Generic Solar Hot Water Heating

This following is a technical evaluation of the standard active solar hot water heating system using standard components (available on the Internet or from distributors). The system uses components that are reliable, easy to install, and easy to. Operating cost considerations are more critical than initial cost considerations; thus, this technical evalation prioritizes performance, reliability, and ergonomic considerations. The following schematic identifies the major standard system components and the list provides further detail for each numbered component in the system.

This is a two-loop closed system for use in locations where there are freezing conditions. The primary heat transfer fluid (HTF) is DowFrost HD mixed with pure (distilled) water at the proper concentration for the worst case temperature. See http://www.dow.com/heattrans/prod/glycol/dowfrost.htm for additional information on what is the proper mix ratio for the worst case temperature.

The major concern with solar heating systems is stagnation, i.e., over-heating which can either damage or decrease the reliability of the components. The collector area and storage tank must be properly sized for actual hot water usage and the local conditions, including solar insolation, collector azimuth and tilt, and length and insulation of piping. In most cases, a standard pump can be used, one just uses larger diameter pipe for long runs or larger systems.

The below schematic is a generic depiction of a single storage tank/heat exchanger system. The components are numbered for easy identification of the descriptions of function in the following list.

The pipe insulation for the primary loop is required. Although high temperature pipe insulation, such as from K-Flex Insul-Tube (formerly known as Rubatex) is preferred, standard hot water pipe insulation may be adequate for many installations. Additional means for protecting the insulation from UV light is required. Additional details about the high temperature insulation may be downloaded from http://www.kflexusa.com/products/insultube/. Linesets of premade lenghts of copper tubing, sensor wires, and insulation are available (http://www.linesetsinc.com/linesetsadvantage.php).

All valves, piping, and gauges are standard and have appropriate characteristics for the application. The setting for the tempering valve is normally 120 ºF, but can be adjusted. The thermostat for the backup heaters in the storage tanks is also set to 120 ºF, but may be set to 125 ºF, so that during the winter the water temperature out of the mixing valve is the same as the water temperature during the summer. Connections to the collectors and other components should be solder/brazed but can use standard (NPT) threaded compression fittings. Proper torque values to apply to connections with threaded fittings will vary by model type. Smaller systems use ½ inch Type M copper tubing, larger systems need ¾ inch Type M.

