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ICC-SRCC™ Overview

Overheat & Freeze Protection in OG-300 Certified Solar Thermal Water Heating Systems

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INTRODUCTION

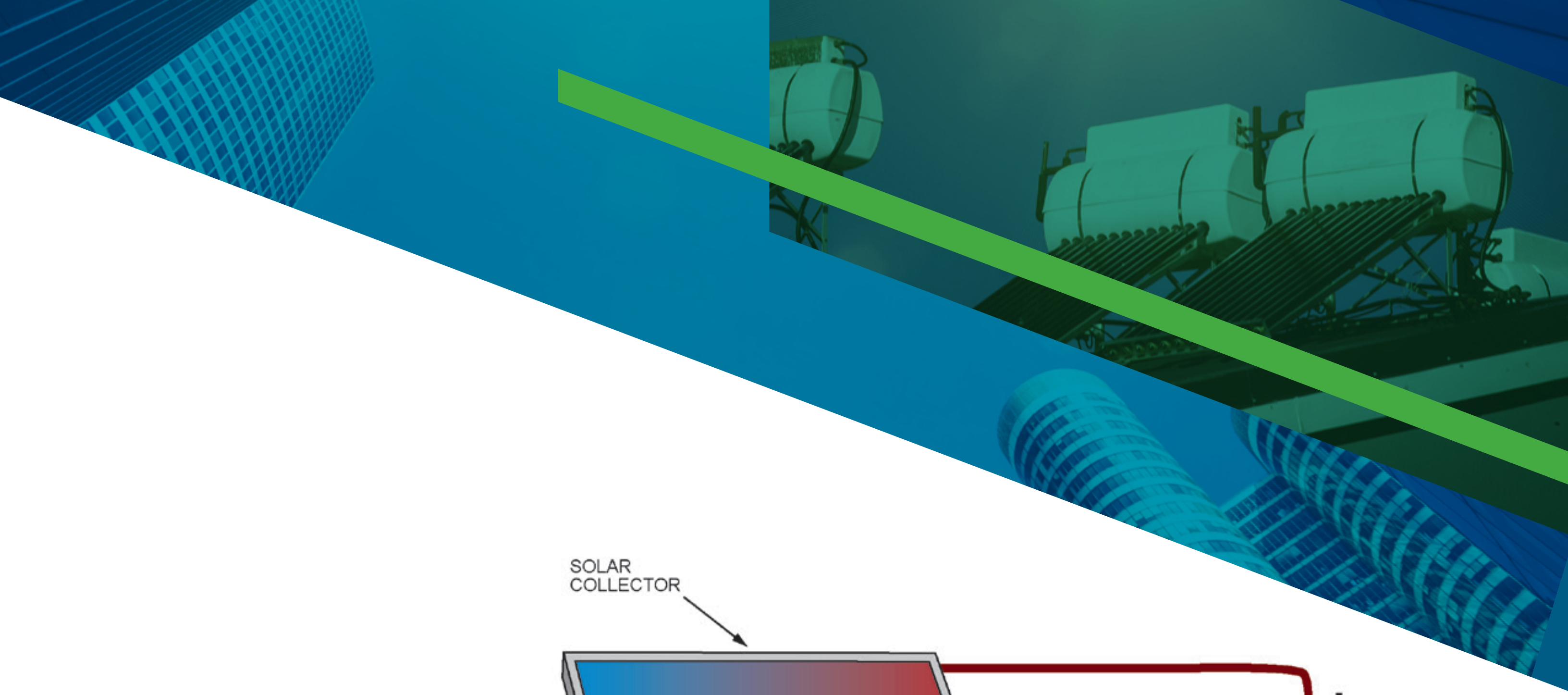
Freeze and overheat protection are critically important design considerations for solar water heating (SWH) systems. ICC-SRCC certifies and rates SWH systems under its OG-300 certification program, regardless of suitability for use in any specific climate (also known as climate appropriateness). The program relies on manufacturers, installers, and local code authorities to ensure systems are installed in appropriate geographies with respect to local temperatures, solar intensity levels, orientation, and water quality. ICC-SRCC publishes a certificate for each OG-300 certified system, available on the ICC-SRCC website at www.solar-rating.org. These certificates describe the overheat and freeze protection methods employed by each system. ICC-SRCC does not imply that because a certain freeze or overheat protection method is listed, that that method is approved by ICC-SRCC, since the program does not require laboratory testing of each system for the wide range of potential climatological and operational conditions possible. To do so would be prohibitively expensive and time-consuming. Therefore, the following study examines factors that cause freeze and overheat damage and methods of preventing this damage. It is the responsibility of the end users and stakeholders to understand climate and other possible factors that could result in failure of the system and seek the most appropriate freeze or overheat protection method for the application.

