SOLAR SIX PACK™
INSTALLATION MANUAL

Solar Six Pack™
Inexpensive Quality

Pet Safe Propylene Glycol
Anti-freeze Closed Loop

1. Solar Thermal Collector
2. SPOC Heat Dump Glycol Temp./Pressure Protection
3. PV Power Panel 10-20W
4. 25’ Rubber hose line set from roof to tank
5. Pump and Digital Electronic Control Unit, PV Powered
6. Patented “Solar Wand” Heat Exchanger (Double Wall) Screws into Your Hot Water Tank, Existing or New.

EXISTING WATER HEATER

BUTLER SUN SOLUTIONS, INC.
525 Stevens Avenue West, Solana Beach, CA 92075
## REVISION HISTORY

The latest version of this manual is available for download from our website at:

[www.butlersunsolutions.com](http://www.butlersunsolutions.com)

<table>
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<th>Date</th>
<th>Revision</th>
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| August 31, 2007   | 5        | Modular solar collectors:  
Parallel/Series fluid connections  
Collector mounting rails  
Control system functions, identification & schematics:  
Overflow reservoir level minder option: Temperature gauge installation:  
Evacuated tube mounting requirements:  
Pump blow up repair diagrams:  
Anti-scald valve blow up repair diagram: |
| May 1, 2009       | 6        | Integrated Pump Station; Anti-Scald Heat Trap                                                                                                                                                                                     |
| August 2012       | 7        | Solar Six Pack™ Simplified Installation                                                                                                                                                                                            |
| May 1, 2013       | 8        | SRCC Review Changes, Update Figures for Flushing, Filling and Mixing Valve installation                                                                                                                                             |
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ACRONYMS

ABS  Acrylonitrile Butadiene Styrene – a tough, light, and water-resistant plastic, black in color, used for drain line pipes.  (NOTE: ABS/PVC co-extruded pipe is sold in most parts of USA except on the East coast, where they use PVC drain pipe)
BSSI  Butler Sun Solutions, Inc.
PVC  Poly Vinyl Chloride – a plastic used to make drain and sprinkler pipes, white in color
ASTM  American Society for Testing Materials
AWG  American Wire Gauge, a size scale for electrical wires
AWWA  American Water Works Association
DIP  Down Inlet Pipe on water heater
GFCI  Ground Fault Circuit Interrupter – a device that detects and opens a circuit if electrical current is detected in the ground leg, indicating a ground fault or short-circuit
GPM  Gallons per Minute
GPS  Global Positioning System receiver, which can act as both compass and latitude measuring device.
Insolation  Power coming from the sun per unit of surface area, approximately 1,000 Watts/m$^2$ at solar noon.  May also be annual daily average which for San Diego is 6.5 kWh/m$^2$/day.
LCA  Linear Current Amplifier – electronic controller that improves performance of PV-powered pumps
NPT  United States National Pipe Thread Standard
pH  Log Scale of H+ ion activity; 1 to 6 is Acidic, 7 is neutral, 8 to 14 is Basic
psi  Pounds per Square Inch – a measure of pressure
psig  Pounds per Square Inch Gauge -- pressure measured above atmospheric pressure
PV  Photovoltaic panel – a flat panel containing solar cells that convert sunlight directly to electric power
SPOC™  Self Pressurizing Over-Temperature Capsule – a patented component of the BSSI solar hot water system that provides overtemperature protection, as well as pressure regulation, air bubble removal, and fluid inventory management for the solar loop.
SOF  Solar Orientation Factor – a measure of relative solar system performance as a function of Tilt angle and East-West orientation
SRCC  Solar Rating and Certification Corporation
Stagnation  The condition where solar energy is being absorbed by the solar collectors and there is no fluid flow to remove the heat.
Introduction

Solar Rating and Certification Corporation (SRCC) Information

The solar energy system described by this manual, when properly installed and maintained, meets the minimum standards established by the SRCC. This certification does not imply endorsement or warranty of this product by SRCC.

Butler Sun Solutions, Inc. (BSSI) solar hot water systems are SRCC OG-300 certified systems. SRCC certification indicates the systems meet set standards for quality and operational effectiveness. SRCC certification is often required for rebate programs, including the Federal 30% tax credit. The following table (Table 1) lists systems that have been certified by the SRCC as of the time that this manual was prepared. In the System Model Number “PV1” indicates a Photovoltaic-powered pump is used to circulate the Propylene Glycol antifreeze fluid in the solar collector loop. “S1” indicates a 115 VAC Delta-T controller is used to power the pump.

Systems have been certified with a variety of popular flat plate and evacuated tube solar collectors, and as both single tank and dual tank systems in a range of sizes. For a list of the currently certified BSSI systems and for actual system performance ratings in your region, go to www.solar-rating.org the SRCC web site.

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<td>BSS-S1-50GA</td>
</tr>
<tr>
<td>0.7</td>
<td>2003016B</td>
<td>BSS-S1-40GB</td>
</tr>
<tr>
<td>0.8</td>
<td>2003016A</td>
<td>BSS-S1-40GA</td>
</tr>
<tr>
<td>1.8</td>
<td>2003001L</td>
<td>BSS-S1-80ED</td>
</tr>
<tr>
<td>1.6</td>
<td>2003001K</td>
<td>BSS-S1-50ED</td>
</tr>
<tr>
<td>1.4</td>
<td>2003001J</td>
<td>BSS-S1-40ED</td>
</tr>
<tr>
<td>1.5</td>
<td>2003001I</td>
<td>BSS-S1-40EC</td>
</tr>
<tr>
<td>1.5</td>
<td>2003001H</td>
<td>BSS-S1-50EC</td>
</tr>
<tr>
<td>1.5</td>
<td>2003001G</td>
<td>BSS-S1-80EC</td>
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<td>2003001E</td>
<td>BSS-S1-80EA</td>
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<td>1.6</td>
<td>2003001C</td>
<td>BSS-S1-50EA</td>
</tr>
<tr>
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<td>2003001B</td>
<td>BSS-S1-40EB</td>
</tr>
<tr>
<td>1.4</td>
<td>2003001A</td>
<td>BSS-S1-40EA</td>
</tr>
</tbody>
</table>

### Tools and Skills Needed

Following are suggested lists of skills, tools and equipment you may need to successfully complete the installation of your solar hot water system. Some installations will be easy and all of the suggested tools may not be required. We have tried to be as comprehensive as possible with the tool list; however, we do not guarantee that you will not need other tools or supplies, based on your specific installation situation. Roof installations can be dangerous since there are hazards such as ladders and slippery, sloped surfaces. If after reading this manual there is any doubt in your mind about self-installation, hire a professional. Be sure that your licensed professional has the appropriate liability and Workers’ Compensation Insurance for your state. We will list qualified professionals on our website as they become known to us. If we don’t list someone in your area, go to the Solar Energy Industries Association website (www.seia.org) and look for a SEIA member company in your area. SEIA members subscribe to a strict code of ethics based on customer satisfaction. The American Solar Energy Society has a new website, www.findsolar.com, which lists qualified solar hot water installers by postal zip code. Murphy’s Law may come into play, but Do-It-Yourselfers are very resourceful and will be able to complete a professional installation and be happy with their new solar hot water system. A growing gallery of solar systems installed all over the USA is included on our website, www.butlersunsolutions.com.

#### Skills needed by Installer or Do-It-Yourself Handyman

- Basic carpentry, to route umbilical and cover cladding
- Basic roofing skills to secure the collector to the roof without creating water leaks.
• Basic plumbing using wrenches and pipe connections
• Basic soft solder pipe sweating, if solar collector array is connected by sweat solder connections.
• Basic electrical to check outlet prior to plugging controller into outlet or connecting 12VDC for the PV powered system.

Safety Equipment

• Rubber soled, lace-up shoes with good traction (no flip-flops or sandals on roofs)
• Leather gloves to protect your hands
• Safety glasses or a face shield to protect your eyes and face
• Electrical outlet polarity and fault detector
• Stud, wire and pipe finder
• Collector cover such as a tarpaulin, heavy blanket or craft paper
• Fire Extinguisher
• 100-foot, grounded, GFCI extension cord, or cordless tools for drilling, cutting and soldering
• Extension ladder
• 100 feet of ⅜-inch rope for pitched roofs.

Supplies You May Need To Provide

• Some municipalities require a solar site shadowing survey, which requires a Solar Pathfinder or equivalent. Many regional rebate administering offices that require this will lend you a Solar Pathfinder.
• One gallon of propylene glycol antifreeze (e.g., Peak Sierra®, carried by NAPA Auto Parts stores). Antifreeze is normally not shipped with BSSI systems, so you must obtain it locally.
• New flexible hot water tank inlet and or outlet lines of appropriate length
• Teflon® pipe tape for threaded fittings
• Plastic or metal down spouts, including elbows and angles, to hide the umbilical in outside wall installations
• Black electrical tape
• Assorted nails and screws
• Roof patching mesh
• Standard roof jack flashing for 2” roof penetration
• Collector supporting and elevating hardware if needed
• ¼-20 hollow wall anchors to hold collector down on roof (Stainless Steel or corrosion resistant fasteners)
• Flange and pipe mounting hardware
• Caulking
  o Henry’s Roofing Tar in caulking tubes for roof penetration and fastener seals
  o GE Clear Silicone II or equivalent for caulking split pipe and fittings.
Generic Tools

- Compass or GPS receiver to act as a compass and to obtain the site latitude
- Level or level/inclinometer combination to measure the collector tilt angle.
- Thin stick or measuring tape
- Milwaukee M-Spector™ or equivalent video probe system to inspect the sacrificial anode and look into walls for wires and pipes.
- Pipe wrenches, 12”, 14”, 16”.
- A 15/16-inch drill bit if your hot water fitting has an obstruction below it.
- 3/4-inch NPT pipe tap
- Adjustable wrenches, 8” and 14”.
- Wood hole saw, 2” diameter and 2.5” diameter
- Rubber hose cutters
- Indelible magic marker
- Wood and metal files
- Skil® Saw
- Sawzall® Saber Saw
- Electric drill ½-inch chuck capacity
- Twist drill bits up to ½-inch.
- Masonry/Tile drill bits
  - 1 inch hammer drill quality masonry bit or a 1 ⅛-inch

Special Tools

The following special tools have been found to make the installation job go faster and easier. Some are supplied with our system kits (e.g., the fill/flush tubes), and others are useful for professionals doing many installations. Figure 2 shows some of these tools.

1. Battery Operated Filling Pump System with battery output to run pump to check system circulation, and ¼-inch OD plastic fill tube to go from flush valve to filling pump.
2. Hose to connect to a clean source of water for flushing out the system (NOTE: NOT THE HOT WATER TANK DRAIN); female hose fitting on one end, ¼ inch compression on the other (provided with system kits)

3. ¼-inch OD plastic drain tube about six feet long to go from fill/drain valve to bucket (provided with system kits)

4. Combination screwdriver for tightening hose clamps

5. Digital volt meter, preferably with a thermocouple to measure temperature.


7. Pinch-off valves for rubber hose (used to seal hose ends for maintenance activities)

8. Rubber hose cutters or scissors.

Figure 1  Special Tools to Speed Wand and Rubber Hose Installation

**Do’s and Don’ts (What Your Mother Never Told You About Solar Hot Water Installation!!)**

1. **Don’t** open the SPOC™ and play with the radiator cap; it is inspected and installed at the factory. To check the fluid level or fill the reservoir, open the cap with the float switch. Or, pump fluid into the system from the pump station using a manual or powered pump.

2. **Don’t** connect flushing hose to the hot water tank drain valve. This can put debris, which will plug the Wand, into the closed solar loop. Use only a clean water source.

3. **Do** remember, if you did not wire out the top element push button reset on an electric tank, to tell the customer that the high limit switch may trip during sunny weather especially if they are away from home for several days. The limit must be manually reset or they may have no hot water after a string of cloudy days.
4. **Do** remember to set the tank top safety snap switch, thermostat to 185°F or higher. Lower temperature push button resets must be replaced with higher temperature ones or wired out based on local codes, with homeowner’s consent.

5. **Do** leave the upper thermostat setting alone; the customer will complain if you have several cloudy days and his hot water is not hot enough.

6. **Do** remember to set the gas hot water tank temperature at 120°F, just above warm.

7. **Do** check system operation by reading the temperature gauge at mid-day (e.g., between 10 AM and 2 PM) when the sun is out. The power and pump LED’s should be on and the temperature should be above 120°F.

8. **Don’t** forget to tell the customer that their new anti-scald valve may lower the temperature of hot water at the faucets.

9. **Don’t** panic when you turn on the gas burner in a newly filled old tank or a new tank full of cold water and you hear dripping on the burner assembly that sizzles and makes you think the tank is leaking. It is just condensation of water out of the gas combustion products and will stop when the tank gets hot.

10. **Don’t** allow the customer to turn up the tank temperature setting. This may cause the tank to overheat and shut down the solar system. The anti-scald mixing valve should keep the tap temperature constant no matter how hot the tank gets.

11. **Do** tell the customers that, if they want hotter water, they should set the mixing valve temperature higher.

12. **Do** tell the customer that because the SPOC™ Overflow is full, some fluid may spill on the roof during the first few weeks of operation.

13. **Do** tell the customer that, if the pump shuts off under full sunlight, he may hear a bumping noise on the roof. This is normal. If the customer hears this bumping noise his water tank back-up temperature may be set too high.

14. **Do** remember to tell your gas hot water heater customers that tank overheating can melt the fusible link in their gas burner regulating valve. If this happens the valve will need to be replaced or the fusible link function restored with a similar fusible link or limit switch. It has only happened to us on one out of 600 systems, but be warned.

### Hazards of All Types
As a do-it-yourselfer, you must be comfortable assuming and mitigating the risks identified below. If you don’t feel qualified to assume these risks, we recommend that you hire a licensed contractor who is experienced with roof mounted solar installations.

#### Drinking Water Contamination Hazard
The system is designed to prevent cross-contamination of the heat exchanger fluid with potable water. The Solar Wand™ is a double-walled heat exchanger.

**CAUTION:** If water or heat exchanger fluid begins leaking from the top of the heat exchanger Wand, it means corrosion has breached a heat exchanger.
Hot Water Scalding Hazard

Hot water can scald you. Hot water can also be under pressure and squirt out. Wear leather gloves to protect your hands and safety glasses or a face shield to protect your face when opening the Hot Water Tank Drain Valve and removing tank inlet or outlet fittings, and be careful when opening solar system fill or drain valves or working on any solar tubing connections that are hot.

