Solar Rating & Certification Corporation
500 New Jersey Avenue, NW
Sixth Floor
Washington, DC 20001
t: 888.ICC.SAFE (422.7233)
t: 202.370.1800
f: 202.783.2348
www.solar-rating.org

Overview of Overheat & Freeze Protection Mechanisms

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Solar Rating and Certification Corporation (ICC-SRCC)

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

INTRODUCTION

Freeze and overheat protection are important design considerations for solar water heating (SWH) systems. ICC-SRCC currently certifies SWH systems under its OG-300 certification program, regardless of suitability for use in any specific climate (also known as climate appropriateness), and relies on manufacturers, installers, and local code authorities to ensure systems are installed in appropriate geographies with respect to local temperatures, solar intensity levels, and water quality. ICC-SRCC publishes a certification page for each OG-300 certified system which describes its overheat and freeze protection methods. ICC-SRCC does not imply that because a certain freeze or overheat protection method is listed, that it is approved by ICC-SRCC. 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 failure factors and to seek the most appropriate freeze or overheat protection method.

FREEZE PROTECTION

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. SRCC publishes a FTL (Freeze Tolerance Limit) for each OG-300 certified system which is specified by the manufacturer/supplier of the system based on 18 hours of constant exposure at the listed temperature. This value should be used cautiously because it is not well validated and does not assure total freeze protection. Freeze protection methods commonly used in OG-300 certified systems are shown below:

1) **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
2) **Drainback**: Water or a water/glycol mixture that can be used in the collector loop. When the pump stops running at sunset or when the tank has reached a high temperature limit, the fluid drains from the collector into a tank in a conditioned space, protecting the fluid from freezing or overheating.

3) **Direct forced recirculation**: When the collector temperature drops toward freezing, the system controller turns the solar pump on to send 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.
4) **Direct forced circulation with freeze valve(s)**: Depends on automatic drain valves (image shown) to open onto the roof 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 and maintenance of the freeze valve.

5) **Thermal mass (ICS) with or without freeze valve(s)**: 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: Pipe runs 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.
6) **Freeze valve(s) with freeze plugs in the collector**: Some collectors have a frost plug for freeze protection. Since the loop is under city pressure, considerable water loss could occur. The frost plug may need resetting or replacing by a repair contractor.

OVERHEAT PROTECTION

System overheating can degrade heat transfer fluids, accelerate scaling, cause premature component failure, and reduce system performance. OG-300 certified systems have been reviewed 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:

1) **Drainback, with or without glycol**: 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.

2) **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 pool or the ground.
3) **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.
4) **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. The system expansion tank in these systems must be sized to accept all the liquid in the collector.
5) **Pressure stagnation**: Increased pressure in the collector and solar loop allows the fluid temperature to rise and delay boiling.
6) **Pump cycling**: When the tank high temperature 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 (below).
7) **Vacation (holiday) mode**: When the storage tank high limit is reached, the collector pump stops. At night the pump runs continuously to 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 (above).
8) **Pump shut-off at a pre-determined tank high limit temperature** (only on direct systems): Collector with integral stagnation protection(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 solar system. Only the heat transfer fluids shown in the SRCC approved parts list in the installation manual 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.

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.