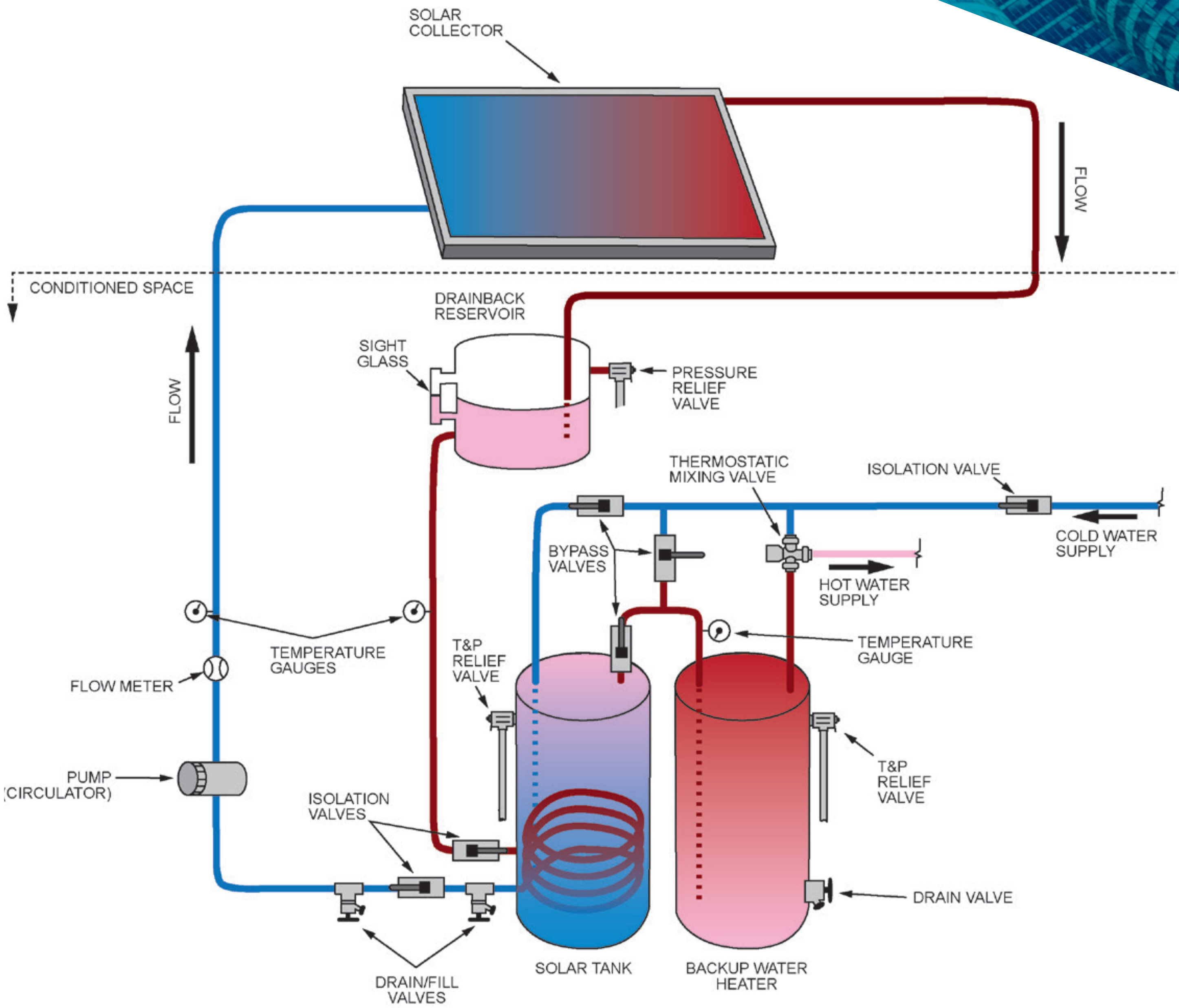
FREEZE PROTECTION METHODS

Freeze protection methods prevent damage to a solar water heating (SWH) system due to the expansion of freezing water. Studies have shown that freeze damage is possible anywhere in the continental U.S. ICC-SRCC publishes a FTL (Freeze Tolerance Limit) for each OG-300 certified system which is specified by the manufacturer/supplier of the system. This is derived from the temperature at which the system is anticipated to withstand 18 hours of constant exposure. This value should be used cautiously because it is not validated through independent testing and does not assure total freeze protection under all conditions.

The freeze protection methods commonly used in OG-300 certified systems are shown include:

- **Antifreeze Fluid.** Usually propylene glycol with inhibitor and buffer chemicals added. The fluid must be checked periodically to verify that it still provides protection, since some fluids can break down over time.
- **Drainback Tank.** Piping from collectors in unconditioned space is sloped toward a drainback tank installed within conditioned space (see example below). When the pump stops running, (e.g. at sunset or when the tank has reached a high temperature limit) the fluid in the collector drains into a drainback tank, protecting the fluid from freezing or overheating. Water or a water/glycol mixture that can be used in the collector loop.
