Bonneville Power Administration

THE BRIGHT WAY TO HEAT WATER™

SOLAR WATER HEATER PROGRAM

GENERAL AND TECHNICAL SPECIFICATIONS

1. GENERAL PROGRAM SPECIFICATIONS

1.1. The solar water heater (SWH) must be installed at a residence with electric service provided by the Utility.

1.2. The participating customer must be the owner of the property or the owner's legally assigned representative.

1.3. To qualify for Bonneville incentive, service hot water to the property must be supplied by an electric water heater.

1.4. Only solar water heaters determined eligible by Bonneville qualify for the Program. Owner-built systems and additions to existing systems do not qualify.

1.5. The eligible solar water heater must be purchased from a contractor determined eligible by the Utility to participate in the program.

1.6. The installed SWH shall be inspected by a Utility representative to determine compliance with all program requirements.

2. GENERAL EQUIPMENT SPECIFICATIONS

2.1. Systems must undergo a technical review by Bonneville to be determined eligible for the Program. Desired design life for the system is 20 years.

2.2. All solar collectors must have OG-100 certification by the Solar Rating and Certification Corporation (SRCC). All solar water heating systems must have SRCC OG-300 certification.

2.3. Eligible solar water heating systems shall incorporate freeze and over heat protection strategies that:

a. Require no regular manual operations on the part of the residence occupant,
b. Result in no lost electrical energy due to re-circulation of heated water during cold winter conditions,
c. Result in no lost electrical energy due to drain of heated water, and
d. Possess demonstrated or theoretical reliability in weather conditions common to climates of the Pacific Northwest.

2.4. Equipment and installation shall comply with all applicable building and electrical codes, and building permits shall be required for all installations where applicable.

2.5. Equipment, materials, and installation shall comply with manufacturers' specifications, SRCC Document OG-300, Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems, the specifications included in this document, and any others required by Bonneville or the Utility. Bonneville reserves the right to require compliance with installation specifications that may exceed or differ from those of a manufacturer and/or SRCC.

3. INSTALLATION SPECIFICATIONS

A. Consumer Documents

1. *Customer has received contractor's installation and manufacturer's component warranties.*

   Contractor shall provide customer with a written warranty stating the equipment and installation will be free from all defects in workmanship and materials for at least two years from the date of final approval by the Utility. Warranty shall include all labor for any repairs within the warranty period. Manufacturer's component and material warranties shall be supplied to customer and may be used to satisfy part of this warranty requirement.

2. *Customer has received an owner's manual and complete operating instructions*.

   Contractor shall provide customer with a comprehensive owner's manual for the system, including detailed operation and maintenance instructions to help ensure effective and persistent system operation.

3. *If SRCC OG-300 certified system, OG-300 sticker is attached to front of owner's manual, and OG-300 label is attached to system.*

   To document to the customer that the installed system has been OG-300 certified by the Solar Rating and Certification Corporation (SRCC), the SRCC OG-300 sticker shall be attached to the front of owner's manual, and the separate OG-300 label shall be attached to system (usually on the solar storage tank).

4. *Customer has received required building permit(s) for the system installation.*

   Contractor shall secure all Building Permits required by law for the installation of a solar water heater and arrange or have the customer arrange for all required permit inspections.

B. Backup Water Heater

1. *Solar water heater serves primary auxiliary water heater(s).*

   The SWH must pre-heat water for the water heater(s) that supply the largest percentage of the hot water load at the residence.

2. *Auxiliary heater is electric, has a minimum capacity of 40 gallons, and both thermostats are set to 120^{o} F (or not to exceed 140^{o} F).*

   The auxiliary water heater shall be electric, and both thermostats shall be set to 120^{o} F, or not to exceed 140^{o} F. A minimum of 40 gallons of auxiliary water heating is required to ensure customer has adequate service hot water capacity. An energized top portion of a single tank may be used if specification 3.D.31 is achieved by the non-energized bottom portion of the single tank.

3. *Anti-convective piping with sweat fittings is installed at hot water outlet and cold water inlet.*

   Anti-convective plumbing loops or traps connected with sweat fittings shall be installed to inhibit hot water migration through the piping system. These loops or traps shall 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 will not meet this specification due to potential leakage from the gaskets.

4. *Closed cell pipe insulation with a minimum ¾-inch wall thickness is on all exposed hot water pipes and first 5' of exposed cold-water inlet piping.*

   All exposed hot water pipes and the first 5' of exposed cold water inlet piping connected to auxiliary water heater shall be insulated with minimum ¾-inch closed cell pipe insulation to reduce heat loss through the piping.