CAUTION: BEFORE LOOSENING ANY PIPE CONNECTIONS NEAR THE HOT WATER TANK ALWAYS TURN OFF THE POWER AND/OR GAS TO THE HOT WATER TANK TO ALLOW THE WATER TO COOL DOWN AND TO RELIEVE THE TANK’S INTERNAL PRESSURE. ADDITIONALLY BE SURE TO ALWAYS ATTACH A HOSE TO THE DRAIN VALVE BEFORE OPENING IT.

Ladder Hazard

Working on ladders is dangerous. Be sure that the ladder is properly placed and seated on the ground. Do not lean back while moving collectors from the ground to roof. Do not over-reach when running the fluid lines and umbilical. It is safest to have someone hold the ladder.

Falling Hazard

Working on roofs is extremely dangerous, and sure footing is required. Be sure to wear rubber-soled shoes that cover your entire foot and are laced snugly. (Do not wear sandals or flip flops on roofs.) Falling to the ground can be deadly. Be sure to stay a safe distance from the roof edge. Do not use collectors as a support, even if they are attached to the roof—solar collectors are not designed to be handrails. Plan the installation to place the collector on the roof safely away from the roof edges. Safety ropes and harnesses are required for steep roofs and can add safety on low pitch roofs. A solar installer fell off a roof in 2009 and died. This is the most deadly hazard; harnesses and ropes save lives.

Electrical Shock and Fire Hazards

Do not drill into the roof or walls until you have looked or verified using a stud, wire & pipe finder that no pipes or electric lines are in your drill path. If you have any doubts about what is inside the wall or roof, drill a small pilot hole and look or probe to be sure that it is safe to drill. Drilling into electric lines, water pipes or gas pipes can be both dangerous and costly to repair.

The Solar Six Pack™ solar hot water system is designed so building materials adjacent to solar components are not exposed to elevated temperatures. The maximum temperatures inside the solar collector on stagnation are 400°F, whereas the outside of the solar collector is only about 20°F above ambient. The same is true for the fluid lines in the umbilical. No high temperatures are generated by the solar system that would affect performance of standard building materials.
Electrocution Hazards

Beware of electric shock hazards. Do not stand in water and touch electrical components. Test the 3-pronged polarized, electrical outlet you intend to use for the controller. Using an electrical outlet polarity and fault detector, check to be sure that the hot, neutral and ground are properly wired. A ground fault circuit interrupter (GFCI) outlet is recommended to reduce the possibility of electrical shock. Plug-in ground fault interrupters do not require an electrician and provide the same electrical shock protection.
STEP 1. Planning The Installation

Figure 1.1 Good Installation Planning Results in A Clean, Professional Installation

1.1 Installation Overview

The following sections outline a recommended procedure for system installation – those skilled in solar installation may have better or faster ways of achieving the same professional installation. But the described procedures have been found to be an effective way of installing the solar system without being exposed to excessive risks. Safety tips are included, but if there is any question of risk, hire a certified contractor with roof expertise. Always use caution when working around ladders, on roofs and near hot pressurized water. A professional installation will serve you well for years to come.

Figure 1.2 provides an overview of the system and its major components for reference purposes. The system has been engineered for easy installation. The patented Solar Wand™ is a double-walled heat exchanger that is the heart of the system. Figure 1.3 provides a cut away view of the Wand. The Solar Wand™ screws into a standard hot water tank, converting it into an efficient, low-cost solar storage tank. The Wand connects to a pump station which contains system charging valves, back flow prevention valve, electronic controls and temperature and pressure gauges. The solar pump and control system are powered by a photovoltaic panel on the roof.
Both flat plate and evacuated tubes work well with our system. The collectors are generally installed on a rooftop or other exposed location. A flexible umbilical containing rubber hoses and electrical cables connects the collectors to the pump box. After installation, aluminum cladding is used to cover and protect exposed portions of the umbilical.

Figure 1.2 BSSI Solar Six Pack™ Solar Hot Water System
The function and operation of each component identified in Figure 1.2 is described in the sections detailing the installation of each “Can” of the Solar Six Pack. So, for example, the installations instructions for the SPOC™ (Can 2) show how the Self-Pressurizing Unit functions to displace air from the fluid loop and protect the solar collectors from stagnation.

### 1.2 Planning the Installation

This STEP requires you to locate your hot water tank and determine the location where you want the solar collectors to be installed. The collector is supplied with a 25-foot umbilical length to reach from the hot water tank to the solar collector. More umbilical can be purchased if necessary, but generally the collectors should be located as close to the hot water heater as possible. **NOTE: THE TOP OF THE COLLECTOR NEEDS TO BE ABOVE THE ROOF PENETRATION, SO THAT THE TOP OF THE COLLECTOR IS THE HIGHEST POINT IN THE FLUID HEAT TRANSFER LOOP (see Figure 1.1.)**

#### 1.2.1 Determine True South

Ideally, a collector should face True South (plus or minus 20°). There are several methods that can be used to determine True South. A compass points to Magnetic North, so you must use a declination value from a map or declination table to correct a compass reading to get True South. Many GPS systems include a compass feature that may also be used to find True South. If you do not have a compass or GPS, you may note that the shadow of a vertical stick or surface will point to True North at solar noon, and True South is 180° from True North. Internet mapping sites such as Google Maps can be used to estimate the orientation of buildings and their roofs. Finally, note that urban street grids are often laid out on True North-South lines, and can be used for reference.
1.2.2 Choose Collector Tilt Angle

Collectors may be tilted at the latitude angle plus 15° for best winter operation and latitude minus 15° for best summer performance. Tilting at the latitude angle yields the best year round performance. **HINT: SOLAR COLLECTORS ARE OFTEN PLACED PARALLEL TO A SLOPING BUILDING ROOF. THIS IS MORE AESTHETICALLY PLEASING AND MAY RESULT IN ONLY A SMALL (E.G., 10%) PENALTY IN ANNUAL PERFORMANCE.**

The approximate latitude of your site can be found on the Internet (e.g., [www.mapquest.com](http://www.mapquest.com)) or in your local paper. The latitudes of some selected U.S. cities are presented in Table 1.1 for reference. (HINT: Look at other solar collectors in your area, see how they are oriented to South and elevated for latitude) A GPS will also provide the exact latitude of a site. Our website ([www.butlersunsolutions.com](http://www.butlersunsolutions.com)) includes the complete Department of Housing and Urban Development (HUD) Manual for solar system installation. The report includes a solar siting template to show the effects of shadowing from trees or nearby buildings, a magnetic declination map, and other useful information about system siting.

**Table 1.1 Approximate Latitudes of Selected U.S. Cities**

<table>
<thead>
<tr>
<th>City (arranged by decreasing latitude)</th>
<th>Latitude (all North)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchorage, AK</td>
<td>62°</td>
</tr>
<tr>
<td>Juneau, AK</td>
<td>58°</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>47.5°</td>
</tr>
<tr>
<td>Portland, OR; Minneapolis, MN; Bangor ME</td>
<td>45°</td>
</tr>
<tr>
<td>Buffalo, NY</td>
<td>43°</td>
</tr>
<tr>
<td>Chicago, IL; Boston, MA; Detroit, MI</td>
<td>42°</td>
</tr>
<tr>
<td>Denver, CO; Indianapolis, IN; Philadelphia, PA</td>
<td>40°</td>
</tr>
<tr>
<td>Kansas City, MO; St. Louis, MO; Washington, DC; Cincinnati, OH</td>
<td>39°</td>
</tr>
<tr>
<td>Reno, NV</td>
<td>39.5°</td>
</tr>
<tr>
<td>San Francisco, CA; Sacramento, CA</td>
<td>38°</td>
</tr>
<tr>
<td>Nashville, TN</td>
<td>36°</td>
</tr>
<tr>
<td>Albuquerque, NM; Memphis, TN</td>
<td>35°</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>34°</td>
</tr>
<tr>
<td>Phoenix, AZ; Charleston, SC</td>
<td>33°</td>
</tr>
<tr>
<td>San Diego, CA; Savannah, GA</td>
<td>32°</td>
</tr>
<tr>
<td>Houston, TX; New Orleans, LA; Jacksonville, FL</td>
<td>30°</td>
</tr>
<tr>
<td>Tampa, FL</td>
<td>28°</td>
</tr>
<tr>
<td>Brownsville, TX; Miami, FL</td>
<td>26°</td>
</tr>
<tr>
<td>Honolulu, HI</td>
<td>21°</td>
</tr>
<tr>
<td>Hilo, HI</td>
<td>20°</td>
</tr>
</tbody>
</table>

1.3 Collector Location and Orientation

Horizontal (“landscape”) mounting will minimize the height the collector rises above the roof when it is tilted up above the roof slope. Look for a location on the roof which will not be shaded by trees, other parts of the building, or other buildings. The solar collector should not be
shaded between the hours of 8AM to 4PM. For best year-round performance, the tilt should be equal to the latitude angle. Architecturally it may be desirable to place the collector flat on a South-facing roof slope. Placed flat on the roof it will look like a skylight and blend into the roof better. The appearance may be much improved and the performance loss may be minimal.

The Solar Orientation Factor (SOF) is shown in Figure 1.4. This is a factor that shows how the performance of a solar collection system varies with the orientation of the collector. The example shown is San Diego, CA (approximately 30° latitude), and shows that a system can operate with less than a 10% reduction in system performance (i.e., SOF>0.9) over a range of tilts up to about 60 degrees facing South, or with azimuth values ranging up to 60-80 degrees away from True South.

![Figure 1.4 Solar Orientation Factor for San Diego, CA](image)

1.4 Collector Selection

What collector is right for my location? We use some simple rules of thumb, based on the SRCC data plotted in Figure 1.5. The heat exchange area of the Solar Wand™ is only two square feet, less than some other systems with built-in heat exchangers. Because the area is smaller, the solar system must run hotter to transfer the same amount of heat from the solar loop into the hot water tank. The higher loop temperature means that the solar collector will lose more heat to the environment. Hence, if you live above 40° North Latitude in a place that gets really cold in winter, you might want to consider a double-glazed flat plate or an evacuated tube collector. For most of the rest of the United States, single-glazed flat plate collectors work well with our Solar Six Pack™ System. There is a small (about 4%) system performance loss due to the higher loop temperatures, but this is overwhelmed by the installed cost savings.
1.5 Routing the Umbilical

Place the solar collectors so the umbilical can connect from the tank to the solar collectors via a reasonable path. The umbilical can go through the roof into an attic or crawl space over the house or the garage, then to the top of the hot water tank. The umbilical can also be routed off the edge of the roof and down the outside of the house. It can be disguised as a downspout by putting it inside of a downspout painted to match the house or other downspouts on the house.

Structural members penetrated by solar system components must meet Code. Running the umbilical through structural beams is not recommended, but can be done if the penetrations are in the web of the beam and will not compromise the structure.
STEP 2. Installing the Solar Collectors (Can 1)

Mounting of the solar collectors is specific to the type and orientation of the collector relative to the roof. Each manufacturer has their own specifications and mounting approaches, so this manual does not present comprehensive information on collector mounts. Figure 2.1 shows a collector attachment method we have used for concrete tile roofs. A standard ½” or ¾” pipe flange is bolted to the plywood deck, a hole cut in the tile over it, and a galvanized pipe nipple is threaded into the flange after the tile is put back in position. This forms a solid but inexpensive collector mount. Note that the hole should fall on the top of the tile curvature.

![Collector Mounting Diagram]

Figure 2.1  STEP 2 -Collector Mounting

Mounting on asphalt shingle roofs is very simple, requiring only that care be taken to locate the studs and flashing and roofing sealant be used to prevent leaks.

2.1 Collector Orientation Flow Path Do’s &Don’ts

The buoyancy of hot fluid in the solar collectors helps the PV powered pump circulate the antifreeze fluid. The configurations that we know work very well with parallel tube collector designs are shown in Figure 2.2. The importance of the collector orientation is to allow steam to escape easily to the SPOC™ at the top of the collector during stagnation.
Figure 2.2 Collector Orientations for Steam Escape

Serpentine solar collector should only be mounted in the “landscape” orientation as shown in Figure 2.2 illustration 1, since steam will not escape from Portrait Oriented solar collectors (Figure 2.2 illustration 4). The collectors should be installed so the long serpentine tubes are level.

For collectors with headers and parallel riser tubes, the “portrait” orientation is recommended (Figure 2.2 illustration 3) so the flow goes from bottom to top and tends to sweep the steam into the upper header. That header should be tilted about 2 degrees so the steam will go to the highest point, where the SPOC™ is connected. With “landscape” orientations of parallel tube collectors (Figure 2.2 illustration 2), caution must be exercised to allow buoyancy to get the steam to the highest point. Since the liquid flow is horizontal, the collector must be both tilted up to the South (e.g., by 18° or more), and pitched up so the outlet end is at least 4 inches above the inlet end of an 8-foot long collector (6 inches for a 10-foot long collector).

CAUTION: THE COLLECTOR MUST BE TILTED UP A MINIMUM OF 18.5° (4-IN-12 PITCH) TO 26.5° (6-IN-12 PITCH) ANGLE SO THE STEAM CAN MOVE THROUGH THE COLLECTOR FLOW PATH TO THE SELF-PRESSURIZING UNIT WITHOUT BEING TRAPPED.

EVACUATED TUBE COLLECTORS WITH HEATPIPES MUST BE TILTED AT LEAST 18.5° AND PREFERABLY 30° ABOVE HORIZONTAL TO ALLOW GRAVITY TO RETURN THE HEAT PIPE FLUID TO THE BOTTOM OF THE COLLECTOR.

2.2 Serpentine Flow Solar Collectors

The ACR Skyline module is unique to the solar industry. The 20” x 3” x 72” size and light weight (20 pounds) allow the modules to be shipped by UPS and FedEx. The internal plumbing configuration allows the 10-square-foot building blocks to be assembled into arrays, since they can be stacked up or placed end to end. The shape of the row-by-column array can be matched to the area available on the roof. Larger water tanks need more modules, so the size of the solar collector array can be matched to the size of the hot water storage tank. The overview in Figure 2.3 shows how 4 collectors can be used to form a single column or a 2 x 2 array. A photo of four modules arranged in a vertical column is also shown in the figure.
2.3 Parallel Flow Solar Collectors

The inlet and outlet fittings are specifically designed to for parallel flow collectors in either landscape or portrait orientations. The adapters for screw-on collectors are shown on the left half of Figure 2.4, while the solder-on adapters are shown in the right half. Connecting the hoses to these adapters properly is necessary to having the system perform well. The outlet adapters have two separate tubes coming out of them. The one labeled SPOC™ is the steam outlet, and the one that goes 4 to 6 inches down into the header of the collector is the fluid outlet. This outlet adapter separates the steam from the liquid. Make sure you have the hose connections correct.

