rated on/off switch shall be installed between the PV module and the circulating pump.

To allow system diagnosis and servicing, a DC rated on/off switch shall be installed between the photovoltaic module and the circulation pump. The switch shall be installed in an easily accessible location and labeled.

3.2.8 If PV powered system, a high temperature limit shutoff function shall be installed and wired through the circulation pump.

To limit possible high water temperature in the solar storage tank, a 180°F high temperature limit-switching sensor shall be installed on the system. The sensor may be attached to the hot water outlet nipple or piping at the top of the tank, but not in direct contact with the tank's heat exchanger. If mounted on piping, the sensor shall be insulated with minimum 3/4 inch pipe insulation per ***Section 2.6.6***.The sensor shall be wired through the circulation pump in a manner that will interrupt pump operation when 180°F near the top of the tank is reached.

3.2.9 Sensors shall be placed correctly, attached securely, and adequately insulated. Plug sensor shall be installed on solar tank when a fitting is provided.

To ensure correct system operation, a strap type sensor shall be located at the hot outlet of the collector(s) and secured with a stainless steel hose clamp. The tank sensor, if strap type,

shall be attached directly against the inner tank shell and not in contact with any heat exchanger, or any other location that will accurately measure water temperature near the bottom of the tank. When a fitting is provided on the solar storage tank, a plug-type sensor shall be threaded into the tank fitting. Sensors mounted on piping shall be insulated with minimum 3/4 inch wall closed cell pipe insulation.

3.2.10 Sensor wiring shall have UV-rated exterior jacketing; shall be continuously attached and protected from abrasion, contact with 110V/220V lines/conduit, weather, and high temperature; and shall have solid connections.

To ensure long life for the sensor wiring, all sensor wire shall have UV-rated exterior jacketing, be continuously and securely attached to the exterior of insulated collector loop piping (i.e., not dangling or loose), and be protected from damage due to abrasion, weather and high temperatures. Contact with uninsulated hot fluid pipes and 110V/220V electrical lines and conduit shall be avoided. To ensure correct system operation, the sensor wiring connections shall be permanently joined using crimp-type connectors and then sealed with silicone. Braided wire is recommended. It is recommended to shield the sensor wire in areas with a potential for electrical interference.

***EXCEPTION:*** Sensor wiring with jacketing rated to withstand 350+ °F (e.g., silicone-jacketed wire) may be run in contact with hot fluid pipes. To allow for verification of the temperature rating, the wire rating, product name, or model number shall be visible on an exposed section of the wire or on the outside of a pre-wired line set. Also, a specification sheet for the wire or line set shall be included in the Customer Manual (***Section 5.3.1***).

3.2.11 Fill and drain valves shall have brass leak-proof caps.

To prevent unwanted release of collector fluid under pressure if the fill or drain valves are accidentally opened, all fill and drain valves shall have leak-proof caps installed. The caps shall be brass for durability.

3.2.12 Flow meter shall be installed on supply line to collector(s).

To monitor the fluid flow rate in the collector loop, a flow meter shall be installed in the vertical supply line piping to the collector(s) in an easily visible location.

3.2.13 For systems with an external heat exchanger, a means of flow detection shall be installed in the potable water loop.

To monitor flow through the potable water side of an external heat exchanger, a flow meter shall be installed in the potable loop. As an alternative, thermometers shall be installed on the inlet and outlet of the heat exchanger. The thermometers will show a temperature differential when the potable water pump is running and functioning properly. Flow monitoring device(s) shall be mounted in an easily visible location.

3.2.14 Thermometer shall be provided at hot water outlet port on solar storage tank.

To monitor temperature of the solar pre-heated water, a thermometer shall be installed at the hot water outlet port on the solar storage tank in an easily visible location. A readout display of the temperature on a digital controller shall be allowed in lieu of a separate thermometer if the homeowner is educated on how to obtain this reading using the controller.

## *3.3 All Active Antifreeze Systems*

3.3.1 Pressure gauge shall be installed in the collector loop and the typical operating pressure shall be within 20-40 psi.