5. *If auxiliary tank replaced, energy factor is 0.93 if < 60 gal or 0.91 if = 60 gal.*

   To minimize standby heat losses and improve overall system performance, a new auxiliary water heater with volume of less than 60 gallons shall have an Energy Factor of 0.93 or better. Models with volume equal to or greater than 60 gallons shall have an Energy Factor of 0.91 or better.

6. *If auxiliary water heater is replaced or moved, and located over wood framed floor, drip pan with pipe routed to drain or outside is installed.*

   To avoid possible structural damage should the back up water heater leak, if auxiliary 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 is installed per local building code.

7. *Auxiliary tank is insulated to the Program standards. If in Oregon, and insulated to OSEIA standards, industry sticker is on the tank.*

   To minimize standby tank heat losses and to maximize efficiency, the auxiliary tank shall be insulated to the levels in the table:

   The following tank insulation requirements apply to solar water heating systems which have only one storage tank, such as thermally stratified active systems, or the auxiliary tank in systems with two tanks.

Tank Location	Insulation Requirement
In conditioned space[4] on concrete floor[6]	R-10 bottom pad[1]
In conditioned space[4] above insulated wood framed floor	No additional insulation required
In unconditioned space[5]	R-10 bottom pad[1] R-8 top pad[2] R-10 side wrap[3]
In unconditioned space[5]	0.91 EF “new” tank = 60 gallons 0.93 EF “new” tank < 60 gallons R-10 bottom pad[1]

[1] R-10 bottom pad must be high density foam designed for use under water heaters and have an R-value of 10 hr-^{o}F-ft^{2}/Btu.

[2] R-8 top pad must be either 3.5 inches of standard density fiberglass insulation, 3 inches of high density fiberglass insulation, or 3/8” layer of reflective foil-coated bubble wrap installed with a ½” air gap between the insulation and the top of the tank. The top pad must have an effective R-value of 8 hr-^{o}F-ft^{2}/Btu.

[3] R-10 side wrap must be placed around the entire exterior of the tank and have an effective R-value of 10 hr-^{o}F-ft^{2}/Btu. Insulation wraps that use a 3/8” layer of reflective foil-coated bubble wrap must be installed with a ½” air gap between the insulation and the side of the tank.

[4] Conditioned space is inside the heated portion of the building.

[5] Unconditioned space is in the unheated portion of the building, such as the garage, unheated portions of the basement or an unheated utility room.

[6] Concrete floors refer to slab on grade or basements; rug or wood flooring with less than an R-15 layer of insulation beneath them must also meet this insulation requirement.

8. If auxiliary tank has added side wrap insulation, access panels to electric heating elements are left uncovered, and side wrap insulation is continuously secured at panel openings.

   To enable easy access for servicing, and to avoid potential overheating of internal wiring, the access panels to the back up water heater electric elements and thermostats shall be left uncovered by any added side wrap insulation. Furthermore the side wrap insulation shall be securely and continuously attached along all edges of the access panel openings.

C. Collector Siting, Orientation, and Mounting

1. *Collector location has PSF of 0.85 or better, as calculated from lowest edge of the collector(s). If PV powered system, PSF is 1.00.*

   The location of solar collectors shall have adequate exposure to sunlight. The collector location must have the minimum Prime Solar Fraction (PSF) of 0.85 or better within the solar window of 8:00 a.m. to 4:00 p.m., as calculated from the middle of the lowest edge of the collector(s). If the system is powered by a photovoltaic (PV) module, the PSF shall be 1.00, so there will be no shading of the collectors or PV module year round. Shading can disable this type of system. The PSF shall be determined by the contractor by completing a Bonneville sunchart prior to installation and verified by the Utility at the time of inspection.
2. *Collectors are oriented 40 degrees E or W of due south with a tilt angle of 14 to 50 degrees; or non-PV powered systems may also be oriented 41 to 90 degrees W, roof pitch of 5/12 or less, and with a tilt angle of 14 to 30 degrees*.

   To ensure adequate exposure to incident solar radiation, the solar collectors shall be oriented within 40 degrees E or W of due south with a tilt angle of 14 to 50 degrees; or non-PV powered systems may also be oriented within 41 to 90 degrees W, on a roof with a pitch of 5/12 or less, and with a tilt angle of 14 to 30 degrees.

3. *If PV powered system, the module is attached to or mounted within 6 feet of the collector(s).*

   To ensure module power delivery to the DC pump corresponds with solar radiation incidence on the thermal collectors, the panel shall be attached to the frame of the collector or mounted within 6 feet of the collector at a nearby location.

4. *Collector mounting is per manufacturer's specifications*.

   To comply with warranty provisions and ensure long-term integrity of the system, collectors shall be mounted according to manufacturer's specifications.