2.4 Evacuated Tube Collectors

The picture in Figure 2.5 shows a properly mounted evacuated tube system. Note that the SPOC™ self-pressurizing unit is mounted above the manifold, where the heat pipes from the tubes transfer their heat to the antifreeze fluid. The tube heat pipes slide into the manifold and must be coated with a heat transfer grease to assure good thermal contact. Heat pipe evacuated tubes should not be tilted less than 20 degrees above horizontal. Note that the upper rear brackets have been lengthened to achieve a higher tilt angle than the roof, which was 18.5° (4-in-12 pitch) degrees above horizontal.
2.5 Mounting Thermal Collectors

The key to successful roof mounting is to provide a strong and stable attachment for the collectors while not creating leaks in the roof. The collector can be flashed into the roof using standard flashing techniques, or mounted on collector racks made for this purpose. Our website (www.butlersunsolutions.com) includes the Department of Housing and Urban Development (HUD) manual for solar system installation. This report includes roof mounting procedures and illustrations showing how to secure solar collectors to the roof. It also discusses wind loading and how to brace collectors to withstand 100 mile-per-hour sustained wind loads, with peak winds reaching 125 miles per hour. It is important to use corrosion resistant fasteners such as stainless steel if you are in a wet or salt air environment. Various roof mounting methods are shown in Table 2.1.

IMPORTANT: BE SURE TO CONSULT YOUR LOCAL CITY OR COUNTY BUILDING DEPARTMENT TO ENSURE YOU ARE IN COMPLIANCE WITH ALL PERMITS, REQUIREMENTS, AND STATE AND LOCAL CODES AND PRACTICES.
Table 2.1  Roof Mounting Options for Solar Collectors

<table>
<thead>
<tr>
<th>Fastening the Collector to the Roof, Flashing, Rails</th>
<th>COMPOSITION ROOFING OR SHINGLES</th>
<th>CLAY OR CEMENT TILE ROOFING</th>
<th>SHAKE SHINGLES</th>
<th>TAR PAPER, TAR AND ROCK ROOF, USUALLY FLAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flash Collect  into Roof Line (for pitched roofs only)</strong></td>
<td>100 MPH winds cause 25 pounds per square foot loads which can lift the collector off of the roof. Hold-down bolts and fasteners, usually ¼-inch to 5/16-inch diameter bolts, should carry this load, even after they have been severely corroded.</td>
<td>Tar and Metal Flashing (see Figure 3.7 below)</td>
<td>Remove Tile, Flash to Tar Paper, Seal with roofing tar, Re-seal to finish</td>
<td>Not Applicable</td>
</tr>
<tr>
<td><strong>Rack Mounting on Aluminum Rails</strong></td>
<td>Seal rail supports to roof</td>
<td>Drill tiles, remove tiles, mount flanges to roof and seal. Install tile and stand-off, and caulk stand-off to tile (see Figures 3.6 &amp; 3.8).</td>
<td>Seal rail supports to pads placed on shingles (Figure 3.9).</td>
<td>Seal rail hold-down bolts to roof</td>
</tr>
<tr>
<td><strong>Tilting Collector at an angle greater than the roof pitch</strong></td>
<td>Cross-bracing must be used; usually ¼” x 1” aluminum flat stock will suffice. 100 MPH winds cause 25 pounds per square foot load which can lift the collector off of the roof. Hold-down bolts and fasteners, usually ¼-inch to 5/16-inch diameter bolts, should carry this load, even after they have been severely corroded.</td>
<td>Use a commercial roof rail mounting system. Seal all penetrations in the roof needed for mechanical fastening to the roof.</td>
<td>Install a stand-off that is sealed and attached to the roof and which comes above the roof tile and is cement sealed to the tile. Then use a commercial roof rail mounting system.</td>
<td>Use a commercial riser (see Figure 3.10), sealed and attached to the roof, which comes above the shake roof and is cement sealed to the shakes using silicone sealer. Then use a commercial roof rail mounting system.</td>
</tr>
</tbody>
</table>
Figure 2.6 Roof Mounting Using Flange and Pipe Method

Figure 2.7 Roof Mounting Figures from HUD Report
Figure 2.8 Flange/Pipe Anchor Methods

For roofs where the collectors can be closely mounted to the roof, i.e. 6” or less, a simple plate with a threaded stud is used. This arrangement is shown in Figure 2.9.

A tilt rack holding both the thermal and PV panels is shown in Figure 2.10. This arrangement is commonly used on flat roots.

Figure 2.9 Shingle Roof Attachment

Figure 2.10 Rail Mounted Collectors on a Tilted Rack
STEP 3. Self-Pressurizing Over-temperature Capsule (SPOC™) (Can 2)

3.1 Self-Pressurizing Over-temperature Capsule (SPOC™) Description

The SPOC™ system was developed by Butler Sun Solutions, Inc. and is protected under US Patent #7,913,684. The SPOC™ works to protect the glycol antifreeze from overheating upon stagnation of the solar collectors. This is important because normally, antifreeze mixture is basic (pH 8.6) and protects the copper in the solar collector and other system components from corroding. But if antifreeze is heated over 300°F it breaks down to form glycolic acid. All antifreeze has a buffer (usually bicarbonate of soda (Baking Soda)) to keep the solution from going acid if small amounts of glycolic acid are produced.

The SPOC™ (see Figure 3.2 below) uses a radiator cap and an air-cooled radiator (just like in a car cooling system) to limit system pressure to 16 psi, under which conditions it will boil at 247°F. By keeping the antifreeze below 250°F the glycolic acid produced over 10 years is not enough to make the antifreeze go acid. Indeed, we have solar systems with over 20 years of operation without the antifreeze going acid. In operation, the SPOC™ maintains the antifreeze within the temperature/pressure envelope defined by the blue and yellow lines in the figure.

In contrast, so-called “steam-back” solar over-temperature protection systems operate by allowing the antifreeze to boil out of the collector, pushing fluid into an expansion tank. These systems cause the system pressure to go to 40 psi or above. As a result much more glycolic acid is formed. Special antifreezes have been developed like Dowfrost HD, Corn Based Glycols, and
Glycerins that have much higher loadings of buffers to neutralize this glycolic acid and protect the solar collectors from corrosion. These higher loadings of buffers thicken the fluid and increase the viscosity at low temperatures, making them difficult to pump. The temperature pressure line of a steam-back system is shown in Figure 3.2 as a purple line.

![Figure 3.2 Glycol Temperature/Pressure of SPOC™ & Steam Back Closed Systems.](image)

The SPOC™ consists of three parts, shown in Figure 3.3. These parts are a liquid-to-air radiator, a radiator cap, and a fluid overflow reservoir. The liquid-to-air heat exchanger is a pipe with attached fins to allow exterior airflow to remove heat from the pipe efficiently. Like the finned pipes used in hydronic heating in houses, its job is to condense steam and dump heat being generated by the collector when the storage tank is too hot to need it. The radiator cap limits the system pressure and serves three other functions. First, as the antifreeze heat transfer fluid heats up and expands, it pushes any air out of the system through the reservoir; second, it regulates the pressure of the expanding heat transfer fluid to less than 16 psi, limiting the boiling point temperature as discussed above; and third, it draws fluid back in from the overflow reservoir at -2 psi when the system cools off and the antifreeze contracts. The overflow reservoir is just like the coolant system in your car: the overflow tube goes to the bottom, so any air bubbles out and only liquid is drawn back into the closed system. Thus, the radiator cap automatically burps out air from the heat transfer loop and keeps the loop full of fluid and within safe pressure and temperature limits, helping to limit acid formation and corrosion. Finally, the reservoir is fitted with a cap where you can add fluid to the system without opening the radiator cap. The fill cap is fitted with a float switch that triggers a warning light in the pump box if the fluid level becomes low.
A summary of SPOC™ operation is given in Figure 3.4. The diagrams show pressure, temperature and states of the fluid in the system and reservoirs. If the sun is out and circulation of fluid stops, the collector will begin to boil. This can also happen if the storage tank top temperature exceeds the over-temperature set point on a sunny day, causing the fluid circulation pump to shut off until the tank needs more solar heat. Fluid circulation stoppage with the sun out could also be caused by other events such as a pump or controller failure, a wire breakage, or by a plugged pipe in the plumbing.

The system is designed to protect itself from damage if fluid circulation stops. It does this by limiting the temperature and pressure in the collector. When the collector starts to boil, a small amount of fluid is pushed out of the collector past the radiator cap (Figure 3.4) at 16 psig into the coolant recovery reservoir. As the fluid in the collector continues to boil, the steam bubbles must pass through the liquid-to-air heat exchanger to get to the Pressure & Vacuum Radiator Cap. Outside air cools the fluid in the liquid-to-air heat exchanger, so the steam bubbles condense and do not escape from the system or force more fluid out. The liquid-to-air heat exchanger is sized to dissipate most of the heat energy the sun can put into the collector.

The boiling action and steam condensation in the liquid-to-air heat exchanger keeps the collector temperature near 124°C (256°F). This is well below the 260°C (500°F) glycol-water degradation temperature, where strong acids form which can corrode through the copper plumbing. This heat-pipe based collector protection system works the same way a car radiator protects the car’s engine from overheating. When circulation is restored, the system resumes normal operation, and when the system cools down at night, liquid (with no air) is drawn back into the system via the vacuum recovery valve on the radiator cap. Preventing excessive temperature in the antifreeze allows for a preventive maintenance schedule with a recommended five-year
replacement interval. With regular pH checking every five years, systems have run over 20 years without an antifreeze change.

For the system owner and installer the SPOC™ replaces five separate components that need to be plumbed into the solar antifreeze loop in other systems, as shown in Figure 3.5. It works better than the five separate parts it replaces, with fewer components to leak or fail.

Figure 3.5 SPOC™ Replaces Five Parts in Other Solar Hot Water Systems

3.2 Installing the SPOC™

3.2.1 Physical Installation of the SPOC™

Take a level reading on the top of the collect to see which end is higher. It is best if the high end is at least 1” above the low end. The collector fluid outlet and the SPOC™ need to be on the high end. If the angle is not correct, adjust the rack slightly. If the SPOC™ is connected to the low end, too much fluid will be belched out of the solar collector upon stagnation. Proper leveling is critical for proper SPOC operation during stagnation conditions. See Figure 3.1.

The general roof layout is shown in Figure 3.6. The SPOC™ must be mounted so the steam can rise out of the solar collector and into the connection on the SPOC™. This is important, because steam will not go downhill.
The Self-Pressurizing Unit assembly shown in Figure 3.7 is mounted using two large hose clamps around the reservoir. The clamps pass through brackets that are attached to the edge of the solar collector with screws, allowing the SPOC to be leveled.

In the installation process, first loosely attach the hardware, so the middle and far end sliding supports can be moved to level the SPOCTM, and so the far end is about 1 inch above the radiator end. The unit should be nearly parallel with the top of the solar collector. Then, tighten all bolts and screws.

3.2.2 Pressure Testing the System

Just before connecting the fluid line to the SPOCTM is a good time to perform a pressure test on the collector, umbilical, and pump/wand system. Professional installers with a pressure test pump will connect to the collector outlet “T” top port, where the SPOCTM will be connected, and pressurize the system to about 30 psi to verify that there are no leaks. The hand pump is shown in

![Figure 3.6 Positions of Components on Roof](image)

![Figure 3.7 SPOCTM Mounting Brackets and Clamps](image)
**Figure 3.8.** The air being pumped in is cold, so on a sunny day the pressure will rise after the pumping has stopped. If the system holds air pressure for five minutes, then remove the pump and connect the hose to the SPOC™.

![](hand_pressure_pump.png)

**Figure 3.8 Pressurizing Pump for System Leak Checking**

### 3.2.3 Connecting the SPOC™ to the Solar Collector

Attach a short piece of rubber tubing between the radiator assembly and the upper T-connector of the collector (see **Figure 3.9**). A rubber tubing cutter or pair of scissors is useful to cut the tubing to length. For hose longevity, cover the rubber hose to protect it from UV solar radiation. Use the small radiator hose clamps provided to secure the tubing.

![](proper_spoct_solar.png)

**Figure 3.9 Mounting S.P.O.C. unit on Solar Collector**

### 3.2.4 Electrical Connections

The wires from the float level switch need to be connected to the umbilical wires. If you are installing a BSSI system, plug in the attached connector to the PV panel connector. Other installers should take advantage of the float level switch indicator. The switch is closed when the reservoir is full, and opens when the reservoir level drops. If making manual connections, solder and weather-protect the connections to prevent false readings.
3.2.5 Charging the Solar Hot Water System

Unlike a system with an expansion tank which is pressurized to 25 to 35 psi, the SPOC™ limits pressure in the BSSI Solar Six Pack™ to 16 psi above the line pressure automatically. THEREFORE, YOU DO NOT PRESSURIZE THE SYSTEM WHEN YOU FILL IT. Complete system flushing and filling instructions are provided in STEP 11.

Also, the BSSI system is designed so you can fill the SPOC™ reservoir from the pump box location, without going onto the roof. Once you have flushed the system, bled all the air out of the loop, and filled it with glycol, all you need to do is close the drain valve while continuing to pump/charge. This will force fluid past the radiator cap and into the reservoir, filling it to about ¾ full. Then the SPOC™ will be ready to bleed air out and recover fluid into the system when needed.

Using a large, high-pressure pump to fill the system may lift the 16 psi pressure cap and blow fluid into the reservoir. To prevent this, reduce the pressure/flow while charging the system. We typically use an 80 psi, low-flow (0.5-gpm) pump for charging.
STEP 4.  Umbilical Installation (Can 4)

Figure 4.1  STEP 4  Overview of Umbilical Under & Over Roof

4.1 Umbilical Description

The umbilical is the electrical and fluid connection between the solar collectors, SPOC™, and PV panel on the roof, and the controller/pump box in the house near the water tank (see Figure 4.1). A shorter length of umbilical also connects between the controller/pump box and the Solar Wand™ heat exchanger in the hot water tank. The umbilical has been engineered so that it can be routed from the roof to the water tank, even if it is necessary to feed it through tight places. The rubber hoses and electrical wire are flexible and can be bent around a two-inch radius if needed. The umbilical goes easily around a six-inch radius. The hoses, wire and insulation are all enclosed in a flexible plastic covering to make it easy to snake through tight places. As can be noted in the figure, the fluid hoses are color-coded: black for cooler fluid going to the collectors and red for hot fluid coming back from the collectors.

