Thermalstar Technologies

Thermosyphon Solar Water Heater

Ian Woofenden, with data collection by Rose Woofenden

Application: **My family and I put together a stand-alone solar shower at our home in northwest Washington state, using Thermalstar Technologies' simple, unpressurized, evacuated tube water heater. It provides showers primarily for me, but also for the kids when they are willing to withstand the breeze in this outdoor shower and forego the higher water pressure of our indoor shower. Our datalogging session conveniently occurred just after our propane demand heater died, so the whole family used the shower heavily during that time. This solar water heater is a low-pressure unit that will not work in most mainstream applications. It is most appropriate for freeze-free environments, seasonal use, or simple applications.**

Thermalstar's evacuated tube solar water heater.

System: **We datalogged ambient air, collector tube, and tank temperatures using a Hobo logger, three temperature sensors, and a 486 PC laptop. The skin and brains of two adults and five children monitored shower comfort and function.**

Our family has been living with solar electricity for about 20 years. But our water is primarily heated by propane. The complication of pumps, glycol loops, wiring, and installation had kept me from getting out of my editor's chair and putting a solar domestic hot water (SDHW) system on our home. But when I saw Thermalstar Technologies' simple heater, I saw a way to walk my solar thermal talk.

Packaging & Installation

The heater arrived in the back of importer and engineer Andrew Swingler's Volvo stationwagon. Normal shipping is via UPS, but Andrew lives just across the border from me in Vancouver, BC, Canada, and offered to bring the unit down and help set it up. The stainless steel tank and framework are shipped in a cardboard carton. The glass tubes come in a sturdy wooden crate with Styrofoam cradles that keep them intact during transit.

The unit includes a 22 gallon (83 l) insulated tank, a slanted stainless steel reflector, square tubular framework to support the tank, and fifteen simple evacuated tubes. We assembled the tank and framework with common hand tools. It was fairly intuitive and simple. The various stainless steel parts bolt together, and everything fit together well.

After the framework was assembled, we installed the tubes. The tube tops slip up into rubber gaskets inside holes in the bottom of the tank. After a shot of soapy water from a spray bottle, the tubes twist up into the tank with no

problem. They then slip back down a bit for the bottoms of the tubes to rest in the plastic cushion at the base of the reflector.

The unit was fully assembled in less than an hour, and we hoisted it up onto the shower structure that the kids and I had built in advance. We fastened it down with eight, 1 inch (2.5 cm) screws through the unit's feet. The next step was plumbing.

Andrew made a simple faucet rig so we can have hot and cold water and also be able to fill the heater tank when we want to. We plumbed a garden hose to this copper plumbing, fitting it with hose clamps. We added a clear plastic tube next to the tank to show us how full the tank is.

Simple Construction & Function

This heater combines a simple storage tank with "evacuated tubes"—double-wall glass tubes. In between the two glass walls is a vacuum. The bottom of the sealed outer tube contains a gas-absorbing, silver-colored material that ensures a high vacuum. The material will discolor if the vacuum is ever lost (rare).

The tubes are similar to the technology used in old electronics-style vacuum tubes and thermos bottles. They are of a continuous glass construction with no metal to glass seal. According to the manufacturer, the "high quality borosilicate glass" tubes are designed to withstand a 1 inch (25 mm) diameter hailstone falling at terminal velocity. The tubes are cylindrical and much stronger than a flat sheet of glass.

Evacuated tubes have had the reputation of being too fragile. The historical fear of breakage comes from the metal to glass seals of the early single-walled heat pipes. Our system's simple tubes are constructed differently. They are an all glass, double-walled design with no metal to glass seal to fail. These are breakable, but not terribly fragile.

In operation, the inner tube is filled with water, which absorbs the sun's heat. The inner glass is coated with a selective surface—a dark material that helps absorb the sun's heat, but does not let much heat reradiate out of the water in the center of the tube. Unlike most other evacuated tube devices, which are called "heat pipes," these units have no metal absorber or heat transfer device.

Zander Woofenden likes to get clean with liquid sunshine.