To verify the operating pressure in the collector loop, a pressure gauge shall be installed in a visible location in the collector loop. The typical acceptable operating pressure range is 20-40 psi. For system diagnosis, the cooler the operating temperature, the less pressure the

gauge will register in the collector loop. On very sunny and hot days, the pressure may exceed 40 psi. Installer may use this formula to calculate the cold fill pressure:

$$P = [(H * 0.43) + 15],$$

where H is the height of the uppermost piping and system components above the gauge, and P is the fill pressure in psi.

3.3.2 A maximum 150 psi pressure relief valve piped to drain shall be installed in the return line from the collector loop.

To prevent damage of collectors and/or collector loop piping as pressure builds during stagnation, a 150 psi pressure relief valve, piped to drain shall be installed on the supply or return line from the collectors. Generally, the pressure rating of the valve shall be according to the solar system manufacturer's instructions, but must be a minimum of 75 psi and a maximum of 150 psi.

3.3.3 A check valve shall be installed in the return line from collectors near inlet to the heat exchanger.

To minimize nighttime convective heat loss from solar preheated water in the solar storage tank, a check valve shall be installed on the return line of the collector fluid loop near the inlet to the heat exchanger.

3.3.4 An expansion tank shall be installed correctly in the collector loop.

To control pressure fluctuation during expansion and contraction of the collector fluid, a correctly located, rated, sized, charged, and oriented expansion tank shall be installed in the collector loop.

The preferred location for the expansion tank is upstream of the circulation pump. When the expansion tank is upstream of the pump, the pressure created by the pump is added to the pressure held static by the expansion tank, helping to prevent undesirable pressure drops in the loop.

Because the expansion tank should be located upstream of the circulator, the preferred location for the expansion tank is downstream of the heat exchanger to extend its service life. The best place for the tee to the expansion tank is close to the circulation pump inlet.

The expansion tank may be located downstream of the pump on the supply line to the collectors only as a last resort because of structural conditions. The pump will then have to overcome the static pressure being held by the expansion tank, as well as the normal head pressures, possibly causing the pressure in the collector loop to drop, allowing collector fluid to foam or flash to steam.

For standard one and two panel systems, the expansion tank shall have a total tank volume of no less than 4.4 gallons, and shall be charged to the same cold fill pressure as the collector loop (see ***Section 3.3.1***). Larger systems shall have an appropriately sized expansion tank according to manufacturer's or ASHRAE sizing recommendations.

To enable more complete purging of air from the collector loop, the expansion tank shall be mounted in an upside down configuration.

3.3.5 One or both of the following methods of air removal shall be implemented:

1. A threaded plug fitting installed at the high point in the collector loop.

   After all air is purged via the plug fitting during system commissioning, the plug fitting shall be sealed to prevent any fluid loss. To minimize heat loss, a threaded plug fitting shall be insulated per ***Section 2.6.6***, without covering the vent port.

2. A micro-bubbler air separator with manual vent installed in an accessible location on the collector loop.

Installer must first thoroughly purge air from the loop for this method to be effective. Automatic air vents are subject to leaking and shall not be used.

System shall include at least one of these devices to enable complete air removal in the collector piping system. Purging of air in the collector loop is important to keep operating pressures low.

## *3.4 Active Antifreeze Systems with Single Wall Heat Exchangers*

3.4.1 The potable water supply pressure for the building shall be 40 psi or greater.

To meet the requirements of OPSC Alternative Method #08-05, the operating pressure within a single wall heat exchanger must be less than the operating pressure of the potable water system. The rest of the requirements in ***Section 3.4*** are specifically designed to keep the operating pressure within the collector loop of an active anti-freeze system below 40 psi. Therefore, the operating potable pressure at the building shall be 40 psi or greater. If the building has potable water pressure below 40 psi, a vented double wall heat exchanger shall be used, and the requirements in this section shall not apply.

3.4.2 The vertical distance in the collector loop shall be less than or equal to 35 feet.

Active anti-freeze systems with single wall heat exchangers are typically limited to installations on one or two story structures. The vertical distance between the lowest and highest points in the collector loop shall not exceed 35 feet. An installation with a vertical collector loop distance of greater than 35 feet will require higher collector loop pressures, therefore requiring a vented double wall heat exchanger to be used.