The umbilical includes wiring for the PV power to run the pump and controller, fluid level signal from the SPOC, and has the option for other specialty auxiliary signals that might be needed for insolation, collector temperatures, or outside air temperatures in custom installations.
At each end of the umbilical is a six-pin trailer connector. These connectors are used to connect the umbilical to the SPOC™ and PV Panel on the roof, and to the controller/pump box near the water heater (see Figures 4.2 & 4.3). The connectors at each end are identical, so there is no fear that you will install the umbilical “upside-down”. The standard umbilical is 7.7m (25 feet) long. These standard units can be “daisy-chained” together to form umbilicals up to 30m (100 feet) in length. Figure 4.3 also shows the internal wiring of the PV panel and the float switch, so you can understand their operation.
The umbilical has been engineered so that only radiator hose clamps are needed to make leak-free connections of the hose to the fittings. Referring back to Figure 4.2, you will see that there are a relatively small number of fluid connections, as follows:

- Solar Wand™: 2 Connections
- Controller/Pump Box: 4 Connections
- Solar Collector: 2 Connections
- SPOC™: 2 Connections

Total: 10 Connections

The Solar Rating and Certification Corporation has certified rubber hose for use only in Butler Sun Solutions, Inc. OG-300 certified systems. This has been made possibly by the design of the system, which limits the system pressure to 16 psi and hence temperature to 125°C (+257°F). The rubber hose used in our umbilicals is automotive quality and rated by the Society of Automotive Engineers (SAE) for use with Ethylene Glycol, Propylene glycol, Glycerin and Alcohol water based antifreeze solutions. The SAE ratings are as follows:

- SAE J20R3 D2: Rated -40°C to +125°C (-40°F to +257°F) 5/16” to 1/2” ID
- SAE J20R3 D3: Rated -40°C to +149°C (-40°F to +300°F) 5/16” to 1/2” ID
- SAE J20R3: Rated burst pressure is 250 psi

Figure 4.3 System Wiring Diagram
It should be noted that in automotive applications, the outside hose temperature can reach +500°F (i.e., the under-hood temperature of a car on a hot day). In our application, the hoses are heated from the inside by fluid that is never hotter than 247°F. Therefore, as long as the rubber hoses are protected from sunlight, they will last much longer than 30 years.

The hose can be cut to length using a pair of scissors, making it easy to adjust length. Hoses can be spliced using two radiator hose clamps and a two-inch long piece of 3/8” copper tubing (see Figure 4.4). A nut-driver type screwdriver helps in tightening the hose clamps sufficiently to ensure that the fittings do not leak. As shown in the figure, the hose clamps should be tightened until the rubber begins to bulge through the slits in the hose clamps.

![NOTE: TIGHTEN UNTIL YOU SEE THE HOSE COMING OUT THROUGH THE HOSE CLAMP SLITS.](image)

**Figure 4.4 Radiator Hose Clamp Connections (Leak Resistant)**

### 4.2 Installing Umbilical

#### 4.2.1 Physical Installation of Umbilical

Try to find the shortest route to snake the umbilical between the water tank and the collector location. If no interior access is available, then using rain gutter down spout on the outside of the house may be the preferred route. Attic space, crawl space or garage rafters all represent good places to run the umbilical inside of the building. The installer must determine whether to begin on the roof or at the water tank. Holes in dry wall and roof decking must be made carefully and sealed to be sure rodents don’t use them as entrance points. Each installation will be different, but the umbilical’s flexibility makes it easy to install.

The general roof layout of a system was shown in Figure 3.6. The SPOC™ must be mounted so the steam can rise out of the solar collector and into the connection on the SPOC™. This is important, because steam will not go downhill against water.

The roof penetration must be placed so the umbilical comes onto the roof below the bottom of the solar collector. This is necessary so the SPOC™ (Self-Pressurizing Unit) will be located at the highest point in the fluid loop. This will ensure that any trapped air will be pushed out of the
fluid loop and replaced with water/antifreeze mixture from the overflow recovery tank during operation.

The roof penetration must not impair the enclosure function, must not allow vermin intrusion, and must meet applicable codes and national Roofing Contractors Association practices. Penetration though fire-rated assemblies must be designed to not reduce their fire resistance below Code. The roof penetration and roof jack must be properly flashed and water sealed to the roofing material. At the location where the umbilical goes from outside to inside of the house make certain that the opening is sealed properly, to be sure water, insects, and rodents cannot enter (see Figure 4.5).

![Figure 4.5 Roof Jack Penetration UV Aluminum or ABS-Split Pipe](image)

In routing the umbilical, sharp kinks and bends should be avoided where possible. Sweeping bends (two-inch radius or larger) can be made with the rubber hose, being careful not to kink it. For sharper bends (i.e., down to one-inch radius), use a tubing bender to make a neat bend in 3/8” copper tube and connect the hose on each end of the bend. Be careful not to kink the umbilical by routing it unsupported over sharp edges such as rafter timbers, keeping in mind that the rubber hose will become softer as it heats up in operation.

Pre-made umbilicals from BSSI come color-coded, with one red tube and one black tube, so you can distinguish the two tubes. If you are making your own umbilical or extending a pre-made umbilical, mark the tubes so you can tell them apart. The red tube should be used for the return (hot) line from the top of the solar collector. The black tube is the (cold) collector inlet line, and goes to the bottom of the solar collector.

The SPOC™ attaches to the upper T-connector of the collector (see Figures 3.9 & 4.2) with a short length of tubing cut to length using rubber tubing cutter or scissors. For longevity, the hose should be covered to protect it from UV solar radiation. Use radiator hose clamps to secure each end of the tubing.
STEP 5. PV Panel Installation (Can 3)

5.1 Electrical Connections

The standard BSSI Solar Six Pack™ system uses a photovoltaic-powered pump. These have been found to be reliable, simple, and less expensive than AC-powered pump systems. The PV panel is usually mounted on the roof alongside or on the solar thermal collector.

When a PV-power pump is used, it requires a PV panel of the appropriate Wattage, as follows:

- 10-20 Watts El-SID 10
- 30 Watts El-SID 20 “Black Magic”
- 20 Watts Laing D-4 & D-5
- 20 Watts Thermo Dynamics Solar Pump™ P24070EM & P50140EM

5.1.1 Connectors on the Roof

PV panel assemblies from BSSI come pre-wired with a six-pin weatherproof connector which mates to the umbilical and to a two-pin polarized connector that connects to the fluid float switch in the SPOC™. Installation consists of simply plugging the connectors together, and securing any extra cable so that it will not be abraded or damaged by snow, etc.

5.1.2 Connector on Controller/Pump Box

The pump box comes with a six pin male hooded connector which mates to the umbilical. **This plug should not be connected until the system is filled with fluid. Connecting this plug before the system is filled can cause the pump to run without lubrication and could damage or destroy it.**
5.2 Mounting of Photovoltaic Panel

The PV panel should be mounted in approximately the same plane as the solar thermal collector, so it will receive the same solar input that the thermal system receives. The PV panel should be mounted so it is not shaded or shadowed any time during the day by any part of the thermal solar collector, trees or vent stacks raised above roof line. Such shading could cause interruptions in the collector flow, leading to improper operation. The PV panel can be mounted to the side of the thermal solar collectors or be mounted separately. Separate PV collector mounting requires additional roof penetrations similar to those used for the thermal solar collectors. This must be done properly to be sure that no leaks are caused in the roof. One approach is to extend the mounting rails of the solar thermal collector on one side and to attach the PV panels to those rails. Figure 5.2 shows a PV panel that has mounting flanges built-in, so the panel can simply be attached to the side and front face of a flat-plate collector with self-tapping screws. This makes for a clean and simple installation, as shown in the accompanying photo. Due to their ease of use, BSSI is making efforts to purchase only PV panels of this configuration for use with our kits.

![Figure 5.2 PV Panel for Mounting on Thermal Collector](image-url)
STEP 6.  UV Protection of Umbilical on Roof

After a system is leak-checked, any sections of the umbilical that are exposed to sunlight and weather need to be protected. This is done using aluminum cladding (Figure 6.1), 2” ABS/PVC Pipe (e.g., Figure 2.5), or standard sheet metal downspout material (e.g., Figure 5.2). We prefer the aluminum cladding because it is easily placed over the umbilical after leak testing and because of its long life and good looks, but some homeowners prefer to use downspout material if the umbilical is running from the roof to the basement outside. That way it just looks like another downspout. It can even be painted to match the roof or wall.

Straight lengths of 2” plastic drain pipe can be slipped over the umbilical during installation. Angle fittings may be cut in half so they can be placed around the corners and cemented back in place. Once the fittings are in place, they can be glued back together or secured using stainless steel screw-hose clamps to clamp the pieces together while the glue sets. The aluminum cladding comes as straight sections that are wrapped around the umbilical, and corner pieces that are split to clam shell around corners. Sheet metal screws are used to secure the material in place. Downspout material can be slit along one side lengthwise with tin snips or electric shears. Corners and angles can also be cut to measure. Then, it is opened up, slid over the umbilical, and secured with sheet metal screws. Either the aluminum or downspout materials can be secured to walls or rafters using screws from the inside through the back side of the pieces, before the umbilical is laid into the inside. Plastic drain pipe can be secured with screws angled in from the ends, or using large hose clamps or pipe mounting clamps.
STEP 7. “Solar Wand™” Installation (Can 6)

Figure 7.1 STEP 7 Installing the Solar Wand™ Heat Exchanger

7.1 Description of Solar Wand™ Heat Exchanger

The heart of the BSSI Solar Six Pack™ system is the Solar Wand™ heat exchanger, which is protected by US Patent # 6,837,303 B2. The Solar Wand™ is a double-wall, protected heat exchanger, as shown in the cutaway view in Figure 1.3. The magic of the wand is that simply screwing it into the top of a standard hot water tank converts that tank into a solar storage tank. Hot fluid from the solar collectors circulates through the inside of the Wand, providing an immersion heater that heats the water in your tank from the inside out like a solar-powered heating element (see Figure 7.1).

In operation, the Solar Wand™ is immersed in the water tank and directly heats the water at the Wand surface. This heated water rises to the top of the tank and is replaced with colder water for the Wand surface to heat. In this way the Wand preserves the natural stratification of the hot water tank, with hotter water on top and cooler water at the bottom. This natural convection inside the hot water tank does not require any pumping. The Solar Wand™ is a double-walled heat exchanger, so it meets all Uniform Solar Energy Code requirements and is certified by the International Association of Plumbing and Mechanical Officials (IAPMO). As of this writing we have over 2,000 Wand-years of experience with Wands in customers’ tanks, as shown in Figure 7.2. There are over 550 Solar Wand™ systems operating successfully today, with our oldest operating systems installed in 1986.
7.2 Installation of the Solar Wand™ Heat Exchanger

7.2.1 Disconnect & Depressurize Tank

The Solar Wand™ is normally installed in the HOT WATER OUTLET of the existing hot water tank. The water tank must be depressurized first. This is accomplished by turning off the water supply to the tank. This valve should be inside the house at the water service entrance, or at the cold-water inlet to the hot water tank. If no cold water shut-off exists in the house, the water must be shut off at the street and a shut-off valve should be added at the cold water inlet line to the hot water tank while the pressure is off. Once the supply valve has been located and turned off, open a water faucet in the house and let it run until there is no pressure. Leave the faucet on.

**CAUTION: HOT WATER MAY CAUSE SCALDING. TO PREVENT INJURY PROCEED WITH EXTREME CAUTION.**

Next, remove the heat source from the tank. Shut the gas valve if you are installing in a gas hot water heater. If you are installing in an electric hot water heater, shut off the electric circuit breaker supplying the water heater.

**CAUTION: TURN OFF THE SOURCE OF FUEL OR POWER BEFORE BEGINNING TO WORK ON THE HOT WATER TANK. DOUBLE-CHECK, IF NECESSARY, TO BE CERTAIN THAT THE FUEL OR POWER HAS BEEN SHUT OFF!!!**

Allow the water in the tank to cool off BEFORE draining the tank using either the drain valve at the bottom of the tank or a siphon or pump to lower the tank level from the top. On older tanks where proper annual draining has not been done, solid materials accumulate around the inside of the drain valve opening. Opening the valve may allow these solids to jam the valve and keep it from closing, requiring replacement. If you must remove the drain valve, be sure to flush the tank and run a long drill or rod through the opening to ensure the passage to the drain valve is open and clear of sediment.
7.2.2 Inspect Sacrificial Anode

If possible, inspect the anode using a lighted mirror or borescope device such as a Milwaukee M-Spector™, and looking into the tank through the hot water tank outlet port as shown in Figure 7.3. If the sacrificial anode is eroded, so the 1/8-inch diameter steel center wire can be seen at any point, replace the anode with a new one. If a new one is not available immediately, you can continue with the Wand installation and install the new anode when it arrives. It usually takes an impact wrench to remove the anode rod. It can be done with long handled wrenches, but impact driver and sockets are the preferred way. CAUTION: WEAR PROTECTIVE GLOVES AND EYE PROTECTION. SOCKET WRENCHES CAN SHATTER UNDER THE HIGH LOADS NEEDED TO REMOVE THE ANODE.

Figure 7.3 Sacrificial Anode Inspection

7.2.3 Prepare Tank for Wand Installation

Remove the hot-water outlet and cold-water inlet connections using pipe wrenches or adjustable wrenches, and check and clean the threads with a ¾-inch NPT pipe tap if needed. In most cases the hot water outlet is a ¾” NPT female thread and when cleaned with a pipe tap, the Wand will fit right through. If it hangs up on the bottom thread, a rat tail file will be needed to take the edge off.

Some hot water tanks have the hot water outlet necked down to hold a down inside pipe (DIP) tube, like the cold water inlet. If the hot water outlet fitting is necked down you will have to drill or file out the opening, as shown in Figure 7.4. Usually this can be done in 30 minutes with a half round file. You may save time during the filing process by using a Dremel® tool and abrasive grinding bit. Although metal filings will not harm the tank, the number of filings that go into the tank can be minimized by using a vacuum cleaner or a small magnet, or by turning the tank so filings fall out of the tank during the process. Any filings that do remain in the tank will eventually dissolve in the water or will settle harmlessly to the bottom of the tank and oxidize to iron oxide.