Features

High Points:

- Simple assembly and installation
- All stainless steel construction
- Simple evacuated tubes (not heat pipes)
- No pumps, glycol, electronics, or wiring
- Very effective solar heater
- Low cost
- Completely passive heating

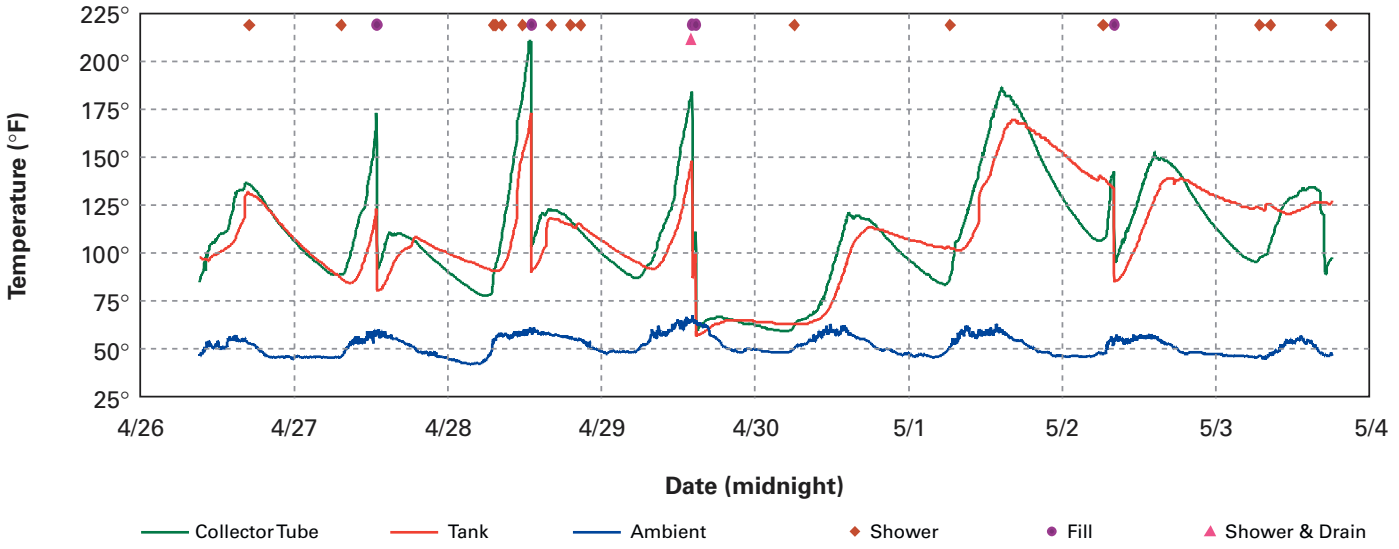
Low Points:

- Maximum internal pressure must be limited to below 5 PSI
- Doesn't interface easily with conventional pressure systems
- Manual fill
- No scald protection
- Needs cold water for mixing

List Price: US$649, including high quality crating suitable for North American delivery

Warranty: A one-year limited warranty, with extended warranty available, covers frame, tank, and evacuated tubes against manufacturing defects.

SDHW Heater Temperatures



They are simply double-wall tubes filled with water, and open at the top. The tops of the tubes, inside the bottom of the tank, allow a free-flowing exchange of water via gravity and thermosyphoning between the tubes and the tank. There is no connection or manifold between the individual tubes at the bottom, and the tank acts as a manifold at the top.

The sun heats the water in the tubes, and since hot water rises, the hottest water goes up into the tank. Cooler water (which is denser and tends to go down) seeps down into the tubes in a continuous cycle that puts the coolest water in the tubes and the hottest water in the tank.

The surface heating area of the system is about 1 m² (10.8 ft.²). At full sun, the manufacturer's rated temperature rise is 18°F (10°C) per hour with a full tank and 36°F (20°C) per hour with a half tank. These figures are based on full sun (1,000 W/m², perpendicular to the tubes and with zero difference between tank and ambient temperatures), ideal conditions not often found in the real world.

The data my daughter Rose collected showed half the temperature rise of the rated figures, perhaps due to the relatively low ambient temperatures during our test. Recent summer observations showed performance somewhat closer to the importer's claim with a half-full tank. True performance figures will probably be less than ideal conditions would give, and will vary with local conditions.

