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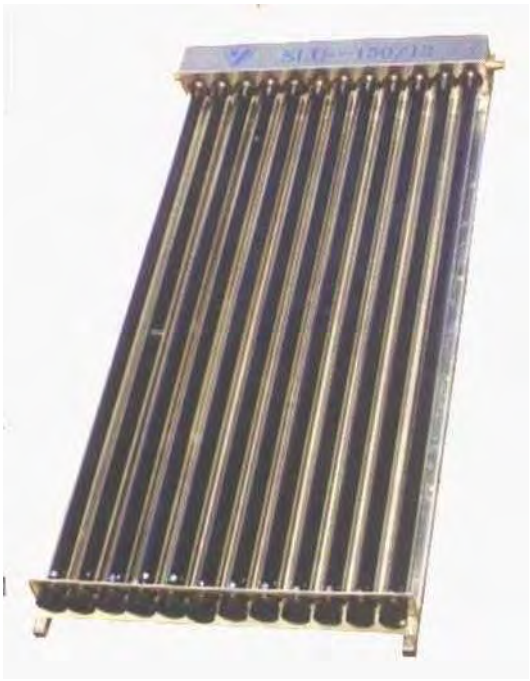
Solar Hot Water

Installation Manual

Solar Water Heater

Evacuated U-Tube Split System



SOLAR RATING & CERTIFICATION CORPORATION

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Split (Indirect) Solar Water System Installation Manual:

This manual explains how to install a system of evacuated tubes with the collector panels separated from the storage tank. Systems described use Freefuelforever evacuated tube collectors, either for service hot water or swimming pool heating. In the case of swimming pool heating, locations that never freeze may forgo the solar hot water tank, the heat exchanger and expansion vessel. Any location that freezes or has minerals in the water should use a heat exchanger to avoid collector damage.

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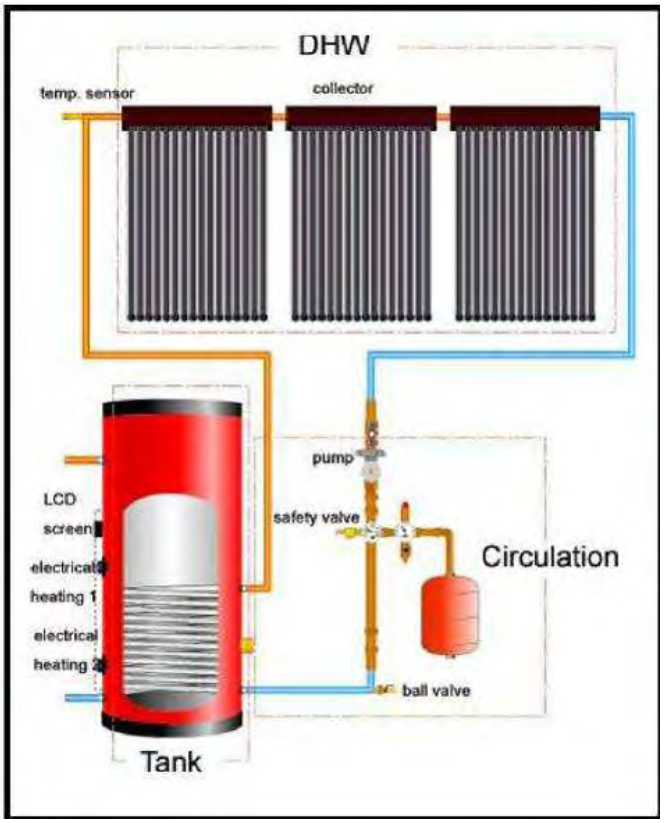

Figure 1: Split (indirect) solar system layout diagram.

Component Descriptions:

Solar collector

The solar collector converts solar radiation into heat and transfers the energy to a freeze-proof solar liquid. Temperatures in a solar collector can reach more than 200 Celsius.

Solar circulation

A circulation pump ensures heat transfer from collector to storage tank. Automatic control starts the pump as soon as the collector is warmer than the tank. The control unit also contains various safety devices such as manometer, safety valves, release pipes and an expansion vessel. This accounts for the differences in volume resulting from changing temperatures in the heat transfer liquid.

Collector tubes:

The selective absorber coating on the inner glass tube results in maximum radiation absorption while the vacuum between inner and out tubes results in almost complete elimination of convection and conduction heat losses. In a u-tube model, the heat is transferred from the absorber on the inner glass tube surface to a metal cylindrical fin, which holds a copper pipe through which the water flows. In the water in tube

model, the water to be heated comes in direct contact with the inner glass tube, which results in greater heat transfer, but in much lower working pressures.

Storage Tank

Solar energy is almost never available at the same time it is needed. Most domestic hot water is used in the morning and evening when the sun is not yet shining or has already set Different models of hot water storage tanks therefore act as mediums between solar energy production and consumption. Stainless steel spiral coils inside the tank serve as the heat exchanger. An alternative to the steel coils is a tank-in-tank system.