Figure 7.4 Clearing Blocked Tank Port with 15/16” Drill Bit

Some hot water tanks manufacturers are now placing the sacrificial anode under and attached to the hot water outlet. When you remove the outlet, the anode will come with it. To see if this
might be the case, look on the top of the tank for the hexagonal nut of the sacrificial anode (see Figure 7.5, below). If you find it, then it is OK to remove the hot water nipple and prepare for Wand installation. **If you do not see an anode nut it is safe to assume that your anode is under your hot water outlet nipple.** If this is the case, do not try to remove the nipple; you will damage it and have to buy a new one with anode attached. If your anode is below your hot water outlet, then you must proceed as shown in Figure 7.5. The Wand is placed in the cold water inlet port, and the cold water is plumbed into the drain port using a tee. The hot water outlet is not changed. Note the plumbing for the anti-scald mixing valve, which mixes cold water into the hot water out of the tank to avoid scalding temperatures at the tap.

![Figure 7.5 Plumbing for Sacrificial Anode on the Hot Water Outlet Nipple](image)

7.2.4 Checking the Depth Under the Port

Use a thin stick or measuring tape to measure the depth inside the tank under the hot water outlet port to be sure that the Wand will fit correctly. Long Wands need 46.5” from the bottom of the tank to the top of the threads; short Wands need 36.5” from the bottom of the tank to the top of the threads. Sometimes scale will build up and reduce the tank depth. If this has happened the tank must be flushed out to remove the scale build up. If the tank depth is not enough to allow the Wand to be inserted and screwed in to seal, then a shorter Wand must be used.

7.2.5 Wand Installation

If the water tank is in a confined space, it may be a challenge to insert the Wand into a port on the top of the water heater. Several ways to approach this problem are discussed in the following paragraphs.

There is often a hole in the ceiling for the vent pipe over a gas hot water heater. This hole can sometimes be used to install the Wand by slipping the top of the Wand up the flue until the bottom can be inserted into the port. The Wand has some flex and in many cases this will work.

Alternatively, if you need to make a hole in the ceiling for the umbilical to come through, this can also be used to install the Wand. If you place this hole over the port the Wand is to go in,
this may allow you to slip the top of the Wand up the hole into the attic or crawl space until the bottom will go into the port. If one of these methods does not work, then you must lean the tank.

If the tank needs to be leaned over to insert the Wand, the following procedure must be followed:
- Disconnect the pressure/temperature relief outlet piping if it prevents tipping the tank.
- If the tank has anti-earthquake restraints, disconnect them.
- Disconnect the cold-water inlet to the tank, and move piping out of the way.
- Make sure the electrical power supply or gas is turned off, then disconnect the electrical or gas connections to the tank so the tank can be tilted.
- Drain the water from the tank, so hot water will not spill out when the tank is tilted to a 45 degree angle and so the tank will weigh less.
- Lean the tank over and insert the Wand carefully, being sure it goes in straight and does not touch the electric heating elements or central gas heating tube.
- Screw in the Wand and tighten with a pipe wrench to ensure that the pipe threads seal.
- Return the tank to an upright position and secure the tank with anti-earthquake restraints if needed.
- Reconnect the gas or electric lines and pressure/temperature-relief piping.

Some water tanks have extra thick insulation on the top of the tank, which may interfere with the Wand side port. If you find this to be the case, cut the sheet metal on the top of the tank radially from the hot water outlet a couple of inches with tin snips and use a hammer to bend the pie slices down at the center, crushing the insulation and making room for the side port connection.

When the Wand is in position for final installation, wrap the male ¾-inch pipe threads on the Wand with at least 6 wraps of plumber’s Teflon® tape. Screw the Wand into the port that has been prepared for it. Use a pipe wrench on the long body of the Wand, being careful not to damage the side hot water outlet (if present). With the Wand tight in the hot water outlet, position the solar ports to the angle you wish and tighten the ferrule nut. After you fill the system be sure to go back and look for leaks shown in Figure 7.6.

**Figure 7.6 Wand Top Leak Check**

7.2.6 Mixing Valve Installation

A mixing valve is used in solar systems to avoid scalding temperatures by mixing some cold water into the hot water at the outlet of the hot water tank. The most important consideration in the installation of the mixing valve is to prevent hot water thermostiphon. Thermostiphon occurs when hot water from the top of the hot water tank rises by natural convection to the valve, cools off, and then drops back to the tank. With mineral-laden water, the cooling off process deposits minerals in the valve, and these deposits can make the valve dysfunctional in less than one year. Although the mixing valve is not actually part of the solar water heating system, an installer may be called out to replace it when the customer no longer gets hot water. Proper installation will allow these valves to operate for many years without call backs.
The proper installation of the Solar Wand™ and the mixing valve are shown in Figure 7.7. To avoid thermosiphon, the piping to the valve should be plumbed with and 8” so that hot water will not rise into the valve, cool off and deposit minerals in the valve. Installation of shutoff valves around the mixing valve is also recommended so the valve can be easily serviced if there is a problem.

![Figure 7.7 Proper Mixing Valve Placement](image)

If for some reason that is not possible and the mixing valve needs to be above the hot water tank outlet, then a heat trapping loop must be installed. This is a loop that starts at the hot water outlet, goes about six inches above the mixing valve and then down to it. The hot water from the top of the tank gets trapped in the top of the loop and cannot deposit minerals in the mixing valve.

When mixing valves become fouled with deposits, they stop allowing hot water flow to the house. The cure for the problem is to disassemble the valve and soak the interior parts of the valve in household vinegar for several hours. The vinegar softens and dissolves the deposits, after which the parts can be scraped clean and reinstalled in the valve.

### 7.2.7 Insulation of Piping Around the Hot Water Tank

For OG-300 certification, all interconnecting hot water piping and the final 1.5 meters (five feet) of metallic cold water supply pipe leading to the system, or the length of piping that is accessible if less than 1.5 meter, and all collector loop piping must be insulated with a minimum of R-2.6 (F°-ft²-hr/ft²°F) or greater insulation value. The insulation supplied with the system is 1/2” wall Rubitex™, giving R-3.3. All components exposed to public traffic are maintained below.
140° F or insulated/isolated. All exterior piping insulation must be protected from ultraviolet radiation, excessive temperature and moisture damage. We provide aluminum cladding and elbows for this purpose (see Step 6).
STEP 8. Pump Box Installation (Can 5)

8.1 Description of Pump Box

The pump box is a small insulated box that mounts near the hot water tank (see Figure 8.1) and that contains the solar system circulation pump as well as several sensors and valves. It is connected to the umbilical and to the Solar Wand™ with flexible hoses, and has an electrical connector to the umbilical for power and sensor connections. The inside of the pump box is shown in Figure 8.2. The components in the box include the pump, a pressure gauge showing the pressure in the solar loop, a thermometer showing the temperature of the fluid returning from the collectors, flush and fill/drain valves for charging the system with antifreeze, a temperature sensor for the solar storage tank, and a back flow prevention valve for prevention of thermosiphoning in the collector loop at night.

The pump box includes three LED indicators. The green LED indicates that the PV panel is producing power for the system. The yellow LED indicates that the pump has been enabled (and
should be running). The red LED is a warning indicator that the level in the overflow reservoir of the SPOC™ is low and the fluid level should be checked. Illustrations for interpreting the gauges and indicators are shown in Figure 8.3. The operation of the valves to flush and then fill the system will be explained in STEP 11.

![Pump Box Gauges, Valve, Sensor & Cover](image)

**Figure 8.2 Pump Box and Components**

### 8.2 Pump Box Installation

Find a location for the pump box on a wall near the top of the tank. Mounting near eye level makes reading the gauges and lights convenient. Use the screws provided to secure the pump box to the wall. If you can’t hit a stud, you may have to use dry wall anchor screws (not provided).

### 8.3 Pump Box Connections

Once the pump box is mounted, the top fittings of the pump box get connected to the 3/8” rubber hoses coming down from the umbilical with hose clamps. The hoses are color-coded red and black: black for cooler fluid from the pump to the collectors, and red for hot fluid coming back from the collectors. The umbilical hoses should be supported so they will not kink when they heat up and become softer. Short lengths of the same colored hoses are used to connect the bottom fittings of the pump box to the Solar Wand™, with the red one attaching to the top of the wand and the black one bringing fluid to the pump from the bottom fitting of the Wand. Colored
rings are installed on the tubes of the pump box and on the Solar Wand™ to aid in connecting the hoses to the correct fittings.

A six-pin electrical connector connects the top of the pump box to a mating connector from the umbilical, providing a connection to the PV panel and to sensors on the roof such as the reservoir float switch. Finally, a thermostatic snap switch is provided that is installed on the solar storage tank to measure the tank temperature and prevent system operation if the tank is too hot.

<table>
<thead>
<tr>
<th>PRESSURE RELIEF = 15 PSIG</th>
<th>VACUUM RECOVERY = 2 PSIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE PSI GAUGE</td>
<td>Head         [ 4.3 ]</td>
</tr>
<tr>
<td></td>
<td>Heating Up &amp; Bright Sun [ 20.3 ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent Cloud Cover [ 4.3-20.3 ]</td>
</tr>
<tr>
<td></td>
<td>Cooling Down &amp; Night [ 2.3 ]</td>
</tr>
</tbody>
</table>

Head from gauge to SPOC divided by 2.31 feet/psig; 10 feet of head/2.31 = 4.3 psig

<table>
<thead>
<tr>
<th>INDICATOR LIGHTS</th>
<th>LED</th>
<th>Normal</th>
<th>Tank Overheated</th>
<th>Reservoir Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Panel Power</td>
<td>Green</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>Pump Command</td>
<td>Yellow</td>
<td>ON</td>
<td>OFF</td>
<td>ON/OFF</td>
</tr>
<tr>
<td>Add Antifreeze</td>
<td>Red</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEMPERATURE GAUGE</th>
<th>Sunny Day Normal</th>
<th>Sunny Day No Circulation</th>
<th>Sunny Day Restricted Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid From Solar Collector</td>
<td>60-105 °C</td>
<td>Below 60°C</td>
<td>Above 110°C</td>
</tr>
</tbody>
</table>

**Figure 8.3 Instrument Readings and Meaning**

### 8.4 Pump Servicing

Hot water tank replacement and pump repair are the two most common system maintenance items. The pump can be isolated by using rubber hose clamps to pinch off the hoses above and below the pump as shown in **Figure 8.4**. The pump can then be removed and repaired or replaced without draining the entire system and without losing too much fluid.

**Figure 8.4 Pinch off Clamps**
An exploded diagram of an El-SID pump is shown in Figure 8.5. The electrical driver can be removed and replaced without losing any fluid. Sometimes, debris (e.g., insect parts) gets stuck in the rotor and the pump must be taken apart and cleaned. This can be avoided if the system is flushed properly. Pipe dope is not supposed to be used in the system, but if by chance some sneaks in it will get on the rotor shaft and stop the pump, so it must be removed and cleaned with mineral spirits. The system will then refill itself from the overflow reservoir, which should be topped off with antifreeze mixture.

**Figure 8.5 Ivan Labs EL-SID™ Pump Repair**

For hot water tank replacement clamps like those shown in Figure 8.4 are used to pinch off the Wand tubes so they can be removed from the Wand without losing fluid. It is a good idea to unplug the pump box before closing the tubes, so the pump will not be trying to pump fluid during this process. The tank can then be removed and the Wand moved from the leaking hot water tank to the new one. After installing the new tank in position, the tubes can be reattached to the Wand, the pump box can be plugged in, and the system will resume normal operation.

### 8.5 Electronic Controls (Delta-T)

The standard PV-powered “Insolation based” control is what is shipped with most systems going to the Southwest, where winter temperatures are higher on average. When there is enough sun to drive the pump, it runs. In early morning or late afternoon the pump may be sending heat from the hot water tank to the solar collector, cooling the tank and heating the outdoors. In sunny Southwest climates this loss is small. In Northern climates it can be a larger loss. This problem
is eliminated by the use of a Delta-T controller which will only turn the pump on when the solar collector is hotter than the water tank.

All the control electronics needed are provided with the pump box and are an integral part of it. If a delta-T control is used, one set of wires to the roof will connect a collector temperature sensor, which will be connected to the six-pin hooded connector on the roof. If one is supplied it should be attached with a radiator hose clamp to the collector outlet copper tube. The tank top sensor is attached to the pump box and should be mounted to the tank as shown in Section 10.3.

For AC-powered systems an AC-to-low-voltage-DC transformer is used to supply the motor power. If a customer insists on an AC-powered system, we will provide the system with AC pumps and Delta-T controls. All AC or DC systems are prewired and factory checked before shipping. NOTE: Although some people persist in the notion that PV power systems are more expensive, Figure 8.6 demonstrates that the PV-powered systems that BSSI provides as our standard configuration are actually less expensive to start with, and have no operating costs compared to an AC system. In fact, over a 30-year system life, the overall cost of an AC-powered system approaches 2.5 times the cost of a PV-powered system! For this reason, we recommend PV-powered systems unless there is an overriding reason not to use them.

![Figure 8.6 AC vs. PV Powered Pump System](image-url)
STEP 9. Pump Box-To-Umbilical Connection (Cans 4 and 5)

Figure 9.1 STEP 9 Umbilical to Pump Box Connection

9.1 Route Umbilical
Route the umbilical carefully to the top of the pump box. It should be supported to keep it from sagging along its length and not be subjected to sharp turns that could kink the rubber hoses, which become softer when they are hot.

9.2 Connect Hoses
Connect the red collector return line to the top of the pump box on the left side, and tighten the hose clamp securely. The red hose is 10 mm inside diameter and the fitting is 9.5 mm outside diameter, so it is important to make sure the hose clamp is tight. There may be short rings of tube already on the pump box tubes to indicate where the red and black hoses should go.

Connect the black collector feed line to the top of the pump box on the right side (where the pump is), and tighten the hose clamp securely.

9.3 Don’t Plug In Power
Do NOT connect the electrical power connector to the top of the box at this time. Connecting this power lead will provide power to the pump, and if the rotor is not lubricated by the antifreeze fluid it can damage the pump. A damaged pump caused by running dry is not covered under warranty.
STEP 10. Pump Box-To-Tank Connections (Cans 5 and 6)

Figure 10.1 STEP 10 Pump Box to Tank Connections

10.1 Connect Hoses

Connect the upper hose connector of the Solar Wand™ to the bottom of the pump box on the left side using a short length of red hose, and tighten the hose clamps on both ends securely.