- **Direct Forced Recirculation.** When the collector temperature approaches freezing, the system controller turns the pump on to circulate warm water from other parts of the system to the collector. Viability depends on availability of power, system responsiveness and the quality of the potable water. Such a system will repeatedly circulate warm water to the collector as long as freezing temperatures are detected.
- **Freeze Valves.** Temperature-actuated automatic flush valves, known as freeze valves (image shown) may be used to flush cold fluid in the collector(s) from the system whenever near-freezing conditions exist. Dribbling water from the system through the freeze valve causes warmer water to flow through the collector. Viability depends on water quality, maintenance of the freeze valve and correct installation. Water drained from the freeze valve must be routed and disposed of appropriately.





Drainback System Example (Indirect)

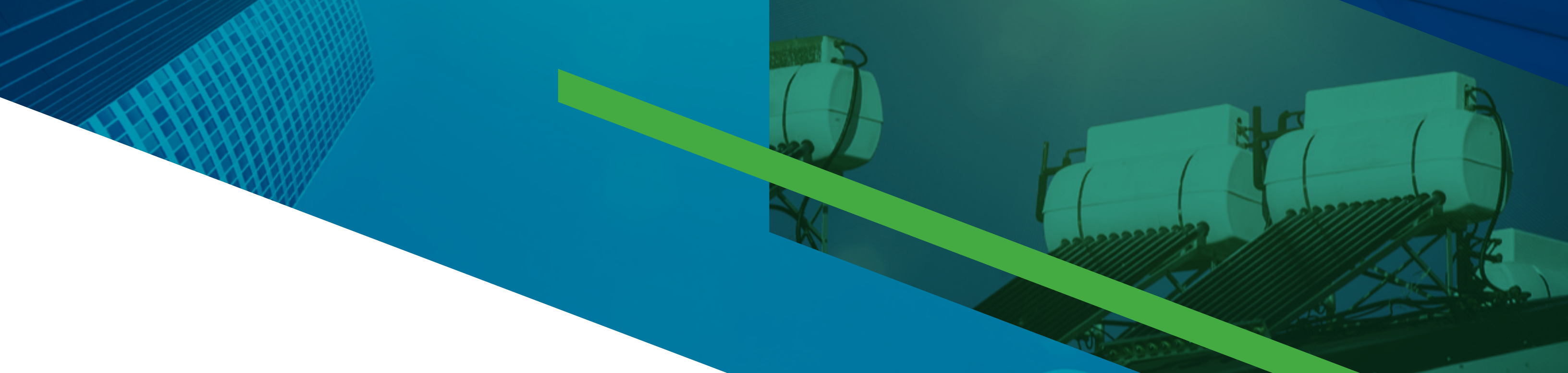
- **Thermal Mass.** The large volume of water in an integrated collector storage (ICS) collector takes a long time to freeze. The protection is effective down to a specified Freeze Tolerance Limit, which should be compared with local climate conditions: Note that piping to and from the collector are still subject to freezing. Freeze valves may be added to such a system to further extend the freeze resistance.
- **Frost Plugs.** Frost plugs are devices that can be installed on ports in a collector that are expelled in whole or in part when pressures rise the collector as a result of freezing. The resulting pressure relief can prevent collector and piping damage. However, after the water thaws, considerable water loss can occur. The frost plug may need to be reset or replaced periodically.