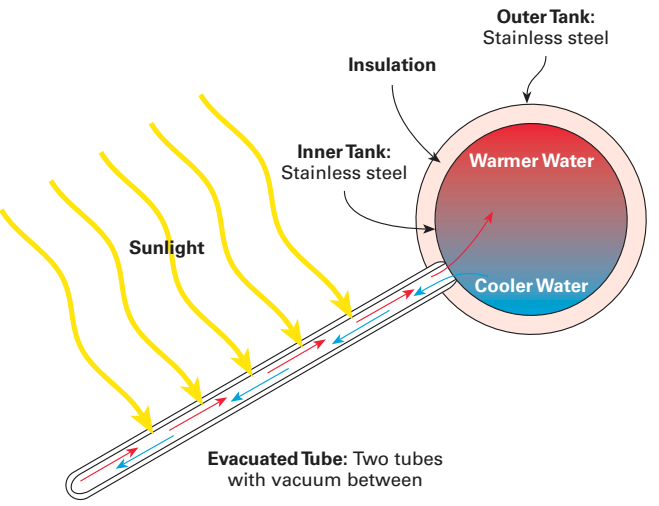
The tank is well insulated with about 2 inches of polyurethane foam, and holds heat surprisingly well. I usually shower in the morning before the sun is on the collector, and normally have to add cold water. The tubes lose little heat because of the selective surface and the vacuum, which make it hard for heat to travel out of the water.

First Use

We installed the unit in early January, a time when not much sun makes it into our clearing past the 130 foot (40 m) Douglas-fir trees. During a few months in the winter, we only get a few hours of direct sun on the shower site, and it's in the mid-to-late afternoon. So it took several weeks before we really could test the unit properly. But I was impressed early on at how quickly the unit heats water. Even with only a few hours of marginal sun, the unit would heat a tankful of our 55°F (13°C) water to useable temperatures (100–120°F; 38–49°C) over two or three days.

This unpressurized solar water heater is an open system, and will not stand up to standard house pressure. It

Thermalstar Operation



Tech Specs

Capacity: 22 gallons (83 l)
Empty Weight: 60 pounds (27 kg)
Footprint: 44 by 50 inches (112 x 127 cm)
Height: 47 inches (119 cm)
Collector Slope Angle: 38 degrees
Number of Tubes: 15
Collector Dimensions: 42 by 43 inches (107 x 109 cm) of exposed area
Individual Tube Diameter: 1¾ inches (4.5 cm)
Individual Tube Length: 46 inches (117 cm)
Tank Diameter: 12 inches (30 cm)

provides hot water with gravity pressure only, and has a single opening on the bottom of the tank for filling and drawing hot water, and another opening at the top that acts as pressure relief, vent, and overflow. When we want to fill the unit, we open the fill valve on the shower wall, and turn it off again when the tank overflows. Thermalstar now has an automatic fill apparatus for this unit. This would make the unit more convenient, but might also mean somewhat less control over the tank temperature.

The graph shows ambient, tube, and tank temperatures over an eight-day period in late spring. Unfortunately, we were not set up to monitor solar insolation, but the conditions were generally sunny, though not hot (ambient temperature gives some indication of insolation). Note the decrease in temperature when we filled the unit, and the recovery rate.

Programming

The beauty of this unit is that all the programming necessary is in the brain of the user. This is a two-edged sword, of course, but for folks who like to be hands-on and don't mind working with the changes in the weather, it's great. No set points, no buttons, and no LCD screens. Just fill the thing up and let the sun do the work.

We did add an indoor-outdoor digital thermometer, with the outdoor probe tucked into the tank. Before we use the shower, we can check the temperature and know how much cold we'll need to add. I find that I like my showers between 110°F and 120°F (43 and 49°C). Any hotter than that and I'm mixing in a bit of cold (it doesn't take much). This heater routinely heats water to 140°F (60°C) or more, so it's good to know what to expect when you turn on the tap.

Hot Water!