3.4.3 The collector loop cold-charge pressure shall be appropriate for the height of the collector loop and between 20 and 30 psi.

To ensure collector loop operating pressure remains below 40 psi (the minimum potable water pressure required in ***Section 3.4.1***), the cold charge pressure for an active anti-freeze system with a single wall heat exchanger shall be appropriate for the collector loop height. Cold-charge pressures shall also be limited to between 20-30 psi, because charge pressures below 20 psi may allow the glycol fluid to foam, and charge pressures above 30 psi are likely to cause the collector loop operating pressure to exceed 40 psi.

To determine the correct cold charge pressure, measure the vertical distance between the pressure gauge and the highest points in the collector loop, then find that distance and the corresponding fill pressure in Table 5, below.

**Table 5. Recommended collector loop cold-charge pressures for system with single wall heat exchanger**

| Collector Loop Height (ft) | Charge Pressure (psi) |
|---|---|
| ≤10 | 20 |
| 15 | 22 |
| 20 | 24 |
| 25 | 26 |
| 30 | 28 |
| 35 | 30 |
| >35 | *Do not use single wall HX.* |

3.4.4 A micro-bubbler air separator with a manual vent shall be installed in the collector loop.

Trapped air in the collector loop is a major cause of inflated collector loop pressures. To allow air to escape and keep loop pressures below 40 psi, a micro-bubbler air separator with

a manual vent shall be installed in the collector loop of an active anti-freeze system with a single wall heat exchanger. Installer must also first thoroughly purge air from the loop.

3.4.5 An insulated threaded plug fitting shall be installed at the high point in the collector loop.

To enable air or gas removal in the collector piping system, a threaded plug fitting shall be installed at the high point in the collector loop. To prevent freezing and consequently allow for correct operation, the fitting shall be insulated with minimum ¾ inch wall closed-cell type insulation, without covering the vent port.

## *3.5 Active Drainback Systems*

3.5.1 If System has multiple collectors, collectors shall be mounted in a single flat plane.

To avoid collector fluid flashing to steam during startup under stagnation conditions, the collectors in a multiple-collector array shall be mounted in a single flat plane. The mounting of collectors in a "saw tooth" configuration shall not be used for drainback systems.

3.5.2 Collectors shall be pitched a minimum of 1/8 inch per foot to inlet and piping shall be continuously pitched between collector and drainback reservoir with a minimum 1/8 inch per foot.

To allow the fluid to completely drain from the collectors and piping exposed to freezing conditions back to the system reservoir tank, the collectors shall be pitched a minimum 1/8 inch per foot to the inlet, and piping shall be pitched between collector and drainback reservoir a minimum 1/8 inch per foot.

3.5.3 There shall be no inverted U-loop piping configurations between the storage tank and the pump.

To ensure air cannot get trapped in the collector loop piping, which can cause the pump to cavitate and prematurely fail, there shall be no inverted U-loop piping configurations between the storage tank and the pump.

3.5.4 A 150 psi pressure relief valve shall be installed on the drainback tank.

To relieve system pressure buildup, a 150 psi pressure relief valve shall be installed on the drainback reservoir tank and piped per local plumbing code.

3.5.5 Drainback tank shall have R-4 or better insulation.

To minimize heat loss and enhance system efficiency, the drainback reservoir tank shall be insulated to manufacturer specifications or R-4 minimum.

3.5.6 If residential system, pump shall provide minimum 1 gpm start-up flow rate.

During sunny periods, when drainback systems high-limit and collectors are left empty, very high stagnation temperatures can occur in the collector(s). If the system activates during such conditions and has an under-sized pump, cool collector fluid can be protractedly flashed to steam in the collectors, causing very high pressures within the collector loop. These pressures can result in discharge of collector fluid through the pressure relief valve. To prevent such occurrences, the pump shall be adequately sized according to the manufacturer's guidelines for the vertical distance of the collector loop and shall provide a minimum cold-start flow rate of at least 1 gpm.

3.5.7 If non-residential, system has set point control function that prevents pump operation when collector temperature exceeds 205°F.