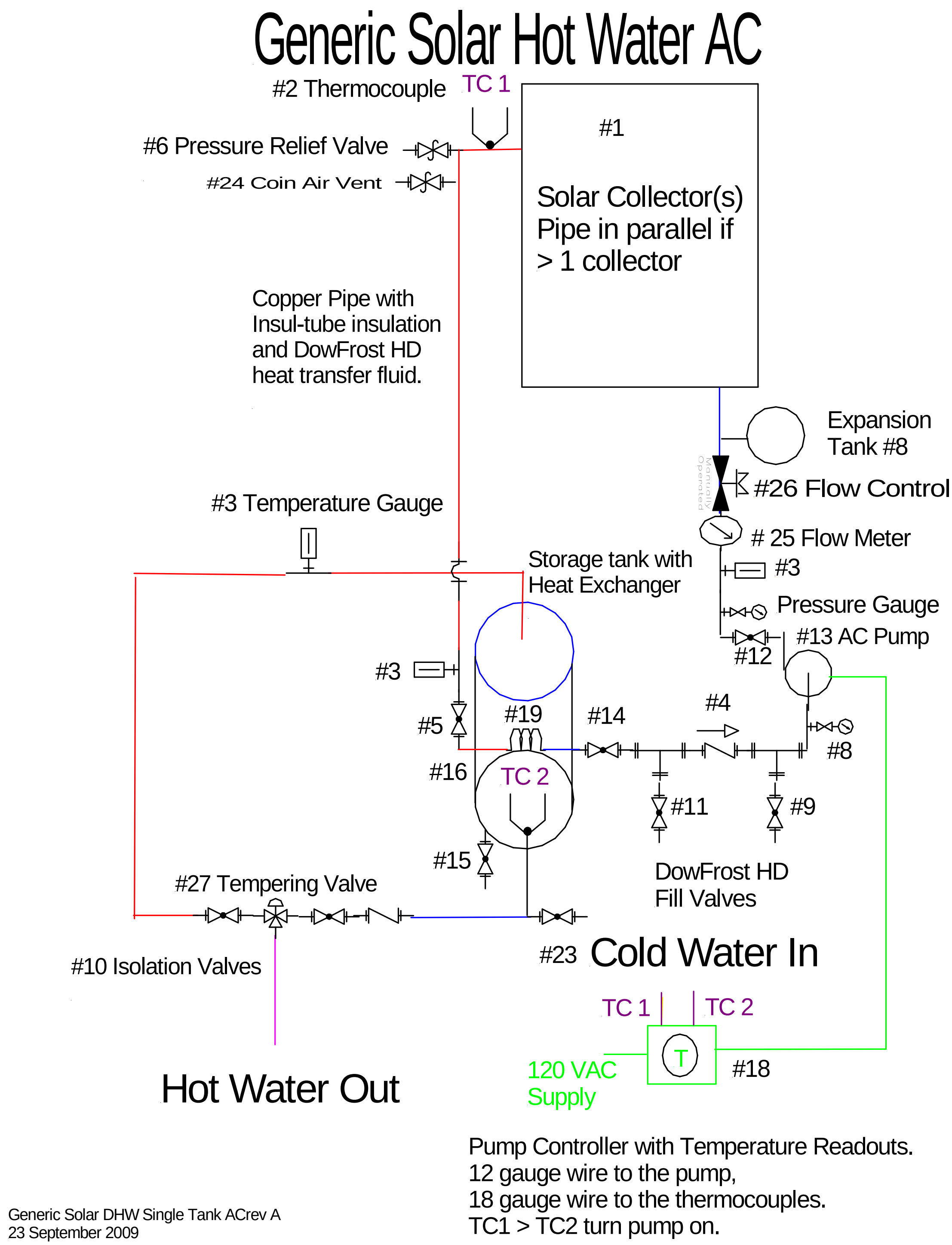

Figure 1: Single Tank System Schematic

Typical System Components

1. SunEarth Solar Collector(s): Absorbs the sun's heat energy and transfers this heat to the HTF circulating through the collector. http://www.sunearthinc.com
2. Collector Sensor: A thermocouple wired to the system controller that works in conjunction with the tank sensor to automatically turn your circulating pump on and off at preset temperature differentials.
3. Tank and Line Thermometers are used to determine proper system operation. Line thermometers will show an approximate 5 - 12° temperature difference between the collector supply and return lines on sunny days. In a single tank system, the tank thermometer will read the temperature of the water after the mixing valve feeding your fixtures. In two tank systems, the thermometer will read the finished solar tank temperature. One can use standard 0-250 ºF temperature gauges or use a combination gauge with pressure, item #7.
4. Check Valve is installed to properly charge the loop with DowFrost HD. The check valve will also minimize convective (thermo-siphoning) evening heat loss in the system. The heat in the solar storage tank will rise through the collector loop piping in the evening into the much cooler solar collector and dissipate heat unless prevented from doing so by a check valve. If one uses a check valve integral with the circulation pump, then this check valve can be replaced with a ball valve.
5. Isolation Ball Valve: Used in conjunction with component No. 14 to isolate the solar collector loop from the solar storage tank.
6. Pressure Relief Valve: Will release glycol loop HTF at 150 PSI. If this valve opens and HTF fluid is expelled contact your contractor immediately. This valve also can be opened to vent the lines when charging the HTF loop. Set at 150 psi, e.g., Watts series 530C.
7. Pressure Gauge: Indicates the pressure in the charged DowFrost HD collector loop. The loop is pressurized to ~ 45 psi, both to minimize static head to the pump and to imporve the DowFrost HD characteristics.
8. Expansion Tank is pre-charged with air to allow for the expansion and contraction of the HTF as it heats and cools. The Amtrol Radiant Extrol® expansion tank is designed to work with DowFrost HD, for most systems, the RX-15 tank is appropriate. http://www.amtrol.com/extrol.htm
9. Charge (ball) Valve: Used to charge the collector loop with DowFrost HD and also to eliminate air from the system.
10. Isolation Ball Valves used to isolate the tempering valve and hot water outlet for troubleshooting system problems.
11. Drain/Purge (ball) Valve: Used to charge the collector loop, purge air from the loop, and drain the HTF.
12. Isolation Ball Valve: When closed in conjunction with No. 14 will isolate the circulation pump for repair or replacement.
13. Circulating Pump circulates the HTF through the collector loop. This should be a bronze pump, both to minimize corrosion issues and for a better thermal coefficient of expansion to minimize thermal stress at the connection of the pump and piping. Stainless is acceptable, noting cast iron is not recommended. Either the Grundfos (http://www.grundfos.com/web/homeus.nsf) UP-15-18B5 or the UP-15-42B5 or Taco (http://www.taco-hvac.com/en/index.html) Model 008-BF6-J is suitable with a flow meter and flow control valve to properly set the flow to optimize the collector efficiency.