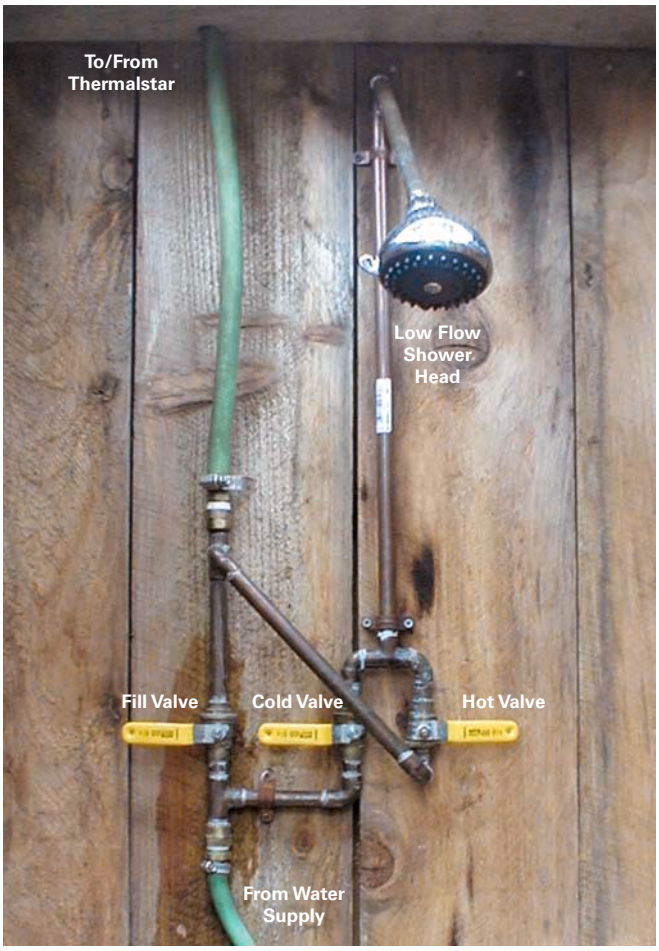
With our very low-pressure system and a wide showerhead, our water usage is not high. The 22 gallon tank takes about 30 minutes to empty. This gives time for several reasonably long showers. Once summer started, I had lots of hot water. Sometimes I splurged and took two showers a day—one under the stars.

If the weather is predictably sunny, I like to refill the tank when it's almost empty, providing that I do it right after my morning shower, so it will have the longest time possible to reheat. But I tend to try to get as much water as hot as possible, so I sometimes fill it too much, too late, and end up with a lot of "lukehot" water. Since it's mostly me using it, I really only need to fill it once or twice a week at most. If the weather is not terribly sunny, it's better to fill it partially so it can get some water hot enough, instead of lots of water not hot enough.

Temperature Extremes

We haven't run this heater through a winter yet. But winters are mild here, and I suspect we will be able to use it much of the year. If we're going to get a hard freeze, it's easy to drain the tank. And if we want to drain the tubes, removing two bolts from the front feet and tipping the unit backwards will accomplish this easily.

One fill/drain port requires creative plumbing.



However, Andrew has assured me the tubes will *never* freeze before the tank due to the natural thermosyphoning effect and the fact that ice will always form at the top of the system. Water is at its maximum density at 39°F (4°C), so the freezing water always rises to the top. The volume of the tank (at least half full) would require subzero temperatures to freeze. These units are common in China, where they use them in heavy freeze areas with the only freeze problems being the water in the send and return pipes.

I am fairly confident that my unit is safe here in the temperate coastal Northwest. But you should use your judgment about what conditions it will be subjected to in your area and how well it is freeze protected with only insulation stopping the heat loss.

At the other end of the temperature spectrum, if the tank is left empty when the weather is hot, the seals could "bake" onto the tubes, requiring a possible gasket exchange, which is easy to do. Stagnating the unit in full sun still isn't a good idea, and will void the warranty if stagnation occurs for more than 30 days.

Recommendations

This is not a product for someone who is unwilling to work within this solar water heater's limitations. It is hands-on with filling the tank, monitoring the temperature to optimize performance and avoid scalds, and determining adequate freeze protection. This unit is not intended for integration into a standard household pressurized water system.

On the positive side, Thermalstar Technologies' low-pressure solar heater is a reasonably priced, well-made unit. If you have a low-pressure application, such as a solar shower for a cabin or camp, dishwashing station, or other situation needing a modest amount of hot water, I recommend this product to you. It's low-tech/high-tech, using high quality materials and sophisticated design in a simple application.

Thermalstar Technologies has these units manufactured in China, where the technology is quite common. Flying into a Chinese city, you can see hundreds of them on the rooftops. I'm glad to hear that thousands of people in China are taking advantage of the sun's heat, and I'm happy to use some of their good technology here in the U.S.

Access

Reviewers: Ian & Rose Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

Importer: Thermalstar Technologies, Vancouver , BC, Canada • 604-318-1881 • thermosiphon@thermalstar.ca • www.thermalstar.ca

Onset Computer Corporation, PO Box 3450, Pocasset, MA 02559 • 800-564-4377 or 508-759-9500 • Fax: 508-759-9100 • sales@onsetcomp.com • www.onsetcomp.com • Hobo dataloggers