Strategies for Avoiding Glycol System Overheating

Installers discuss preferred design and equipment options to minimize thermal system overheating. In any location, even one with mild winters, a hard freeze can burst the tubing in solar collectors that utilize water as the heat transfer fluid. In freezing climates, using glycol antifreeze instead provides the most reliable freeze protection for collectors.

However, on the other end of the temperature scale, collector overheating during the summer months or when buildings are unoccupied will break down the buffers in the glycol that prevent acidity, and this breakdown compromises the solution's protection against freezing. In the best case this requires a service call to replace the glycol; in the worst case it can destroy collectors.

Intense summer irradiance and higher temperatures combine to provide solar collectors with ideal conditions for making hot water. But conditions can be too ideal. When the collector area to storage capacity is oversized or a thermal space heating system has a seasonal load imbalance, overheating can occur. Basic shifts in usage patterns, like not using hot water during vacations or dormitory vacancies, can also result in overheating.

Solutions to the overheating problem are numerous and varied. Some are passive; some are active; some are easy retrofits; and some are best accomplished during installation. While a drainback system design is an easy overheating protection solution, some thermal professionals question these systems' effectiveness against freeze protection. Several other approaches that protect against system overheating are practiced. I asked some seasoned contractors and inventors for their solutions. Some of their ideas address smaller systems, and some can be deployed on systems of any size. Their cool answers to the overheating problem follow.

PERSPECTIVES ON OVER-TEMPERATURE CONTROL

By Chuck Marken

Rob Stout, Southwest Solar Design

A steep tilt angle is Rob's choice to mitigate summer temperatures in the combination space heating and domestic hot water systems he designs and installs in northern New Mexico. On combined DHW and radiant floor systems, he has been using a 70° tilt from horizontal since 1999 with good success.

"Bristol Stickney of Cedar Mountain Solar was very helpful in the '90s as we evolved what we called *Rob's ideal solar system*. I've since been moving toward simplicity of design. With the collectors tilted at 70° from horizontal, there is less collector area pointed at the summer sun. This, combined with the efficiency drops above 150°F, tends to stall collection at about 170°F. By mid August, as the sun's path gets lower, the collectors are typically generating more energy than is needed for DHW; but this is just the right time of year to preheat high mass slabs. Over several years, I've been increasing the mass of the slab with compacted soil over rigid insulation and increasing the slab thickness to 4 inches. The most recent has 14 inches of mass over 3 inches of rigid insulation.

"The slab surface temperature in summer is 70°F or slightly less. By dumping some heat into the floor starting mid August, the mid September slab temperature rises to about 75°F and starts to provide some heat to the living space. More importantly, the temperature deeper down in the mass has come up from the 60°F range. I don't have this seasonal swing data logged, but by giving the mass 3 to 4 months of minimal heat input during the summer due to the 70° collector tilt, I would imagine the temperature at the bottom of the mass has lost much of its stored heat."

Bristol Stickney, Cedar Mountain Solar Systems

Bristol employs active control strategies to minimize overheating in solar thermal space and domestic water heating projects.

"We install two-stage heating thermostats in every heating zone of a project that has thermal mass embedded radiant heat. Solar heat is used to achieve the high set point of the two thermostat set points, and boiler heat to achieve the low set point. This allows regulated heat banking in the floor's mass.

"When the room thermostat high limit is satisfied, we also cycle the solar collectors at a safe high temperature usually from 200°F to 180°F—cooling the collectors just enough by turning on the coolest zone in the house. This typically allows the collectors to operate within an acceptable temperature range without affecting slab surface or room temperature.

"We also use the reradiate feature by running the system at night to cool the tank. We use dc, PV-powered pumps in all of our systems, so there's always collector circulation, even during in a power outage. To reradiate, we use temperature controls and an ac/dc converter to turn on the PV pump at night as needed."

Barry Butler, Butler Sun Solutions

When most people think of antifreeze, they probably think of cars or trucks—not solar water heaters. The auto industry is where Barry went for an overtemperature solution. He designed a system component that incorporates a 16 psi radiator cap placed after a small-finned tube radiator. Barry has been operating one of these devices in conjunction with a twocollector propylene glycol system using Peak Sierra Pet Safe Antifreeze for over 20 years. The system has been regularly stagnating for several weeks a year since 1986. He checks the condition of the propylene glycol solution at least once a year to see how it is doing. The solution still has a pH of 8.6 and, according to Barry, looks and smells like it just came off the shelf.