14. Isolation Ball Valve is closed in conjunction with No. 12 to isolate the circulation pump for repair or replacement.
15. Flush Valve is used to drain the solar storage tank and to flush sediment from the tank on an annual basis.
16. Tank Sensor is wired to the DTC. Works in conjunction with the collector sensor to turn the circulating pump on and off at preset temperature differentials.
17. Cold Water Dip Tube: Forces incoming city cold water to the bottom of the solar storage tank to prevent mixing with the warm water at the top of the tank. *(not shown)*
18. The differential temperature controller DTC) automatically turns the circulating pump on and off when there is sufficient heat to be gained from the solar operation. The controller also may be set to limit high temperature build up in the solar storage tank by enabling a night recirculation mode to cool the tank, also known as a vacation mode. The Eagle-2 DTC is recommended, although versions from Heliodyne and Steca will work. http://www.solar.imcinstruments.com/
19. Heat Exchanger transfers heat from the solar collector loop to the potable water in the solar storage tank. The size chosen for each system depends on hot water usage and the area (ft^2) of the collectors. An 80-gallon Rheem Solaraide tank is recommended for most one or two collector systems. http://waterheating.rheem.com/content/rheem/products/rheemsolar.shtml
20. Anode Rod: The "sacrificial" anode rod is installed in your solar storage tank to prevent corrosion to the tank lining by neutralizing aggressive water action. Anode rods have a finite life and require periodic replacement depending on annual tank temperatures and water quality. Determine a replacement schedule with your installation contractor. *(not shown)*
21. Heating Element & Tank Thermostat: The solar heat exchanger/storage tank is equipped with an auxiliary 4500 watt, 230 volt electrical heating element. The thermostat controls the temperature setting of the auxiliary heating element. *(not shown)*
22. Temperature and Pressure Relief Valve: Universally required by the plumbing code on water heaters. Will automatically release and dump water at either 150 PSI of pressure or 210° F in temperature. *(not shown)*
23. Cold Water Supply Line Isolation Ball Valve when open allows potable water to fill the solar storage tank or back-up water heater. When closed isolates the solar storage tank and backup water heater from the pressurized city cold water supply line.
24. Coin Vent is used the vent the primary loop when charging the system with DowFrost HD. Air in the line is vented, then the valve is closed. Use Amtrol model 747
25. Flow meter is used to measure the flow rate. The recommended pumps, needed to overcome the head, have a higher flow rate than optimum for the collector heat transfer efficiency.
26. The flow control (globe) valve regulates the flow rate to near the optimum level. Generally collectors operate best near 1 gpm.
27. Mixing Valve automatically blends hot water from the solar storage tank with incoming city cold water to the set point, which is typically 120 ºF. A Watts (http://www.watts.com/) 1170 is recommended.
28. Optional Time Switch allows you to automatically or manually turn the auxiliary heating element in the solar storage tank on and off.

System Schematic Comments

While, in general, the schematic is adequate, there are some items that need additional review:

1. If there is any form of check valve, e.g., may include some forms of pressure regulation, between the storage tank and the cold water supply, an additional expansion tank is required. In normal operation of a standard hot water heater, there is not enough ΔP caused by the ΔT within the hot water heater to justify an expansion tank. However, with solar hot water heating, the daily ΔT can be much higher, resulting in a higher ΔP that could cause problems, if there is not an expansion volume. Well systems typically have an bladder tank to maintain relatively constant pressure, with no check valve between the tank and the cold water inlet to the hot water tank, so the ΔP is automatically adjusted for. If either the well system or city water have a check valve in-line, then an additional expansion tank, accounting for the volume of the storage tank needs to be included.
2. This schematic shows the pressure relief valve for the HTF (heat transfer fluid) to be near the piping peak elevation. For many urban settings, the pressure relief isinside the house, near the storage tank/heat exchanger, with a safety drain tube.
3. Since some DTCs have the capability for more than two inputs, the location for additional sensors, similar to component #'s 2 & 16, are not shown. Possibilities include the hot water out of the tank or the hot water out of the mixing valve. If a BTU meter is used, then the 3rd sensor would be in the cold supply to the collector, i.e., along with component #2, would provide the ΔT to be used with the flow, to calculate the BTU (kWh) produced by the solar heating.

Documentation

Documentation on how to install components is typically available from the manufacturer. An Internet search can find other suggested methods, including appropriate tools and materials.

The DIY (Do-It-Yourself) installation should generate a manual including:

Detailed descriptions of all standard components used, e.g., the pump curve, the DTC readings.
A system schematic, showing all components.

- Periodic monitoring, i.e., when and what temperatures, pressures to read.
- Trouble-shooting when operation is not normal, especially a flowchart.
- Preventive maintenance items and schedule, e.g., checking DowFrost HD.
- Corrective maintenance items, i.e., how to fix problems.
- System set points and programming, e.g., of DTC.
- Other system component information requirements will be clearly identified, e.g., expansion tank size based on primary loop volume, pump head loss, collector volume, and storage tank/heat exchanger volume.
- Expected lifetime (MTTF or MTBF) for all major components. The following table is an example of what is needed.

Component	Warranty	Units	MTBF	Units
Collector	10	Years	40	Years
Controller	5	Years	20	Years
Pump	2	Years	15	Years
Pipe Insulation	1	Year	15	Years
Tank/HX	10	Years	15	Years
Sensors	1	Year	30	Years
Gauges	1	Year	30	Years
Piping	10	Years	50	Years
Wiring	10	Years	50	Years
Mounting Hardware	10	Years	50	Years
Valves	1	Year	40	Years