Connect the lower hose connector of the Solar Wand™ to the bottom of the pump box on the right side (where the pump is) using black hose, and tighten the hose clamps on both ends securely.

10.2 Mount Tank Top Temperature Sensor/Thermostatic Switch

Route the sensor wire from the bottom of the pump box to the hot water tank. The thermostatic switch should be mounted on bare metal close to the top of the tank as shown in Figure 10.2. The Temperature/Pressure relief valve is an easy place to put it, as shown in the photo. Another easily-accessible spot is the top of the anode. The sensor should be covered with insulation so the metal sensing surface does not get cooled by air passing over it. The switch is provided with a metal spring that can be stretched around a pipe to secure it firmly, as shown in the figure. If the spring cannot be used, the sensor can be bonded to the tank or metal element using JB Weld™ or other high-temperature epoxy or adhesive.
Other temperature sensors are thermistors or digital temperature sensors. The temperature sensor is a short piece of copper tubing flattened at one end, with a sensor epoxied into it and a cable coming out of the un-flattened end. This sensor needs to be placed in contact with the tank outer wall, near the top. It must be placed under the tank’s foam or fiber insulation. The recommended place to install the sensor is near the top electric heating element of an electric water heater, or at the pressure/temperature relief valve near where it connects to the tank. Using a screwdriver, peel the plastic shield around the pressure relief valve away from the tank’s outer sheet metal shell. Then, using a screwdriver, push a hole through the rigid insulation at an angle until you contact the tank wall. Move the screwdriver around to make the hole big enough for the sensor. Carefully push the sensor into the hole so it is in contact with the tank wall. Push the tank insulation back in place, and slide the plastic disk back in place (see Figure 10.3).

**Figure 10.2** Thermostatic Snap Switch Mounting Options

**Figure 10.3** Tank Top Temperature Sensor

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**NOTE:** BE SURE TO TAPE OR FILE OFF ANY SHARP SHEET METAL EDGES THAT COULD CUT INTO AND SHORT THE SENSOR WIRES, AND DO NOT USE A POWER DRILL TO DRILL INTO OR PUNCTURE THE TANK WALL
STEP 11. Flushing & Filling the System

![Diagram of flushing and filling system]

**11.1 Flushing the System with Water**

Every newly installed system should be filled and flushed with fresh water before antifreeze is added (see Figure 11.1). Collectors or umbilicals that have been stored in your garage or barn may have spider webs, bee hives, or other insect infiltration. These should be flushed out with water before being connected to the system. Then, a full system flush will remove any remaining debris or dirt in the components and lines and ensures the system is well sealed before operation. The following procedure can be used to fill the system with fresh water using the flushing kit supplied with the system shown in Figure 11.2.

![Flushing Kit for Solar Six Pack]

**CAUTION:** NEVER CONNECT THE FLUSHING HOSE TO THE HOT WATER TANK DRAIN VALVE. DEBRIS FROM THE BOTTOM OF THE TANK CAN BE FLUSHED INTO THE SYSTEM CAUSING THE WAND TO PLUG AND THE SYSTEM TO NOT CIRCULATE.

**CAUTION:** The flushing process uses fresh water. If you attempt to flush the system when the air temperature is below 20°F (-7°C), the water may freeze in the collectors and cause damage. If you must fill a system when the temperature is below 20°F (-7°C), you will need to fill and flush the system with antifreeze instead of water. To do this you will need a pump capable of 2 gallons per minute of flow at 50 psi.
Prior to flushing the system, the Self-Pressurizing Unit reservoir should be empty of fluid and the radiator cap should be in place and tightened (this is done at the factory, so you should never need to mess with the radiator cap). There is no need to open the SPOC™ reservoir cap. The circulation pump must be off by being unplugged or unwired during the process. All fittings around the pump and Wand should be checked for tightness if this is the first filling of the system. The overall process is illustrated in Figure 11.3.

**Figure 11.3 Water Fill/Flush Process**

1. Familiarize yourself with the valves inside the pump box (Figure 11.1). There are two ¼” inch needle valves – the flush valve above the pump, and the fill/drain valve below the pump. These needle valves connect the system to external hoses or pumps for flushing and filling. To OPEN these needle valves, turn the small T-handles counterclockwise several turns. A pair of pliers may help to turn them. In addition to these valves, there is also a backflow prevention valve built into the top of the pump assembly to prevent thermal siphoning at night.

2. A hose-bib-to-¼-inch tube adapter is included in the installation kit. Connect this assembly to a garden hose that is attached to a CLEAN source of water, NOT THE WATER TANK DRAIN VALVE. Attach the ¼-inch flexible hose to the flush valve (see Figure 11.2); the flush valve is the upper of the two valves (see Figure 11.3).

3. Connect the fill/drain valve to a length of ¼-inch plastic tubing and put the other end of the tube into a bucket or antifreeze container.

4. OPEN the flush and fill/drain valves. When pressure is applied, the backflow prevention valve will CLOSE between the two needle valves to prevent short-circuiting of the flow.

5. If you believe that you may have dirt in the system that could get lodged in the Solar Wand™ during the flush/fill operation, take the Wand out of the loop before water flushing.
as shown in Figure 11.3-Step 1, flush the system, then reconnect the Wand and flush again as shown in Figure 11.3-Step 2. If you know your system is just out of the box (i.e., clean), you can flush without removing the Wand from the loop.

6. Next, pressurize the hose to full line pressure. This will cause water to flow rapidly up through the collectors, back down through the Wand and circulation pump, and out the fill/drain valve. Flush the system with several gallons of water, until the water that comes out is clean and free of debris and air bubbles. Make sure that the flush and fill/drain valves (connected to the hose) are wide open. Any leaks will show up now, so look for them.

7. After the system is full of water, leave the flush valve on and close the fill/drain valve for a few seconds. This will cause fluid pressure to open the radiator cap and push a little water into the overflow. The system is now flushed and the overflow has a little water in it.

8. Close the flush valve, then depressurize the hose and remove the garden hose, and then remove the ¼-inch adapter from the flush valve.

9. Verify that the flush and fill/drain valves are closed. The system is now flushed and filled with water.

10. Start the circulation pump by plugging in the 115VAC to 18VDC transformer if one is needed, or by connecting the plug in wires to the PV panel or a 12 VDC power supply. If it is cloudy, you can use a 12VDC power supply instead of the PV panel for this test. The pump lights will show the rotor is spinning and you can feel the pump body for the rotor vibration.

11. Disconnect the circulation pump power for antifreeze filling.

11.2 Antifreeze Preparation

The Solar Six Pack™ system uses antifreeze to protect components from freezing, to provide resistance to boiling in the summer, and to provide lubrication and corrosion protection. Propylene glycol antifreeze is used, which is non-toxic and available at auto supply stores. One brand we recommend for our systems is Peak Sierra™, as shown in Figure 11.4. It can be found at most NAPA Auto Stores. It is phosphate free and is usually sold full strength. Be careful what you buy – some antifreeze is already diluted 50% when you buy it. Also, “antifreeze” solutions sold for freeze protection of RV sewer systems is not suitable because it lacks sufficient buffering and corrosion protection components. If the fluid is already diluted, use it straight out of the bottle. If it is full strength, you will need to dilute it with tap water. Propylene Glycol from oil and corn are both acceptable, as are Glycerin-based antifreezes for cars. **NOTE: Never use Ethylene Glycol-based Antifreeze: It is Toxic, and will void your warranty!**

![Figure 11.4 Peak Sierra™ Antifreeze](image-url)

In order to mix the proper antifreeze heat transfer solution you must decide what level of freeze protection is required based on your local climatic conditions. In warm climates at least a 50/50 mixture of propylene glycol with water must be used for boiling protection. This will allow the system to operate down to -32°C (-26°F). Below that temperature, slush will form which will not
circulate, but which will also not damage the collectors unless the temperature drops below -48°C (-54 F). For a system to operate as low as -48°C (-54 F) a 60/40 propylene glycol/water mixture is required. Other mixture properties can be obtained from the propylene glycol packaging.

For filling the system, mix the propylene glycol antifreeze with water by volume to form an appropriate mixture. Most systems require about one to two gallons of fluid, so a one-gallon bottle of pure antifreeze is sufficient. In a clean container, mix the one gallon of propylene glycol with about 2/3 of a gallon of water. This will give a 60/40 mixture by volume. The slightly higher concentration is used so that any water remaining in the system as the antifreeze is added will not dilute the mixture below the desired 50/50 mix.

### 11.3 Antifreeze Filling Using Gravity

**CAUTION: BEFORE ATTEMPTING TO FILL THE SYSTEM IF THE SUN IS SHINING, COVER THE COLLECTOR WITH SOMETHING OPAQUE SUCH AS A TARPAULIN, HEAVY BLANKET, OR CRAFT PAPER.**

If you have a high pressure pump go to **Section 11.4.** If you do not have a pump, read on. For this procedure, you will need access to the SPOC™ reservoir on the roof. You will also need a container with enough antifreeze mix to fill the system plus some extra (usually one to two gallons). A single person can fill the system via the siphon method described here, but having an assistant to do the pouring makes it easier. The procedure is illustrated in **Figure 11.5.**

1. Be sure the circulation pump is unplugged, the flush and fill/drain valves are closed, and the system is full of water. If it is sunny, cover the collectors to prevent them from boiling while you are filling the system. If you are replacing the antifreeze in a system due to degradation, perform a flush with fresh water and collect and dispose of the old antifreeze properly (see **Section 12.6**).

2. If this is the first time the system is being filled, re-check all the fittings around the pump and Wand for tightness and leaks after flushing.

3. Mix up a gallon of 60% propylene glycol and 40% water mixture by volume. The higher concentration is so that any water not flushed from the system will not dilute the mixture to below 50/50. If your climate requires higher concentration, start with an even higher initial concentration mixture.

4. Connect a drain tube to the fill/drain valve (lower valve). Place the end of the tube into a clean bucket or container.

5. At the SPOC™, remove the overflow reservoir lid and siphon out any water that is in the reservoir from the flushing process.

6. Fill the SPOC™ reservoir with fresh antifreeze solution. Open the fill/drain valve, while having someone continue to pour antifreeze into the SPOC™ reservoir to keep it nearly full. If you are doing this procedure alone, you may need to stop a few times to refill the reservoir as you drain fluid so no air is drawn into the system. The backflow prevention valve in the pump box prevents flow through the collector, so antifreeze will come down the collector return line, through the Wand and into your bucket. When the water has been replaced with antifreeze the color will go from clear to light green; when that happens, close the drain valve. This is illustrated in **Figure 11.5-Step3.**
7. Move the drain tube to the fill valve (upper one). Open the fill valve, while having someone pour antifreeze in the SPOC reservoir. Now the fluid comes down through the solar collector and the inlet line to the fill valve and into your bucket. When the water has been replaced with antifreeze the color will go from clear to light green; when that happens, close the fill valve. This is illustrated in Figure 11.5-Step4.

8. The system should now be filled with fresh antifreeze. You can plug in the power to the pump box, uncover the collectors, and start or resume normal operation. Be sure to check for leaks as the system warms up and pressurizes. Keep the remaining fresh antifreeze mixture for topping off the system in the future.

11.4 Antifreeze Filling With a High Pressure Pump

Filling the system with a high pressure pump is similar to the flushing procedure described in Section 11.1. The manual and electric pump connections are shown in Figure 11.6.
1. Unplug the system circulation pump so it is turned off.

2. At the SPOC™, remove the overflow reservoir lid and siphon out any water that is in the reservoir from the flushing process.

3. Fill the overflow reservoir with antifreeze mixture and replace the overflow cap.

4. At the pump box, connect a ¼-inch plastic pump hose to the flush valve (at the top of the pump) and the other end of the tube to the pump as shown in Figure 11.6.

5. Connect a ¼-inch plastic drain hose to the fill/drain valve (at the bottom of the pump) and put the other end of the tube into a clean pail or other container as shown in Figure 11.6.

6. Open the flush and fill/drain valves.

7. Turn on the electric pump or use your hand pump to fill the system. When green fluid appears in the drain hose, move it from the bucket to the antifreeze bottle and pump a little longer to get any air bubbles out.

8. Close the fill/drain (bottom) valve first, pump about 10 seconds more to push air out through the radiator of the SPOC™, then close the flush valve (top), and you are done filling.

9. Plug in the system circulation pump, uncover the collectors, and the system is ready to run. Keep the remaining fresh antifreeze mixture for topping off the system in the future.

**Figure 11.6 Antifreeze Filling Using a Pump System**

- **Steps**
  1. Hook up garden hose to valve A and open valve A.
  2. Connect drain hose to valve B, then open valve B.
  3. Turn garden hose full on and flush system with city water.
  4. Turn off garden hose and close valves A & B.
  5. If overflow reservoir in SPOC is not empty, siphon it to almost empty.
  6. Connect Glycol Filling pump to valve A.
  7. Open valves A & B.
  8. Pump until fluid in the drain hose turns to green.
  9. Turn off valve B; now antifreeze is going into the overflow reservoir.
  10. Pump about 1/2 gallon into the overflow reservoir, then close valve A, and turn off pump.
WARNING: DO NOT PLUG IN THE PUMP UNLESS THE SYSTEM IS FULL OF FLUID. THE PUMP WILL BE DAMAGED AND NOT COVERED BY WARRANTY. Dry pump operation is easily recognized and will cause you to pay for a new pump.

### 11.5 Removing Trapped Air From a Filled System

If circulation does not occur after filling with antifreeze, air may have been sucked into the system. To flush out the air, mix up more antifreeze solution and repeat the filling process in Figure 11.5 or 11.6 again. As you drain fluid, the bucket will fill with antifreeze mixture and trapped air bubbles will be swept from the system, so watch for them. Save the antifreeze solution – it can be used in the future for topping off the system.

**NOTE:** If circulation is occurring and some air bubbles are still trapped in the system, do not worry. When the solar collector heats up in the morning, several cubic centimeters of air and liquid are expelled from the system. The air bubbles up through the overflow reservoir fluid and escapes. The liquid is trapped in the overflow reservoir. At night, when the system cools off, antifreeze liquid is drawn back into the system. This action eliminates trapped air from the system and keeps the system full of fluid at all times. It is a good idea to check the overflow reservoir a few days after the system is installed and to refill it if it is not full. The fluid you add is equal to the air that was removed from the system. When the system is circulating properly the temperature gauge near the pump will read at least 140°F (60°C) between 10AM and 2PM.