"The over-temperature radiator has about 1.8 square feet of surface area capable of protecting the solar system from excessive boil over and fluid loss caused by stagnation. Stagnation occurs when solar energy is being absorbed in the solar collector, and no fluid flow is removing the heat. In this case the fluid in the solar collector will boil at 16 psi, creating steam at 256°F. The steam makes its way out of the top of the solar collector and toward the radiator cap. However, it



Fluid management system Designed by Butler Sun Solutions, this passive thermal system cooling component incorporates a 16 psi radiator cap and a small-finned tube radiator with a surface area of 1.8 square feet.

must pass through the liquid-to-air heat exchanger first.

"The differential temperature between the outside air and the steam causes heat to be removed from the steam and be delivered to the outside air. This heat loss to the surrounding air condenses most of the steam back to water, which then finds its way back to the solar collector. The small amount of steam that blows past the radiator cap and enters the overflow reservoir is condensed as it bubbles through the fluid in the reservoir. It is held there as liquid for reintroduction into the system upon cooling at night."

Steve Baer, Zomeworks

The patented Tide Tank is Steve's idea of a multiuse product. The Tide Tank, in addition to solving the overheating problem, also works as an expansion tank, check valve and pressure relief. I think this is a simple and elegant solution with a less than elegant appearance. The Tide Tank is not currently available for purchase, but Steve is working on a model with a lower profile that will be in the future.

"The tank works on the property of the antifreeze solution's expanding physically when it becomes hot. The tank is placed at a point above the highest point of the collectors and must be precisely filled on installation. Once the tank is filled to the right level, at the right temperature, the overflow valve is closed. The system is ready for operation.

"The antifreeze is routed out of the collector to a pipe located high in the Tide Tank. This pipe is higher than the return to the heat exchanger and acts as a check valve to prevent losses at night due to thermosyphoning. As long as the heat transfer fluid's temperature stays below the fill set point of about 170°F, the system operates like any other closed loop antifreeze system. When the solution temperature rises above 170°F, it exits the tank in the over-temperature



Tide Tank plumbing Steve Baer of Zomeworks designed the Tide Tank more than 20 years ago. The tank's functionality is driven by the property of the antifreeze solution physically expanding as its temperature increases.

overflow pipe. The overflow is piped to a finned tube radiator on the back of the collector, cooled and returned to the pipe going to the heat exchanger."

Kelly Keilwitz, Whidbey Sun & Wind

To control summer overproduction in the combination space heating and DHW systems he installs near the Washington State coast, Kelly uses a number of techniques, from steep collector tilt angles to PEX loops used as diversion zones to dissipate heat.

"Tilting the collectors at latitude plus 30° (about 70° to 75° from horizontal in my service area) limits heat production during the summer months. This is a steep tilt angle for 4 x 10 foot collectors and is structurally easier to achieve with evacuated tube collectors, which have less wind resistance.

"A radiant fan-coil heater installed in the crawl space is a fairly expensive option. These units are readily available in many heat outputs for different sized systems. Another approach I use is to install PEX tubing loops in the soil under patios, new slabs that would otherwise not have been heated, greenhouse beds and crawl spaces. The concept is to store the diverted heat in a way that benefits from annualized solar heating. While the annualized heating concept isn't very efficient, it does make some use of excess system heat. If in-floor heating is already being installed, running extra diversion loops typically doesn't add much to overall project cost. When installed in soil, careful fill selection and compaction control are necessary to prevent damaging PEX tubing.

"Additionally, using a swimming pool or hot tub as the diversion load is a good option, if available. The swimming pool may be the best option since it's a virtually endless dump load. Of course, it's better to first heat the swimming pool from solar, before the DHW. With the Federal tax credits for solar hot water systems, I can configure the system as a DHW system with a large pool dump. This uses the dumped heat to great benefit. Note that diversion systems dumping to a hot tub or pool usually require a stainless steel heat exchanger, which tend to be expensive. But this can still be a cost effective approach when the collectors are significantly oversized for the summer load.

"Finally, some controllers have a holiday mode that will circulate the system at night to keep the tank temperature from getting too high. The holiday mode can work for systems where the potential for overheat-

ing is minimal and occasional. This over-temperature control approach is best used with flat plate collectors, since evacuated tube collectors are well insulated and do not lose much heat via radiation to the night sky."