5. *Framework will resist deterioration.*

   To maintain structural integrity of the support system and the collectors, all mounting components, racking materials, and collector framework shall resist deterioration. Wood shall be pressure treated; steel shall be primed and painted to prevent rust; aluminum shall be anodized. Joiners and fasteners shall be of similar, non-reactive metals of adequate strength.

6. *Solar collectors are raised off roof surface or properly flashed to the roof.*

   To prevent buildup of debris and roof leaks due to standing water and/or ice dams, collectors shall be raised off roof surface a minimum of 11/2 inches, or properly flashed to shed water and snow.

7. *All roof penetrations are permanently sealed using appropriate materials and techniques.*

   To prevent roof damage and water leaks, all roof penetrations shall be permanently sealed. Pipes shall be run through properly installed roof pipe jacks. Lag screw and spanner bolt penetrations for collector mounting shall have metal flashing (except on metal or composition type roofs), and shall be sealed in and around the holes and over the entire fastening assembly. Sealant used shall be 20 year silicone sealant.

D. Equipment and Installation (All systems)

General

1. *System operates properly*.

   System shall be fully operational according to its design.

2. *All solar system components are new (not used)*.

   To ensure customer's warranty protection for the equipment and installation and to ensure system reliability and performance, only new system components and materials shall be utilized.

3. *All components, including solar storage and auxiliary tanks, are located to allow access and are adequately protected*.

   To facilitate servicing and/or replacement of system components, the installation shall be configured to provide adequate access to all parts and components of the system, including solar storage and auxiliary tanks. "Adequate" access means:

   a. not having to remove tanks or permanently affixed building components in order to access system components for servicing, and
   b. not having to remove permanently affixed building components in order to access system components for replacement.

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

4. *Means for changing the sacrificial anode rod has been 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.

5. *The solar storage and auxiliary tanks and related components (excluding collectors and integral passive systems) are located in an enclosed tempered space.*

   To protect the system from freezing conditions, the solar storage tank, auxiliary 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:

   a. An interior heated space
   b. 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^{o}F during periods of winter design dry bulb temperatures for the location. A detached fully enclosed exterior space with adequate supplemental heat would meet this specification.
   c. 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.
   d. 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.
   e. 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.

6. *Any building insulation (attic, floor, wall), disturbed due to system installation, is 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 that the contractor document any pre-existing or other damage, not due to the solar installation, and submit it to both the customer and the Utility.

7. *All penetrations to building shell are sealed.*

   To prevent intrusion by insects or vermin, all penetrations to building shell (walls, etc.) resulting from installation of the solar system shall be permanently sealed with appropriate water and pest proof materials.

8. *Monitoring/maintenance instructions per Bonneville/Utility specifications are plainly mounted/displayed in plastic job ticket holder.*

   Monitoring and maintenance instructions, as approved by Bonneville/Utility for each SWH type, shall be mounted in a plastic job ticket holder in a plainly visible location near the solar storage tank. For ICS and Thermosyphon systems, these shall be mounted near the auxiliary water heater. These instructions shall include:
   a. Clear instructions on how to monitor system performance.
   b. Description and recommended frequency of homeowner maintenance.
   c. Diagram of system noting location of valves and monitoring devices.
   d. What to do and who to call in an emergency and when the system needs professional maintenance or repairs.
   e. How to protect the system from overheating due to stagnation during periods when system is not in use during summer months.

9. *Monitoring devices are installed and are easily visible*.

   To determine easily that system is operating and is delivering solar heated water, monitoring gauges and valves must be installed and must be easily accessible and visible.

10. *Corrosion between dissimilar metals has been avoided in all structural components*.

    Like or compatible metals shall be used to prevent corrosion between dissimilar metals.

11. *The potable water supplied to the solar storage tank meets minimum quality standards.*

    To maximize the operational life of the solar storage tank and in some cases other solar system components, the potable water supplied to the system shall meet the following minimum water quality standards:
    a. less than 1000 ppm total dissolved solids
    b. less than 500 ppm total hardness
    c. less than 400 ppm total alkalinity

Plumbing/Piping

12. *There are no leaks in the system plumbing.*

    All plumbing and connections are installed properly to ensure no fluid leakage in the system.

13. *All piping in the system is copper or cross-linked polyethylene type, and all fittings are either copper or brass. Cross-linked polyethylene piping connections are made with compression fittings.*

    To ensure there is no failure in the piping and fittings due to high operating temperature or pressure, all pipes shall be copper or cross-linked polyethylene type, and all fittings are 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 180°F and therefore is not acceptable for collector loop piping in active systems. Galvanized fittings and nipples, and PVC, CPVC, and polybutylene pipe shall NOT be used for any plumbing in the system.