### 11.6 Antifreeze Maintenance

Check the antifreeze pH every two years by placing a drop from the flush valve onto a pool or spa pH indicator strip. The normal pH for new antifreeze is 8.6, which is a little Basic. If the pH is between 7.0 and 8.6, the antifreeze is OK and does not need replacing. Every five years, or if the pH goes below 7.0, the antifreeze in your system should be replaced with fresh antifreeze.

The procedures outlined above for filling the system can be used to flush out the old antifreeze material and replacing it with fresh fluid. Based on the fluid required to initially fill the system, estimate the amount of fluid that will be needed and mix up that amount plus some extra. Because you may not be able to tell the difference in color between old fluid and fresh fluid as it drains, you may want to flush the system with fresh water first, or you may simply estimate when enough fluid has drained from each half of the fluid loop. Be sure to drain or siphon the fluid from the overflow reservoir of the SPOC™ and replace it with fresh fluid, also.

Used antifreeze fluid (especially the first pail or two of fluid that comes out) should be disposed of it properly. Depending on local codes, propylene glycol should be disposed of in a dry well not a sanitary sewer, not a storm sewer. We recommend returning it to an auto parts store or chemical waste disposal site for recycling. If you are filling the system for the first time, there will be no antifreeze in the system so no special precautions are needed. An alternative is to use “kitty litter” or paper towels to absorb the antifreeze, and then put it in the trash.
11.7 Technical Data Sheet for Propylene Glycol heat transfer fluids

The following data for propylene glycol heat transfer fluid has been gleaned from Material Safety Data Sheets and industry technical data on water/propylene glycol mixtures. We recommend a 50/50 mixture of propylene glycol and water by volume. The following paragraphs contain technical data for this heat transfer fluid mixture and information on fluid handling, safety, and first aid.

11.7.1 Service temperature range for 50/50 Glycol/Water by Volume:

- freezing point
- boiling point

11.7.2 Viscosity over the service temperature range:


11.7.3 Flammable Properties:

- Flammability Classification: OSHA/NFPA Class IIIB combustible liquid
- Flash Point / Method: 109°C (228°F) (PMCC) (Aqueous solution)
- Auto-Ignition Temperature: 371°C (700°F) flash point

11.7.4 Specific Heat Capacity of Propylene Glycol Solutions:

<table>
<thead>
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<th>Specific Heat Capacity</th>
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<tbody>
<tr>
<td>Propylene Glycol Solution (% by mass)</td>
</tr>
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</tbody>
</table>
Table 21—Specific Heat (Btu/(lb • °F)) of Aqueous Solutions of DOWFROST Fluid—English Units

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<td>0.898</td>
<td>0.902</td>
<td>0.864</td>
<td>0.820</td>
<td>0.770</td>
<td>0.713</td>
<td>0.652</td>
<td>0.583</td>
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<td>-20</td>
<td>0.799</td>
<td>0.764</td>
<td>0.702</td>
<td>0.646</td>
<td>0.592</td>
<td>0.542</td>
<td>0.492</td>
<td>0.442</td>
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<td>-10</td>
<td>0.804</td>
<td>0.752</td>
<td>0.693</td>
<td>0.630</td>
<td>0.558</td>
<td>0.505</td>
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<td>0</td>
<td>0.815</td>
<td>0.800</td>
<td>0.758</td>
<td>0.700</td>
<td>0.637</td>
<td>0.566</td>
<td>0.505</td>
<td>0.442</td>
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<td>10</td>
<td>0.851</td>
<td>0.814</td>
<td>0.764</td>
<td>0.707</td>
<td>0.645</td>
<td>0.574</td>
<td>0.505</td>
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<tr>
<td>20</td>
<td>0.920</td>
<td>0.864</td>
<td>0.808</td>
<td>0.758</td>
<td>0.700</td>
<td>0.637</td>
<td>0.566</td>
<td>0.505</td>
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<td>30</td>
<td>0.961</td>
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<td>0.772</td>
<td>0.720</td>
<td>0.660</td>
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<td>40</td>
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<td>0.947</td>
<td>0.881</td>
<td>0.840</td>
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<td>0.985</td>
<td>0.955</td>
<td>0.886</td>
<td>0.845</td>
<td>0.799</td>
<td>0.746</td>
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<tr>
<td>80</td>
<td>0.990</td>
<td>0.976</td>
<td>0.930</td>
<td>0.894</td>
<td>0.825</td>
<td>0.762</td>
<td>0.702</td>
<td>0.642</td>
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<tr>
<td>90</td>
<td>0.993</td>
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<td>0.939</td>
<td>0.868</td>
<td>0.802</td>
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<td>100</td>
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<td>0.972</td>
<td>1.000</td>
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<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
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</tr>
</tbody>
</table>

Specific Gravity of Propylene Glycol Solutions:

- Above atmospheric boiling point.

11.7.5 Specific Gravity of Propylene Glycol Solutions:

<table>
<thead>
<tr>
<th>Specific Gravity - SG -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propylene Glycol Solution (% by mass)</td>
</tr>
<tr>
<td>------------------------------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>60</td>
</tr>
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</table>
Specific gravity - SG -

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>1.008</td>
<td>1.017</td>
<td>1.026</td>
<td>1.034</td>
<td>1.041</td>
</tr>
</tbody>
</table>

1) Specific gravity based on propylene glycol solutions with temperature 60°F.

11.7.6 Vapor pressure over service temperature range:

![Vapor Pressure of Aqueous Propylene Glycol Solutions](image)


11.7.7 Instructions for inspection, treatment, and disposal of fluid:

**Fluid Inspection:**

The Fluid should be inspected every two years, it should be light green and have a pH of 8.4 tested using a standard pool pH test strip. If the fluid is dark brown colored and smells burned and the pH is below 7, change it immediately. We have properly filled and operating systems that have over 20 years of operation with the original charge of antifreeze.

**Treatment:**

If the fluid is in need of changing, flush out the entire system with clean water using city water pressure from a hose. Collect the antifreeze in a bucket. Put solution in a dry well for rapid biodegradation. Do not put into a sanitary sewer.

**Disposal of Fluid:**

Dilute with water and mop up, or absorb with an inert dry material (Kitty Litter) and place in an appropriate waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements. Put solution in a dry well for rapid biodegradation. Prevent flow to sewers and public waters as it may
contaminate said water. Restrict water usage to prevent slip/fall hazard. Soak up small spills with inert solids. Dike and recover large land spills. Notify appropriate authorities if product enters any waterway.

Environmental Fate: Propylene glycol is expected to degrade rapidly in the vapor phase by reaction with photochemically produced hydroxyl radicals. It has an estimated half-life of 32 hours in an average ambient atmosphere. Propylene glycol is expected to degrade relatively rapidly via biodegradation in water. It is not expected to be susceptible to hydrolysis, oxidation, volatilization, bioconcentration and adsorption to sediments. Propylene glycol is expected to degrade relatively rapidly via biodegradation in soil. Degradation in soil does not appear to be inhibited by high glycol concentrations or by subfreezing temperatures. Due to its high mobility and low adsorptivity, propylene glycol is susceptible to leaching. However, concurrent biodegradation may be rapid enough to diminish the significance of leaching. Evaporation from dry (but not moist) soil surfaces is likely to occur.

11.7.8 Emergency first aid instructions:

**Eyes:** Immediately rinse eyes with clean water for 20-30 minutes. Retract eyelids often. Obtain medical attention if pain, blinking, tears or redness persists.

**Skin:** Not expected to present a significant skin hazard under anticipated conditions of normal use. If skin contact occurs, remove contaminated clothing and wash skin thoroughly.

**Inhalation:** Not expected to present a significant inhalation hazard under anticipated conditions of normal use. If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain medical attention if breathing difficulty persists.

**Ingestion:** Ingestion unlikely. If a large quantity is swallowed, give lukewarm water (one pint, ½ liter) if victim is completely conscious and alert. Obtain medical attention.

**Notes to Physician:** Following acute ingestion, signs of toxicity are unlikely. Ethanol treatment, as in ethylene glycol poisoning, is inappropriate. There is no specific antidote. Treatment should be directed at the control of symptoms and the clinical condition. Monitor for acidosis and central nervous system effects.
STEP 12. Clean Up & System Check Out

12.1 Install System Labels

System information labels like the ones shown in Table 12.1 are provided with your system. The system summary label should be affixed to your hot water tank using the ¼” long sheet metal screws provided. If has been removed or lost, print the label out, cut it out, and use clear packing tape to make it waterproof before installing on your tank. The plumber’s reminder label is placed on the top of the Solar Wand™ when it is installed in a tank. It reminds plumbers that the Wand should be moved to the new tank if the hot water tank fails. The fill and drain valve label is attached inside the pump box between the two valves, with the SRCC required Warnings.

Table 12.1 System Information Labels Tank, Ports & Wand
12.2 Site Clean Up Activities

**WARNING: DO NOT PLACE RUBITEX INSULATION CLOSE TO THE HOT WATER TANK COMBUSTION VENT PIPE. IT CAN MELT OR BURN.**

Leaving a clean site is always good for customer relations. A professional-looking installation will put you in a much better position to get word-of-mouth referrals. **DO NOT OVERLOOK THIS IMPORTANT STEP.** The entire project site, including the water tank area and the area around the solar collectors, should be policed and left clean. Wires should be tied up and secured so they are not exposed to damage on the roof or in the house. All exposed heated piping should be insulated, and all insulation exposed to the elements should be protected using cladding or other means.

12.3 Final System Check List

1. Check all pressurized water connections to be sure that there are no leaks in the system. Be sure to look at all fittings around the anti-scald valve and connections to and from the house water. Wipe with a paper towel, then wipe again to be sure that no water is leaking.
2. Check all glycol loop fluid connections to be sure that none of them are leaking. Check on the roof and at the pump box and the Wand. Tighten connections if needed.
3. Be sure tank labels are in place.
4. Verify area is neat and clean and all tools and supplies have been loaded on the truck.
5. You are now good to go.

12.4 Follow-Up

If possible, on the first sunny day after the installation call the customer. Ask him to observe the lights and gauges on the pump box to allow you to verify system operation. **Figure 12.2** gives some guidance on the interpretation of the readings of the system LEDs, pressure gauge, and thermometer. As a quick check, if the sun is out and the pump is on, have the customer read the temperature gauge mounted near the pump. Near mid-day (between about 10AM and 2PM) if the temperature gauge readings are between 54°C (130°F) and 100°C (212°F) the system is working properly. If the temperature is not in this range, have them wait 20 minutes and look again. If the temperature is still not in the range, there may be an air bubble in the system or some other cause of non-circulation. You may then need to return and check the system out yourself.
Figure 12.2 Pump Box Instrument Interpretation

<table>
<thead>
<tr>
<th>Indicator Lights</th>
<th>LED</th>
<th>Normal</th>
<th>Tank Overheated</th>
<th>Reservoir Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Panel Power</td>
<td>Green</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>Pump Command</td>
<td>Yellow</td>
<td>ON</td>
<td>OFF</td>
<td>ON/OFF</td>
</tr>
<tr>
<td>Add Antifreeze</td>
<td>Red</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Gauge</th>
<th>Sunny Day</th>
<th>Sunny Day</th>
<th>Sunny Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>No Circulation</td>
<td>Restricted Flow</td>
</tr>
<tr>
<td>Fluid From Solar Collector</td>
<td>60-105 °C</td>
<td>Below 60 °C</td>
<td>Above 110 °C</td>
</tr>
</tbody>
</table>

PUMP BOX INSTRUMENTATION INTERPRETATION

PRESSURE RELIEF = 16 PSIG
VACUUM RECOVERY = -2 PSIG

PRESSURE PSI GAUGE

Head Heating Up & Bright Sun Intermittent Cloud Cover Cooling Down & Night
4.3 20.3 4.3-20.3 2.3

Head from gauge to SPOC divided by 2.31 feet/psig,
10 feet of head/2.31 = 4.3 psig
Solar Hot Water System Specifications

Overall System

System Description

Description: The Butler Sun Solutions, Inc. solar hot water system is a high-efficiency, low-cost solar hot water system built around the patented BSSI Solar Wand™ (Can 6) that converts a conventional hot water heater tank into a solar hot water storage tank. The standard system uses a PV panel (Can 3) to power the circulation pump (Can 5), and has a flexible, insulated umbilical (Can 4) to connect between the Solar Wand™, pump assembly, and collectors (Can 1). The system can be used with any collectors, including flat plates and evacuated tubes. The final component is the SPOC™ temperature and pressure regulator (Can 2) that automatically manages the antifreeze fluid system. The system holds SRCC OG-300 ratings with many collectors, tank sizes, and configurations (see www.solar-rating.org, the SRCC website).

General System Type: Liquid antifreeze, active circulation, with double-walled heat exchanger inside thermal storage tank, and self-powered pump

Hot Water Tank: 40, 50, 60, 75 or 80-gallon commercially-available hot water tanks from any manufacturer; natural gas, propane, or electric backup power. For OG-300 certification, backup water heaters must be listed and labeled by an accredited listing organization.