During sunny periods, when drainback systems high-limit and collectors are left empty, very high stagnation temperatures can occur in the collector(s). If the system activates during such conditions, cool collector fluid can be flashed to steam in the collectors, causing very high pressure spikes within the collector loop. These spikes can result in discharge of

collector fluid through the pressure relief valve. To prevent such occurrences, all non-residential drainback systems shall incorporate a set point control function that prevents pump operation whenever collector temperature exceeds 205°F. If the controller used in the system is equipped with this function, this function shall be activated. If the controller is not equipped with this function, then a separate control function shall be incorporated.

# 4.0 Requirements for Non-residential and Multifamily Systems

Unless noted in an exception, non-residential and multifamily residential systems shall meet the applicable eligibility and installation requirements in the other sections of this document. In addition, the system design shall be documented to allow for Energy Trust or third-party review, as detailed in ***Section 4.1***.

Energy Trust recommends that custom-designed systems also comply with the following guidelines established by the American Society of Heating, Refrigerating, and Air conditioning Engineers (ASHRAE) for solar heating systems:

- Active Solar Heating System Design Manual
- Active Solar Heating Systems Installation Manual
- Guide for Preparing Active Solar Heating Systems Operation and Maintenance Manuals.

These guidelines are most appropriate for systems with 700 $ft^2$ of collector area or more, but are useful resources for designing systems of all sizes. The documents are available online from the SRCC website[3].

## *4.1 System Design and Savings Estimate*

4.1.1 Estimate of baseline annual water heating energy consumption shall be documented. Allowable methods for estimating energy load are direct metering, utility bill analysis, or calculations using ASHRAE standards. Seasonal loads shall be estimated by month.

To properly size a SWH system and calculate the potential for energy savings, the designer shall provide a reasonable estimate of hot water consumption and baseline energy use. The load may be extrapolated from a period of direct measurement of hot water or electricity/gas consumption, estimated using an analysis of the pertinent utility bills, or calculated using ASHRAE standards. If the load is estimated per unit (e.g., per person, per meal, per laundry load, etc), the number of units shall be documented. All assumptions shall be stated.

4.1.2 Estimate of annual energy savings from the system shall be calculated using the F-Chart method or RETScreen, T*Sol, or equivalent software.

Documentation of the annual savings calculations shall be provided. The savings shall be referenced to baseline consumption calculated using the estimated annual hot water load and the rated efficiency of the water heater providing backup to the solar system.

4.1.3 System shall be designed to supply no more than 65% of the estimated annual water heating energy load.

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[3] http://www.solar-rating.org/

To promote cost-effective energy savings and avoid oversized systems that are prone to overheating in the summer months, the system shall be designed to provide no more than 65% of the estimated annual water heating energy load (i.e., <=65% annual Solar Fraction).

4.1.4 System shall be documented with an elevation drawing of the system showing relative position of components, pipe sizes, and pipe run lengths.

This elevation drawing may be a supplement to the schematic in ***Section 2.1.4*** or may replace the schematic if all components and plumbing design are shown

4.1.5 System design shall be documented with specifications for all key components, including: pump(s), storage and expansion tank(s), controls, heat exchanger(s), valves, and backup heater. Pipe, pump, and heat exchanger sizing calculations shall be provided on request.

# 5.0 System Documentation

## *5.1 System Labeling*

5.1.1 All valves, gauges and instruments shall be labeled using one of the two following methods:

1. Permanent tags attached to each valve, gauge, or instrument, incorporating the following descriptions:
   - Name/identification of the valve, gauge, or instrument.
   - Purpose of the valve, gauge, or instrument.
   - Operation of the valve, gauge, or instrument.

   To ensure the labels stay affixed to the tags over time, plastic tags should be used, or, if stiff paper tags are used, the labels shall be covered with clear plastic packing tape or laminated to the tags. The tags shall be secured with stainless steel or copper wire attachments. Tag templates are available on the Solar Trade Ally Forms & Resources webpage[4].
2. Permanent, individually numbered tags attached to each valve, gauge, or instrument; along with a valve chart, mounted in a frame, that provides the following descriptions for each tag:
   - Name/identification of the valve, gauge, or instrument.
   - Location of the valve, gauge, or instrument, if not within six feet of solar storage tank.
   - Purpose of the valve, gauge, or instrument.
   - Operation of the valve and whether normally opened (N.O.) or normally closed (N.C.).