OVERHEAT PROTECTION METHODS

System overheating can degrade heat transfer fluids, accelerate scaling, cause premature component failure, and reduce system performance. The maximum design temperature for each system will vary depending on the materials overheat protection methods and operational modes selected by the manufacturer. OG-300 certified systems have been reviewed by ICC-SRCC to ensure they can operate within the design pressure and temperature limits specified by the manufacturer/supplier without reliance upon a pressure/temperature relief valve. (Note that a relief valve is still required for the safety of the system and to provide additional safety redundancy) Some system designs rely upon consistent hot water usage and grid power, storage size, or user intervention to prevent damage due to system overheating.

Overheat protection methods commonly included in OG-300 certified systems are shown below:

- **Drainback Tanks.** The collector loop in a drainback system has water which drains back to tank within conditioned space whenever the pump stops. On a hot day, when the fluid in the storage tank has reached its maximum allowable temperature limit, the system controller will turn the pump off to protect the fluid and the system components. The fluid will then drain back to the tank and the solar collector and loop will depressurize and fill with outside air.
- **Heat Dump Radiator or Convector:** These can be a small radiator with convection cooling to cool hot fluids like glycol to the atmosphere. Other versions could radiate excess heat into a thermal sink like a swimming pool or the ground.
- **Vented Collector.** An automatic vent in the collector opens before the temperature rises to a dangerous level, allowing ambient air to cool the absorber by convection. Such vents can be active or passive in design.
- **Steam-Back with Dissolvable Inhibitor.** High vapor pressure in the collector tubing forces liquid glycol and water out to minimize damage, usually occurring when the fluid temperature reaches about 250 ˚F (121 ˚C). Expansion tanks in these systems must be sized to accept all the liquid in the collector.
- **Pressure Stagnation.** Increased pressure in the collector and solar loop allows the fluid temperature to rise and delay boiling.



- **Pump Cycling.** The system controller may utilize a pump cycling control method to prevent overheating. When the tank high temperature limit stops the pump the fluid temperature is allowed to rise to a pre-determined danger setting to increase convective heat loss. When at the danger point the pump cycles on to carry the heat back to the tank heat exchanger. This feature may be combined with vacation mode (described below).

- **Vacation (Holiday) Mode.** Commonly used where there are periods of very low or no demand. In this scenario, the storage tank's upper temperature limit is reached frequently and early, causing the controller to stop the pump. When this mode is employed on the pump controller, the pump runs at continuously at night to radiate thermal energy from the system and cool the fluid as much as possible before the next day. Some controllers are pre-programmed to do this without customer input. Some controllers combine vacation made with pump cycling (described above).

- **Pump Shut-off at a Tank High Limit Temperature.** This approach is only used on direct systems, and employ a controller that shuts the pump off when the fluid in the tank reaches the set high-temperature limit. Such systems must utilize collectors with integral stagnation protection, meaning collector design does not allow temperature to degrade the heat transfer fluid.