14. *Potable pressurized plumbing in unheated overhead spaces is cross-linked polyethylene type piping or (optionally) Type L rigid copper if a draindown system.*

    In applications where potable pressurized plumbing is used in unheated overhead spaces, cross-linked polyethylene type piping shall be used. Optionally, Type L rigid copper may be used for draindown systems only. These materials will better withstand expansion and contraction due to fluid temperature fluctuations. The type L rigid copper will withstand higher potable water temperatures that may occur during draindown system high-limiting and collector refill.

15. *Cross-linked polyethylene piping in unheated overhead spaces is continuous with no connections within the unheated overhead space.*

    To avoid possibility of fluid leaks that could cause damage if piping connections were located in attics or other unheated overhead spaces, cross-linked polyethylene piping used in unheated overhead spaces shall be continuous with no connections within the unheated overhead space.

16. *Brass unions or nipples are used between all dissimilar metals*.

    To prevent corrosion and fluid leaks, only brass unions or nipples shall be used between plumbing components made of dissimilar metals. The use of dielectric unions will not meet this specification due to potential water leakage from the gaskets.

17. *Piping runs are 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 these minimum support spacing requirements:

Pipe Type	Run Type	Maximum Spacing
Rigid Copper	Horizontal	6 feet
	Vertical	6 feet
Flex Copper	Horizontal	6 feet
	Vertical	6 feet
Poly or PEX	Horizontal	4 feet
	Vertical	4 feet

To ensure long term integrity and performance of the pipe insulation, the supports shall not compress or damage the pipe insulation.

18. *High temperature rated closed cell foam pipe insulation with a minimum ¾-inch wall thickness is installed on all pipes in the system. R-12 minimum insulation is installed on potable water piping exposed to outdoor temperature or in unheated spaces*.

To minimize heat loss and minimize risk of fluid freezing, closed cell 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. In colder climates, higher R-values on potable piping may be advisable. To avoid degradation of the insulation due to solar system operating temperatures, the insulation material shall have minimum temperature ratings according to the table below. In situations where high stagnation temperatures are expected, higher temperature ratings on the insulation are encouraged. .

Piping Type	Minimum Temperature Rating Requirement
Active Systems	
Collector Loop	220°F
Passive Systems	
Hot Return	220°F
All Other Piping	180°F

19. *Pipe insulation is properly sized to fit pipe and continuously closed and sealed*.

    To minimize heat loss and prevent freezing, pipe insulation shall be continuously closed and sealed at all joints and seams. Pipe insulation shall be properly sized to fit the pipe.

20. *Pipe insulation exposed to the outside is 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:

    a. 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.

    b. Continuously wrapped in an overlapping manner with an adhesive backed UV- inhibited electrical tape.

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

    d. Continuously enclosed in UV inhibited ABS, PVC, or aluminum pipe or jacketing.

    e. Painted with exterior grade paint compatible with insulation type to match house exterior. (ONLY applicable for under eave or other outside locations not exposed to direct sunlight.)

21. *Underground piping is of the appropriate type and is fully enclosed with appropriately water proofed R-6 insulation designed for underground application, is protected from sharp objects, and is below frost line.*

    If underground piping is used for potable water, to ensure pipe will not burst should freezing occur, it shall be of the cross-linked polyethylene type. If underground piping is used for non-potable water in a collector loop, to ensure pipe will not degrade due to high temperatures, it shall be Type L copper. To minimize heat loss, all underground plumbing shall be insulated with a minimum R-6 insulation that has been appropriately water proofed. To protect the pipe, insulation, and water proofing material from chemical degradation, both the insulation and waterproofing system must be specifically designed for underground application. 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.

22. *Underground cross-linked polyethylene piping is continuous with no connections along the lengths to be buried.*

    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.

Freeze Protection

23. *Approved freeze protection is provided*.

    Freeze protection, as noted in Section 2.3 and approved by Bonneville during qualification of each system type, shall be incorporated.

24. *If an antifreeze system: a vented, double wall or approved heat exchanger has been installed***.**

    To prevent cross-contamination between system fluid and potable water when using an antifreeze system, a vented, double wall heat exchanger shall be installed. The vent will reveal fluid leakage upon failure of the heat exchanger wall(s) indicating the need for replacement. Alternatively, a heat exchanger approved by the governing plumbing board may be used.