Heat Transfer Fluid: Propylene Glycol (e.g., Peak Sierra™), typically 50/50 by volume

Mixing Valve: Watt Mixing Valve (or equivalent), or point-of-use anti-scald fixtures in newer homes

Flushing & Filling: Fill/flush from pump box location. Garden hose for flush, and hand pump (manual or powered) to fill with propylene glycol solution

Certifications:

Solar Rating Certification Corp (SRCC) OG-300
International Association of Plumbing and Mechanical Officials Uniform Solar Energy Code (IAPMO) IAPMO-5663

Warranty: 5 years

Component Specifications (by Can Number):

Can 1. Rated Solar Collectors: Flat Plate-Glass Cover-Selective: SunEarth EC-32&40
Flat Plate- Polycarbonate Cover-Selective: ACR 10, 20 & 40
Evacuated Tubes: Sunda, Apricus, SunMaxx

Can 2. Fluid Management System: SPOC™ Radiator over-temperature & pressure regulator (16 psi) with vacuum relief (-2 psi). Automatically accommodates fluid thermal expansion, provides air removal, and keeps antifreeze below 247°F upon stagnation (no fluid loop flow)

Can 3. Power Supply: Direct PV-powered from dedicated panel, or from 115VAC

All Rights Reserved
Photovoltaic (PV): Nominal 12VDC panel, VOC=18V,  
10-20W, CCA= 0.6-1.2 for El-SID PV-10 
20W, CCA= 1.2 for Laing D-4&5 
30W, CCA= 1.8 for El-SID PV-30 
20W, CCA= 1.2 for Thermo Dynamics 

115 VAC 
AC Pumps- Direct 
Grundfos, Taco, March, Laing, Wilo 
PV Pumps- Class II transformer to 3Amp, 18 VDC power supply 

Can 4. Piping & Umbilical: 
Standard: SAE-rated rubber hose, 3/8” ID (SAE J20R3 D2), insulated, with stainless steel hose clamp joints. 
Optional copper pipe or tubing, stainless steel corrugated flexible tubing. 
Insulation: Rubitex closed-cell rubber foam insulation ½” wall thickness with 1-1/8 ID to cover both umbilical pipes together having an R-Value of 3.2, with PVC overwrap for protection against snags 
Insulation Cover: Aluminum wrap-around pipe cover, with formed elbows, for protection against rain, exposure, and UV damage 

Can 5. Pump Assembly: 
Pump PV Powered: Laing D-5, Solar 090B, or El-SID PV-10 & PV-20 
AC Powered: Grundfos, Taco, March, Laing, Wilo 
Controllers: 
Standard: PV panel with direct DC-powered pump and water tank over-temperature cutoff switch 
DC: BSSI analog or digital pump controller, Art Tec PV-powered differential controller, or Solar Converters Inc. controller 
115 VAC: Independent Energy, Goldline GL-30, Resol Differential Controller (all models), SunEarth/Steca, TR-301-U 

Gauges 
Analog Pump Assembly: PV panel voltage, system pressure, temperature of glycol returning from collectors 
Digital Pump Assembly: Temperatures to/from collectors, storage tank temperature, Temperature rise through collectors, system pressure 

Typical Gauge readings (at 0.4 gpm flow): 
Pressure: 3 psi cold/21 psi hot (1-story building) 
8 psi cold/26 psi hot (2-story building) 
Temp: 140°F-220°F (60°C-104°C) between 10AM and 2PM if the sun is shining brightly 
Voltage: ~18 VDC until the pump starts, then 8-12 VDC 
LED Green: Power OK 
LED Yellow: Pump Enabled by Tank Overtemp switch or controller 
LED Red: Check Fluid (low fluid level in SPOC™ reservoir) 
Valves: One Flush valve, One Fill/Drain Valve (1/4” compression tubing fittings) 
One Backflow prevention check valve 

Can 6. Heat Exchanger: Butler Sun Solutions, Inc. Solar Wand™, AWWA double-wall, protected rating. Nominal heat transfer 4,320 BTU/hr at 200°F
loop temperature and 0.4 gpm flow rate (Maximum ~8,400 BTU/hr)

**System Designation:** Systems are described by a multi-part descriptor that designates the individual components contained in the system. An example system descriptor is shown below, with explanations of the component designations:

**SAHW-46-25R-PD-SPOC47A-4ACR**

- “Solar-Assisted Hot Water” ---
- 46” Wand Length-------------------
- 25’ Rubber Hose Umbilical ---------------
- Pump Assembly, Analog/Digital---------
- 47” SPOC Aluminum ---------------------
- 4 ACR collectors /SunEarth/SunMaxx------------------------

**Estimated System Performance**

The following estimate is based on a nominal system with a 32 sq.ft. flat plate (SunEarth EC-32) solar collector, and a 50-80 gallon storage tank.

System Performance in San Diego, CA (Estimated)

- Energy Produced per Year 10,900 MBTU
- 2,166 kWh
- 125 Gallons of Propane
- System Performance 719 BTU/ Ft2/ day (2.8kWh/m2/day)
- Latitude Tilt Insolation 1,947 BTU/ Ft2/day (5.7kWh/m2/day)
- System Annual Efficiency 35-48% for 50 & 80 gallon tanks respectively
- Solar Hot Water Daily About 40 Gallons/Day
- Hot Water Needs About 65 Gallons/Day for a Family of 4
- Solar Fraction About 52% Provided by Solar

**Maintenance**

- Operation Check Temperature Gauge Any Sunny Day
- Fluid Level Check Add Fluid Light, 4 Months to Dry
- Fluid Fill Roof Fill Overflow Reservoir from Float Cap
- Water Tank Pump Fluid into System to Fill Overflow

**Capacities / Data**

**Solar Wand™ Specifications**

**Description:** Solar heat exchanger that is installed in a conventional hot water tank to convert it to a solar hot water storage tank

**Heat Exchanger Type:** Double-wall, protected
(American Water Works Association (AWWA) Designation)
Materials: Copper, brass, & lead-free braze/solder

Connections:
To Tank: Threaded, ¾” Male NPT
Hot Water Outlet Port: Threaded, ¾” Male NPT
Solar Fluid from Collectors (Top Connection): Hose, 3/8” (9.5mm) ID
Solar Fluid to Pump (Bottom Connection): Hose, 3/8” (9.5mm) ID

Dimensions:

<table>
<thead>
<tr>
<th></th>
<th>SW-36</th>
<th>SW-46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Length:</td>
<td>46.5” (1181 mm)</td>
<td>56.5” (1435 mm)</td>
</tr>
<tr>
<td>Distance from Bottom of Wand to Top of Mounting Threads</td>
<td>36.5” (927 mm)</td>
<td>46.5” (1181 mm)</td>
</tr>
<tr>
<td>Extent Above Top of Tank:</td>
<td>10” (254 mm)</td>
<td>10” (254 mm)</td>
</tr>
<tr>
<td>Heat Exchange Surface Area:</td>
<td>1.56 sq. ft (0.145 sq. m)</td>
<td>2 sq. ft. (0.186 sq. m)</td>
</tr>
</tbody>
</table>

Nominal Operating Temp.: 120º-220ºF (50ºC-105ºC)
Nominal Solar Fluid Flow: 0.5 to 1 GPM
Maximum Pressure: 125 psi (0.86 MPa)
Hot Water Outlet Flow: 18 GPM @ 40 psi (~2 GPM restriction)

Typical Operating Conditions (SW-46):
- Input Solar Fluid Temperature: 200 ºF (93°C)
- Output Solar Fluid Temperature: 182 ºF (83°C)
- Solar Fluid Flow Rate: 0.5 GPM or 4 lb/min (1.9 Liter/min)
- Thermal Power: 4,320 BTU/Hr (1266 Watts)

Peak Operating Conditions (SW-46):
- Input Solar Fluid Temperature: 240 ºF (115°C)
- Output Solar Fluid Temperature: 205 ºF (96°C)
- Solar Fluid Flow Rate: 0.5 GPM or 4 lb/min (1.9 Liter/min)
- Thermal Power Transferred: 8,400 BTU/Hr (2461 Watts)

Certifications:
- SRCC (Solar Rating Certification Corp.): OG-300
- IAPMO (International Association of Plumbing and Mechanical Officials), Uniform Solar Energy Code, Listing: 5663

Warranty: Lifetime

SPOC™ Specifications
Materials: Copper and brass, aluminum, rubber, & ABS plastic
Dimensions:

<table>
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<th>SPOC-47</th>
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</thead>
<tbody>
<tr>
<td>Overall Length</td>
<td>47” (1195 mm)</td>
</tr>
<tr>
<td>Diameter</td>
<td>4.5” (115 mm)</td>
</tr>
<tr>
<td>Inlet Connection to Collector (Hose ID)</td>
<td>3/8” (9.5 mm)</td>
</tr>
<tr>
<td>Specification</td>
<td>Value</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Radiator Length</td>
<td>24” (610 mm)</td>
</tr>
<tr>
<td>Radiator Surface Area</td>
<td>344 sq.in. (0.0056 sq.m)</td>
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<tr>
<td>Reservoir Volume</td>
<td>1.2 gal (4.5 liter)</td>
</tr>
<tr>
<td>Weight (empty)</td>
<td>5.8 lb (2.6 kg)</td>
</tr>
<tr>
<td>Heat Dissipation</td>
<td>12,400 BTU/hr (3.6 kW)</td>
</tr>
<tr>
<td>Suitability</td>
<td>40-60 sq.ft. flat plate, 20-30 tube evacuated</td>
</tr>
</tbody>
</table>

**Recommended Collector Fluid:** Propylene glycol (e.g., Peak Sierra™) 50-50 mixture with water by volume

**Maximum Fluid Pressure:** 16 psi, controlled by radiator cap

**Maximum Vacuum:** -2 psi, controlled by radiator cap vacuum control valve

**Maximum Fluid Temperature:** 247°F, with 50-50 propylene glycol/water

**Reservoir Float Level Switch:** SPST, N/O, Closes on low fluid level to trigger user notification on the pump assembly

**Electrical Connections:** 6-pin shrouded, polarized connector to umbilical, 2-pin polarized connector to PV panel

**Warranty:** 5 years


**Caution:**
Installing a SPOC™ in a system with more collector area than the maximum stated in the table will void the warranty and can lead to boiling over. Boiling over can lead to the collectors and overflow reservoir running dry. Once this happens, the system will heat up well above the 247°F limit, and air can be drawn into the closed loop which will degrade the propylene glycol, potentially forming glycolic acid which will corrode your solar collectors. Butler Sun Solutions, Inc. will not be liable for damages caused by improper use of this product.

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1 This data is representative of this product’s performance, but acceptability for a specific solar collector size or collector system type should be verified by, and is the responsibility of, the user.
System Warranty

SCOPE OF COVERAGE

FIVE (5) YEAR WARRANTY ON PARTS AND MATERIALS

Butler Sun Solutions, Inc. warrants all parts, materials and components installed according to the installation manual to be free of defects in materials or workmanship. This warranty shall be in effect for a period not to exceed 5 years from the date of system installation. This warranty shall cover the cost of parts or materials for repair or replacement of defective parts, materials or components.

HOT WATER TANK PROVIDED BY THE CUSTOMER

Butler Sun Solutions, Inc. will step in and cover the Hot Water Tank Manufacturer’s Glass Lined Tank Limited Warranty if the manufacturer denies a warranty claim based on the installation of our solar wand heat exchanger in the customer’s tank.

TEN (10) YEAR WARRANTY ON THE SOLAR COLLECTOR

If Butler Sun Solutions, Inc. provides the solar collector and balance of system, we will provide the solar collector’s manufacturer’s warranty against leakage due to corrosion.

WARRANTY ON REPAIR LABOR

If Butler Sun Solutions, Inc. provides and installs the complete solar hot water system, we will provide the one (1) year repair labor warranty.

If Butler Sun Solutions, Inc. provides and someone else installs the complete solar hot water system, Butler Sun Solutions, Inc. recommends that the installer provide a one (1) year repair labor warranty. The end user must receive this warranty from the installer. Butler Sun Solutions, Inc. will not provide this labor warranty to the end user for systems that Butler Sun Solutions, Inc. does not install.

WHAT BUTLER SUN SOLUTIONS WILL DO

If a defect in parts, materials and components or other malfunction or failure to perform becomes evident during the warranty period, Butler Sun Solutions, Inc. will repair or at its option replace the nonconforming component or part within a reasonable time, and without charge for the part, not including transportation. In such event, the duration of the warranty is extended while the part or component is not functioning.

WARRANTY PERFORMANCE (Where and How to File Claims)

Warranty claims shall be made to Butler Sun Solutions, Inc., during normal business hours, by the registered owner of the solar hot water system. Contact information as of this writing:

Butler Sun Solutions, Inc., 525 Stevens Ave West, Solana Beach, CA 92075
Registration will be verified by our sales invoice on file. Butler Sun Solutions, Inc. may, if it deems it necessary and reasonable, arrange for a field inspection of the system, or request digital photos of the suspect component, or request return of the part within a reasonable time from receipt of a claim. The field inspector, returned part, or photo evidence will be used to verify failure, establish the probable cause and determine corrective actions required. If the inspection, returned part, or photos reveal a warranty-related defect, Butler Sun Solutions, Inc. will replace or repair at its option the parts and components which have failed. If no warranty-related defects are found, the system owner must pay for the inspection or applicable costs. Butler Sun Solutions, Inc., or its representatives, shall be granted access to the solar hot water system, and if necessary, a sample of, or the complete failed part of, the solar hot water system may be shipped to us or taken for analysis.

LIMITATION OF LENGTH

The warranty on parts, materials and components extends five years from the date of installation on the original retail customer’s home or location. This warranty extends to the first retail purchaser, and to any subsequent homeowners at the same location during the warranty period. Any such transfer will not extend the 5-year duration of the warranty. If warranty service causes an extended period of system nonperformance, the warranty will be extended by the period of time the system did not perform.

WHAT IS NOT COVERED

- Damage due to owner’s unauthorized attempts to repair the products, inappropriate parts substitution, neglect, misuse, abnormal weather conditions and electric power failures, or conditions arising from a defect in a component which is not part of the system.
- Products which are not installed and maintained in accordance with the installation, operation and maintenance instructions, and/or applicable ordinances and codes.
- Consequential damage to your home, inconvenience, loss of time, or loss of the use of your solar hot water system as a result of system malfunction.
- Normal fading and minor deterioration of exterior surfaces resulting from exposure to the elements, except conditions that do or will affect performance.
- Glass or plastic glazing breakage from any cause.

OTHER RIGHTS AND REMEDIES

NO OTHER EXPRESS WARRANTIES

The entire obligation of Butler Sun Solutions, Inc. regarding its solar hot water system is stated within this warranty. Butler Sun Solutions, Inc. does not authorize its representatives or any other person to make any other warranties or assume for it any other liabilities in connection with the sale of its products.
FURTHER, THERE ARE NO WARRANTIES THAT ARE NOT STATED HEREIN.

IMPLIED WARRANTIES

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, including in California, implied warranties or merchantability and, in certain instances, of fitness for particular purpose.

LIMITS OF LIABILITY

The customer agrees that Butler Sun Solutions, Inc. liability for any warranty is expressly limited to the amount paid by the customer for the Butler Sun Solutions, Inc. solar hot water system, and if Butler Sun Solutions, Inc. pays this amount, it has the right to remove the system from the customer’s premises.

RIGHTS TO ARBITRATION

Any dispute between the buyer and Butler Sun Solutions, Inc. pertaining to the warranty may at the option of the buyer or seller, be resolved by arbitration in California according to the rules of the American Arbitration Association.

I ____________________________ have read and understand the provisions of this Warranty on this date ________________.