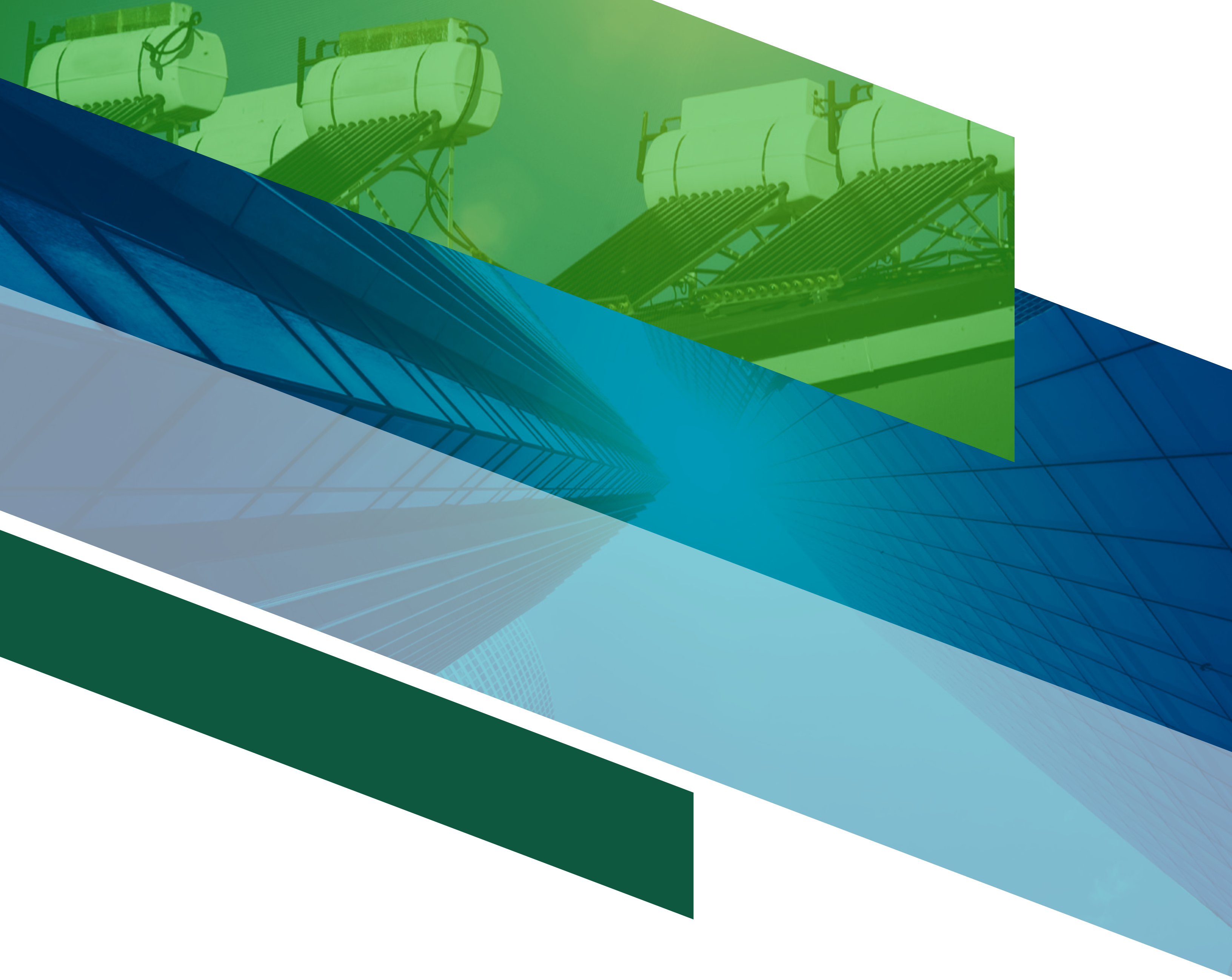
Overheat Protection and Heat Transfer Fluids

The heat transfer fluids used in solar collector loops must withstand all temperatures encountered by the SWH for the application and location. Only the heat transfer fluids shown in the ICC-SRCC certificate and approved for use by the manufacturer may be used in OG-300 certified systems. Use of heat transfer fluids that are not specified will void the OG-300 certification and may significantly reduce freeze protection, overheat protection, and may increase toxicity risk. Heat transfer fluids can degrade over time and must be periodically checked to ensure that they continue to provide the necessary protection. The SWH and fluid manufacturer's manuals specify the recommended frequency and methods for checking the quality of the fluid. Waste fluids must be disposed of in accordance with fluid manufacturer's requirements and local codes and regulation

Overheat Protection and Water Quality

The quality of the water supplied to the solar loop can adversely affect the freeze and overheat protection of a solar water heating system. Scaling potential increases as water temperature increases. Therefore systems that have high temperature surfaces in direct contact with hard or poor quality water are more susceptible to freeze and overheat related failures. For this reason, the site water quality should be assessed before installing a solar water heating system. Use caution with systems that have high temperature surfaces such as stagnating solar collectors or small orifice heat exchangers in direct contact with incoming water.

Note that items listed above do not imply approval by ICC-SRCC beyond their use in systems certified by ICC-SRCC.



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