25. *High temperature propylene glycol antifreeze solution has been used.*

To avoid risk of a health hazard should the collector fluid come in contact with potable water, and to protect system components from corrosion caused by premature chemical breakdown of the antifreeze due to high collector stagnation temperatures, high temperature rated propylene glycol, mixed with distilled or deionized water shall be used. The propylene glycol shall be mixed in concentration with distilled or deionized water according to the lowest expected local temperature as noted in the following table. Because mixtures with higher percentages of propylene glycol can withstand higher temperatures, solutions of up to full strength heat transfer fluid may be used to extend fluid life. As a tradeoff, a higher propylene glycol to water concentration than shown in the table below will lower the heat transfer efficiency of the solution.

Temperature (degrees F)	Minimum percent (volume) glycol required
20	20%
10	31%
0	38%
-10	45%
-20	49%
-30	53%
-40	57%
-50	61%
-60	64%

Valves

26. *Fully ported isolation valves are 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, fully ported valves are installed to enable bypass of the entire solar system. Brass ball valves are recommended.

27. A*nti-scald, pressure compensating tempering valve(s) are installed and are:*
    a) On the downstream side of the backup electric water heater(s).
    b) Located after anti-convective plumbing.
    c) Set no higher than 140^0 F.

    To ensure hot water distribution outlets in the residence are not capable of delivering scalding water, tempering valve(s) shall be installed and be of the commercial grade anti-scald and/or pressure compensating type and adjusted no higher than 140 degrees. The tempering valve(s) shall be installed on the downstream side of the backup electric water heater(s). The valve(s) shall be installed after anti-convective plumbing below the top of the back up water heater tank as defined in specification 3.B.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.

28. *All valves, gauges and instruments are labeled per Bonneville specifications.*

    To identify and describe the purpose and operation of specific devices in the system, all valves, gauges, and instruments shall be labeled. Permanent tags shall be attached to each valve, gauge, or instrument, incorporating Bonneville approved descriptions that include the following:
    a. Name/identification of the valve, gauge, or instrument.
    b. Purpose of the valve, gauge, or instrument.
    c. Operation of the valve, gauge, or instrument.

    Labels with this information shall be attached to the tags. To ensure the labels stay affixed to the tags over time, plastic tags are used, or if stiff paper tags are used, the labels shall be covered with clear plastic packing tape or laminated to the tags.

29. *Temperature & Pressure relief valve is installed on solar storage tank.*

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

30. *Valves are 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 OG300 specifications and/or Bonneville will be supplied for filling, flushing, and draining the collector loop and potable water piping.

Solar Storage Tank

31. *Minimum solar storage tank capacity of 1.25 gallons/square foot of collector net area is provided.*

    To ensure adequate system fluid heat collection efficiency, a minimum solar storage tank capacity of 1.25 gallons/square foot of collector net area shall be provided. It is recommended that 1.75 gallons per square foot of collector net area be provided.

32. *Electric power is not 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.

33. *Solar storage tank is insulated to Program standards. If in Oregon, and insulated to OSEIA standards, industry sticker is on the tank.*

To minimize standby tank heat losses and to maximize efficiency, the solar storage tank shall be insulated to the levels in the table:

The following insulation requirements apply to the solar storage tank in a two-tank system. These tanks do not have a means of heating the water other than solar energy and are almost always located upstream of the auxiliary tank. Solar tanks are generally located in unconditioned space[5] because of their size and because they are usually not part of the original home design.

Tank Type	Conditioned Space[3] Insulation Requirement	Unconditioned Space[4] Insulation Requirement
80 gallon Rheem/Ruud tank with external wrap around heat exchanger	R-10 bottom pad[1] if on concrete[5] R-10 side wrap[2]	R-10 bottom pad[1] R-10 side wrap[2]
Water heater tank with internal, double-wall coil heat exchanger	R-10 bottom pad[1] if on concrete[5] 0.91 EF "new" tank	R-10 bottom pad[1] 0.91 EF "new" tank
Other water heater tank without integral heat exchanger	R-10 bottom pad[1] if on concrete[5] 0.91 EF "new" tank	R-10 bottom pad[1] 0.91 EF "new" tank

[1] R-10 bottom pad must be high density foam designed for use under water heaters and have an R-value of 10 hr-^{o}F-ft^{2}/Btu.

[2] R-10 side wrap must be placed around the entire exterior of the tank and have an effective R-value of 10 hr-^{o}F-ft^{2}/Btu. Insulation wraps that use a 3/8" layer of reflective foil-coated bubble wrap must be installed with a ½" air gap between the insulation and the side of the tank.

[3] Conditioned space is inside the heated portion of the building.

[4] Unconditioned space is in the unheated portion of the building, such as the garage, unheated portions of the basement or an unheated utility room.

[5] Concrete floors refer to slab on grade or basements; rug or wood flooring with less than an R-15 layer of insulation beneath them must also meet this insulation requirement.