   Tags shall be 1 ½" brass or etched plastic (e.g. Seton M4522 or M4551) and attached with brass chain or stainless wire. Valve chart shall be readily visible and attached to the permanent structure within six feet of the solar storage tank. The charts shall be protected from damage and deterioration by lamination or the quality of the frame (e.g. Seton 68624). A copy of the valve chart shall be included in the customer manual and Program trade ally shall keep a copy for the duration of the system warranty. Text of valve charts shall not be smaller than Arial 10 pt. font

[4] http://energytrust.org/trade-ally/programs/solar/resources/

***NOTE:*** If the pump, valves, gauges, and/or instruments are packaged in an enclosed pump station (not accessible for individual tagging), a chart, mounted in a frame, shall be readily visible and attached to the permanent structure within six feet of the pump station. The chart shall be protected from damage and deterioration by lamination, or by the quality of the frame (e.g. Seton 68624). This chart shall have a diagram of the pump station that clearly shows all the enclosed components with a numbered legend that includes the required information (bulleted above) for each component in the station. The diagram and text shall be easily readable.

5.1.2 System shall have all applicable warning labels required in this document.

- Systems with a carbon steel heat exchanger shall have a warning noting that maintenance is critical, as described in ***Section 2.6.3***.
- Systems that contain any additives to the heat transfer fluid (e.g. propylene glycol or corrosion inhibiter) shall have a warning that non-potable water is in use, as described in ***Section 2.7.5***.
- Systems that contain a tempering valve upstream of a tankless water heater shall have a warning as described in ***Section 2.10.3***.

## *5.2 Monitoring & Maintenance Instructions*

5.2.1 Monitoring and maintenance instructions shall be laminated or in a plastic sleeve and securely mounted in an easily visible location on or near the solar storage or backup tank. The instructions shall include:

1. Clear instructions on how to monitor system operation.
2. Description and recommended frequency of homeowner maintenance.
3. Copy of system diagram noting location of valves and monitoring devices.
4. What to do and who to call in an emergency and when the system needs professional maintenance or repairs.
5. How to protect the system from overheating due to stagnation during periods when system is not in use during summer months.

## *5.3 Customer Manual*

5.3.1 Upon completion of installation, contractor shall provide the Program participant with a system owner's manual (the "Customer Manual") and instruct the Program participant on proper system operation and maintenance. The Customer Manual shall be bound in a durable and professional-looking binder, and shall contain, at minimum, the following three sections:

1. System Design and Operation
   - *Monitoring & Maintenance Instructions*

     A copy of the contractor monitoring and maintenance instructions, as described in ***Section 5.2.1***.
   - *Manufacturer Operation & Maintenance Instructions*

     Manufacturer documentation addressing operation and maintenance or system troubleshooting (typically part of installation manual).
   - *Plumbing As-built Diagram*

Schematic diagram that accurately depicts all components installed and the location of valves and monitoring devices.

- *Mechanical Design*

  Description of collector support structure, including engineering specifications of structural elements and manufacturer installation instructions. Provide drawings describing racking or roof attachment systems.

2. Warranties and Installation Documentation

   - *Contractor Warranty*

     Program trade ally's 2-year minimum full system warranty for materials and workmanship. Refer to the ***Program Guide for Solar Water Heating Trade Allies*** for additional details on Contractor Warranty

   - *Manufacturers' Warranties*

     Written warranties and product registration instructions for collectors and tanks.

   - *Incentive Application*

     Final version of signed form showing incentive and configuration approved by Energy Trust.

   - *Permit(s)*

     Copy of approved plumbing and, where applicable, building and electrical permits for the system installation.

3. Manuals and Data Sheets

   - *Parts and Source List*

     Bill of material listing all system components including part numbers.

   - *Material Safety Data Sheets (MSDS)*

     Include a MSDS for any additives to heat transfer fluid or other chemicals used.

   - *Solar Storage Tank Owner's Manual*

     Documentation from tank manufacturer.

   - *Manufacturer Data Sheets for Major Components*

     Including but not limited to: pump, valves, heat exchanger (if separate from tank), controllers, line set (if factory-insulated), and mounting systems.