ADDITIONAL OVER-TEMPERATURE CONTROL SOLUTIONS

Drainback systems. Why not use a drainback design to begin with? Some designers and installers just do not like them. The systems earned a poor reputation in some places from bad controls, substandard installations, sagging tubes and stacking pumps. In some locations, the drainback is the choice of installers, and antifreeze systems are the last resort. Personally, I like drainback systems when the collectors can be installed on the roof. Drainback systems offer great freeze protection if all design and installation rules are adhered to. Overheating potential is solved with a simple high limit on the differential control. Many large thermal arrays are ground mounted out of necessity, which makes drainback system designs difficult or even impossible to use. In these cases, the typical choice is to install an antifreeze based system.

Apricus Heat Dissipator. Evacuated tube manufacturer Apricus has a system component called the *Heat Dissipator* (HD) that can be used to limit the temperature in its evacuated tube systems if overheating potential CONTINUED ON PAGE 66



Apricus Heat Dissipator The Heat Dissipator is designed for use with Apricus evacuated tube collectors and passively cools collector fluid via aluminum heat fins.

exists. The Heat Dissipator is a finned copper tube heat exchanger that is installed on the return line from the solar collectors. When the temperature in the storage tank exceeds 176°F, the controller switches a solenoid that directs the solar return flow through the component before returning it back into the standard flow line. Alternatively, a thermostatic mixing or tempering valve set to a suitable temperature can be used, providing mechanical, automatic regulation of flow through the HD. As the hot water passes through it, heat is dissipated via the aluminum fins to surrounding air, with the vertical fin arrangement promoting a passive air current.

Covering the collectors. This can be a simple task or onerous as hell, depending on where the collectors are. Most system owners do not like this option, but it is worth mentioning because some do not mind. Covering and uncovering collectors usually happens at HVAC changeover times and can be scheduled appropriately.

Check valve bypass. Installing a pipe parallel with the check valve can help prevent collectors from overheating. A ball or gate valve (most pros prefer ball valves) is placed in the pipe and is normally closed. Whenever the system is prone to overheat, the valve is opened. When open, the system will thermosyphon at night and lose heat to the night sky by radiating through the collectors. As with all night radiation designs, this works well only with flat plate collectors because of the superior insulation of evacuated tubes.



Proprietary devices. Some collectors have built-in overtemperature protection. EnerWorks and Thermomax Technologies both incorporate overheat devices that limit the maximum collector temperature.

The EnerWorks collector model COL-4x8-TL-SG1-SD10 has a patented temperature-limiting device that vents out excess heat. This feature is designed to minimize or eliminate the effects of overheating during a typical summer vacation—2 to 3 weeks without hot water use. A thermally actuated spring, located inside the collector at the top,

Check valve bypass

A simple bypass valve fitted with a gate valve can be used to manually enable nighttime reradiation via flat plate collectors to lower tank temperature during building vacancies.



operates the over-temperature protection device. An air baffle at the back of the collector, also located at the top, opens to allow the hot air inside the collector to vent out. Fresh, cooler air comes in through an opening at the bottom, thereby cooling down the absorber. The collector has an internal air channel that allows air to flow in natural convection. When the temperature is low enough, the air baffle closes, and the air in the channel acts as an insulator to keep the heat inside the collector. The temperature of the heat transfer fluid is maintained at approximately 260°F when the device is activated. In addition, the vent is completely passive and mechanical—no electricity is required.

Thermomax Technologies also has a patented temperaturelimiting device. In the Mazdon system, the Memotron tube includes a bi-metal snap disc that limits the maximum collector temperature to 250°F. At this temperature, the disc closes and plugs the neck of the heat pipe, thereby preventing the return of the condensed fluid and thus heat transfer. The disc retracts at temperatures below the maximum programmed limit, allowing the condensed fluid to return to the lower section of the heat pipe, and the collector returns to normal operation. The manufacturer notes on its Web site that, "Memotron is *not* a design feature for seasonal (radiant heating) thermal applications. A heat dump must be considered (space heating applications) when the collected energy exceeds load."

Keeping it cool. Overheating solutions are high tech, low tech and in between. Hopefully, one or more will work for you if you ever run into the problem. Are there any other answers? Sure there are. If you have any methods to solve antifreeze system overheating, be sure to join the discussion online at solarprofessional.com.

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