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

To avoid possible damage should the tank leak, 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, etc.) a drip pan with attached drain pipe routed to a positive drain or outside the structure is installed per local building code.

35. *Anti-convective piping with sweat fittings is installed on cold water supply inlet at top of solar storage tank.*

    An anti-convective plumbing loop or trap connected with sweat fittings shall be installed to inhibit hot water migration through the cold water supply piping to the solar storage tank. This loop or trap shall have a minimum 8-inch vertical drop to constitute an effective convective heat barrier. This loop or trap 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 also will not meet this specification due to potential leakage from the gaskets.

E. Passive Systems (Thermosiphon, ICS, and Hybrid ICS)

1. *Roof-mounted solar storage tanks and ICS systems 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 tank or Integral Collector Storage (ICS) system shall be adequately supported per manufacturer's specifications and/or local building code requirements.

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

3. *Incoming supply line pressure to the system does not exceed 70 psi, and pressure reducing valve (if required) is properly located.*

   To limit incoming pressure to meet rated equipment tolerances and/or limit expansion valve discharge due to pressure buildup in the system, the incoming supply line pressure to the system shall not exceed 70psi. If the incoming supply line pressure to the system exceeds 70psi, a pressure-reducing valve shall be installed and set to 70psi 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.

4. *A 90psi (150psi for ICS) cold-water expansion valve is installed in the collector/solar storage tank supply piping downstream of any pressure reducing valve, check valve or backflow preventer, and in an area not subject to freezing and routed to a positive drain.*

   To relieve pressure buildup in the system and protect system components without wasting energy or hot water, a cold-water expansion valve (pressure only valve) shall be installed to expel cold water during periods of high system temperatures. A 90psi expansion valve shall be used for all thermosiphon systems, and a 150psi expansion valve shall be used for all ICS systems unless otherwise specified by the system manufacturer. The expansion valve shall be installed downstream of any pressure reducing valve, check valve or backflow preventer on the cold inlet supply piping to the collector/solar storage tank, be located in an area not subject to freezing, and be routed to a positive drain or to outside the residence perimeter foundation.

5. *A check valve is installed in the cold water supply line before the cold water expansion valve for thermosiphon and ICS systems.*

   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 and ICS systems. The check valve shall be installed on the upstream side of the cold water expansion valve.

6. *A thermometer is installed between solar storage and auxiliary water heater tank in the inlet piping to and near the top of the auxiliary tank.*

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

7. *Pressure relief valve at ICS collector outlet or temperature /pressure relief valve on solar tank are piped to drain per manufacturer's guidelines.*

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

8. *Vacuum Tube Integrated Collector Storage systems include:*
   a. Circulation loop for high limit heat transfer with a differential controller, a check valve and pump in the piping from the collector(s).
   b. *Meets Specifications F. 3-7, 11-13, 20, & 31.*
   c. *Expansion tank is installed when number of tubes is greater than four*.

   To minimize the effects of overheating during stagnation and transfer the heated water directly to the backup tank, a high limit heat transfer circulation loop shall be installed utilizing a differential controller, a check valve and a pump. The controller setup shall be: a 5-10 degree differential, pump activation at 160 degrees with high limit at 180 degrees. To control greater pressure fluctuation (expansion/contraction) with larger system arrays, an expansion tank shall be installed when the number of tubes is greater than four. This system shall additionally meet Specifications F. 3-7, 11-13, 20, & 31 in active systems.

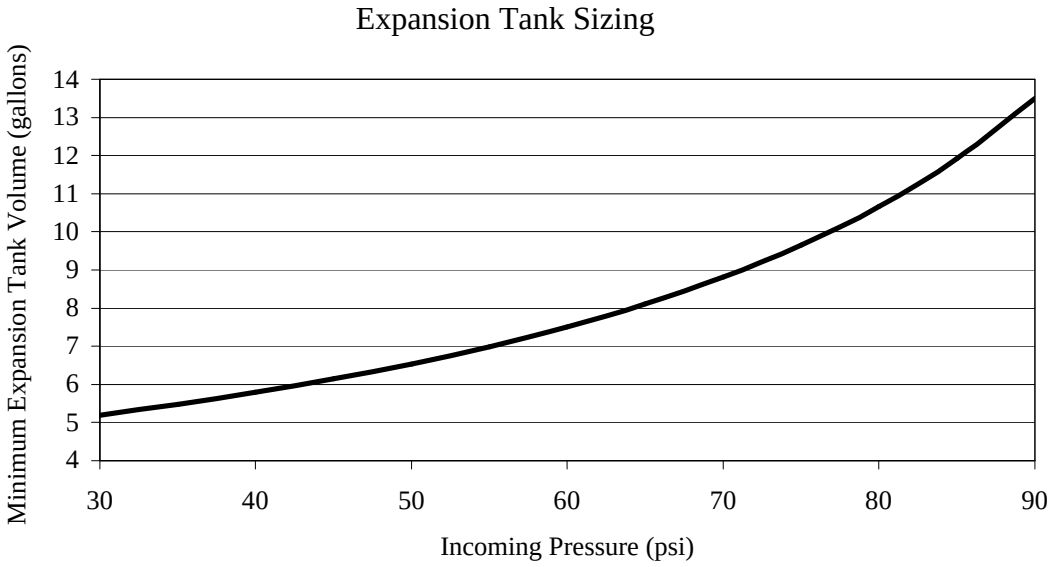
F. Active Systems (All)

1. *Incoming supply line pressure to the system does not exceed 90psi, and pressure reducing valve (if required) is 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 90psi. If the incoming supply line pressure to the system exceeds 90psi, a pressure reducing valve shall be installed and set to 90psi 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. *If a pressure reducing valve, check valve, and/or back flow preventer is/are on potable supply line to the system, a properly sized and located expansion tank is installed.*

To avoid potentially damaging pressure build up from thermal expansion of the potable water in the system, and resulting unwarranted discharge of temperature and pressure relief valves, if a known and verifiable 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 manufacturers recommendations or ASHRAE calculations. The following table shows appropriate expansion tank sizes using calculations from the year 2000 version of ASHRAE's HVAC Systems and Equipment Handbook for a 130 gallon system: (i.e., potable water volume in both solar storage and back-up tanks). Note: Smaller volume systems may require smaller expansion tanks; larger volume systems may require larger expansion tanks.



The air charge pressure in the expansion tank shall be adjusted to match the inlet water supply pressure before installation and shall be installed according to manufacturer's recommendations. The expansion tank shall be located either between the solar storage tank and the back-up water heater, or before the solar storage tank and after any pressure-reducing valve, check valve, or backflow preventer in the cold water supply line.

3. *Collector loop plumbing has been 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.

4. *Fluid has an adequate flow rate and circulates in proper direction*.

   To ensure the heated fluid from the collectors is transferred to the solar storage tank, the fluid must flow from the top of the collectors to the solar tank and with a flow rate appropriate to the size and type of system.
   For forced circulation systems, the recommended range of flow rates is 0.015 – 0.04 gallons per minute (gpm) per sq. ft. of collector area. The table below shows acceptable flow rates for typical system sizes:

Gross Collector Area	Flow Rates
40 sq. ft.	0.5 – 2 gpm
64 sq. ft.	1 – 3 gpm
80 sq. ft.	2 - 4 gpm

   PV powered systems have variable flow rates, with a typical range of 0.2-2.0 gpm. Maximum flow rates in full sun conditions are typically 1.5-2.0 gpm.

5. *Circulation pump is 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.

6. *System has been designed to allow for isolation of the circulation pump.*

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

7. *Controller has correct settings and is mounted within 6 ft. of solar storage tank, hard-wired or plugged into nearest outlet, and wiring is securely attached.*

   To ensure correct system operation the differential controller shall turn the circulation pump on at a 10 to 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 180 degree maximum 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.

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

   To minimize line loss and ensure adequate power is delivered and maintained from the photovoltaic (PV) module, the wiring connecting the PV module and the DC pump shall be of an appropriate gauge (dependent on one-way distance), be ultraviolet resistant, and routed through a separate roof jack with exterior electrical conduit. The electric wire shall be bare or tinned copper, two conductor, PVC insulated, and have a PVC UV rated gray jacket suitable for exterior use or equivalent as per the National Electric Code (NEC). The conduit shall be secured to a roof-framing member and all the wiring shall follow local code and manufacturer's guidelines.

9. *If PV powered system, a DC rated on/off switch is 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 (PV) module and the circulation pump. The switch shall be installed in an easily accessible location and labeled according to Specification 3.D.28.

10. *If PV powered system, a high temperature limit shutoff function is installed and wired through the circulation pump.*

    To limit possible high water temperature in the solar storage tank, a 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, or against the tank's inner shell near 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 R-3/4 inch closed cell pipe insulation. The sensor shall be wired through the circulation pump in a manner that will interrupt pump operation when 180°F high temperature near the top of the tank is reached.

11. *Sensors are placed correctly, attached securely, and adequately insulated. Plug sensor is 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 ¾ inch wall closed cell pipe insulation.

12. *Sensor wiring has UV-rated exterior jacketing, is continuously attached, and is protected from abrasion, contact with 110V/220V lines/conduit, weather and high temperature, and has 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 hot 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.

13. *Flow meter is provided*.

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

14. *Thermometer is 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 of the temperature on a digital controller is allowed in lieu of a separate thermometer if the homeowner is educated on how to obtain this reading using the controller.

Active Antifreeze Systems

15. *Fill valve has a label indicating non-toxic heat transfer fluid to be used.*

    As a health notice warning and as a guide for the scheduled changing of fluid, a label indicating only non-toxic fluid type shall be attached to the fill valve.

16. *Fill and drain valves have leak-proof caps.*

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

17. *Pressure gauge is installed in the collector loop and the operating pressure is within 10-45 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 10-45 psi.
    Note: 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 45 psi.

18. *A 150 psi pressure relief valve piped to drain is installed on the return line from the collectors.*

    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 return line from the collectors.

19. *A check valve is installed on return line from collectors near inlet to 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.

20. *A correctly sized and rated expansion tank is installed on supply line to collectors.*

    To control pressure fluctuation during expansion and contraction of the collector fluid, a correctly sized and rated expansion tank shall be installed on the supply line to the collectors. 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 have a minimum operating pressure of 150 PSIG. 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 it is recommended to mount the expansion tank in an upside down configuration.

21. *A threaded plug fitting is installed at the high point in the collector loop and is insulated.*

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

Active Drainback Systems

22. *Collectors are pitched a minimum of 1/8 inch per foot to inlet and piping is 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.

23. *There are 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.

24. *A 150psi pressure relief valve is installed on 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.

25. *Drainback tank is insulated to Program standards for solar storage tanks.*

    To minimize heat loss and enhance system efficiency, the drainback reservoir tank shall be insulated to the Program standards for solar storage tanks or equivalent, as found in Specification D.33.

26. *Distilled or deionized water and a suitable corrosion inhibitor have been used in the collector loop piping.*

    To safeguard all components in the collector loop and 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.

27. *Fill and drain valves have leak-proof caps.*

    To prevent unwanted release of collector fluid should the fill or drain valves be accidentally opened, all fill and drain valves shall have leak-proof caps installed.

Active Draindown Systems

28. *Collectors are pitched a minimum of 1/8 inch per foot to inlet and piping is continuously pitched between collector and draindown valve(s) with a minimum 1/8 inch per foot.*

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

29. *The system tanks, vents, valves, pumps, and discharge piping are located in an enclosed, insulated space.*

    To protect against freezing conditions and possible system damage, the system's tanks, vents, valves, pumps, and discharge piping shall be located in an enclosed, insulated space. Because the working fluid in draindown systems is pressurized potable water, the components of this system and in particular the draindown valve are more susceptible to damage in freezing weather conditions.

30. *Automatic air vent and vacuum relief valve are installed at the high point in the collector loop and are insulated.*

    To ensure air or gas removal in the collector piping system, an automatic air vent and a vacuum relief valve shall be installed at the high point in the collector loop. To prevent freezing and consequently allow for correct operation, these valves shall be insulated with a minimum of ¾-inch wall closed-cell type insulation without covering the valve caps or vent ports.

31. *A Y-type strainer is installed in collector loop on supply side of the circulation pump.*

    To enable capture and removal of sediment from potable water being supplied to the system, which could cause damage to and/or failure of system control valves or other components, a Y-strainer shall be installed at the low point in the collector loop on the supply side of the circulation pump.

32. *Drain line from the draindown valve is minimum 1/2" rigid copper pipe with a 1/4" per foot pitch to a positive drain and plumbed to within 12" of the valve. Transition poly tubing from the valve is inserted 3" into the copper pipe.*

To ensure the system has the ability to adequately drain (especially in freezing conditions) and avoid any damage due to water being trapped in the collector(s) and/or piping, the drain line from the draindown valve shall be plumbed with a minimum 1/2" rigid copper pipe with a 1/4" per foot pitch to a positive drain. The copper piping shall also be plumbed to within 12" of the draindown valve. High temperature poly tubing shall be installed from the valve and inserted 3" into the copper drain line without a plumbing fitting. In the event of an obstruction in the copper drain line, the system will still have the capability to drain via overflow at the top of the copper drain line.

4. REFERENCES

- SRCC Document OG-300. Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems; Solar Rating and Certification Corporation.
- Installation Guidelines for Solar DHW Systems in One and Two-Family Dwellings; U.S. Department of Housing and Urban Development.
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- Solar Sidebar, Installation Instructions. Heliotrope General.
- Residential Alternative Energy Tax Credit, Oregon Administrative Rules and Amendments. Oregon Office of Energy, 2002.
- Solar Hot Water System Reliability, 1994 Draft Report. National Renewable Energy Laboratory.