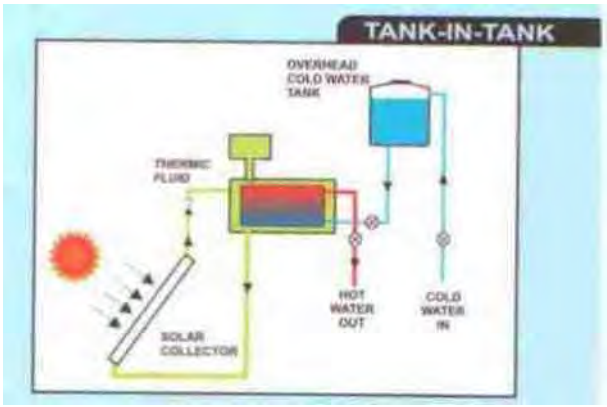

Figure 2: Tank in tank heat exchanger system

Thermo Siphon System Layout

U tube collectors are extremely flexible and can be used with a variety of system layouts, some much simpler than the standard system described above.

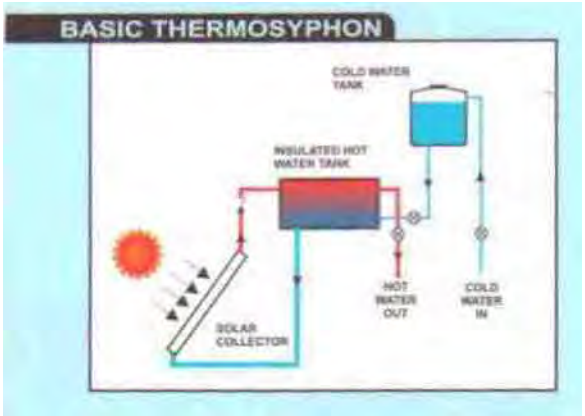

Figure 3: Basic Thermo siphon Split System

A basic thermo siphon system relies on hot water rising and cool water falling. This natural circulation allows the panel to heat a tank of water that is placed above it without requiring a circulation pump or heat exchanger. The u-tube panel must be turned horizontally to allow hot water to rise through the piping. The insulated hot water tank

should not be more than 15 cm above the level of the panel, otherwise flow becomes too slow. If the panel must be located more than approximately a 2 meter distance from the hot water storage tank, a forced circulation system can be used. If the tank must be below the collector, a pressurized thermo siphon system can be used. Only the basic thermo siphon system demands that the tubes be horizontal, but flow is helped by hot water rising in all cases where the collector is horizontal.

Figure 4: Balcony mounted horizontal solar collector.

If the collector must be located above the storage tank, a pressurized system may be used.

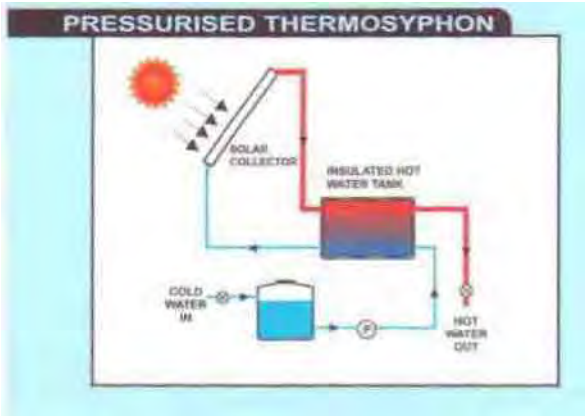

Figure 5: Pressurized Thermo Siphon system

A basic forced circulation system can made like a basic thermo siphon, but simply with a pump to ensure enough flow for effective heat extraction from the collector.

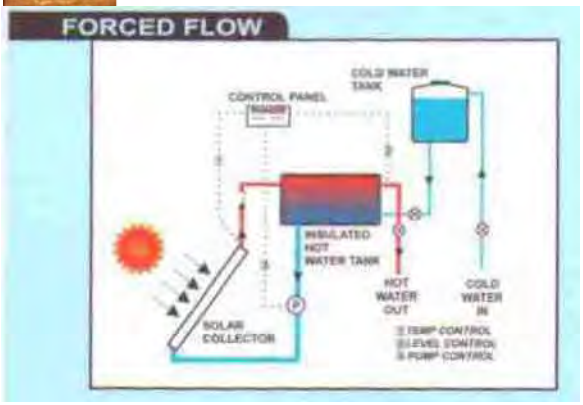

Figure 6: Forced flow direct system

A forced flow system is a split system without a heat exchanger. Tubes can be in any orientation. Horizontal tubes aid the thermo siphon circulation of hot water rising, while vertical tubes track the suns daily movement more efficiently for maximum energy gain.

Installation Procedure:

This manual is concerned with the installation of the solar hot water system. It is assumed that decisions on the number of collectors, general system design and system layout have already been made. The general solar system design manual located on the www.freefuelforever.com website may be downloaded to assist with system design.

Before Installing Collectors:

Prior to installation of the solar collectors, the following items should be addressed:

- ✓ Decide on location of solar hot water tank
- ✓ Check access for piping from solar tank to roof
- ✓ Decide on location for control panel and expansion vessel
- ✓ Install solar hot water tank with heat exchanger
- ✓ Install pipe runs from solar tank to roof
- ✓ Pipes should be installed rising slightly to avoid the creation of air pockets
- ✓ Install expansion vessel
- ✓ Install control panel with circulation pump
- ✓ Insulate all pipe runs
- ✓ When filling the system, ensure all valves are open
- ✓ Check pump works and water flows correctly to roof

Plumbing Schematic

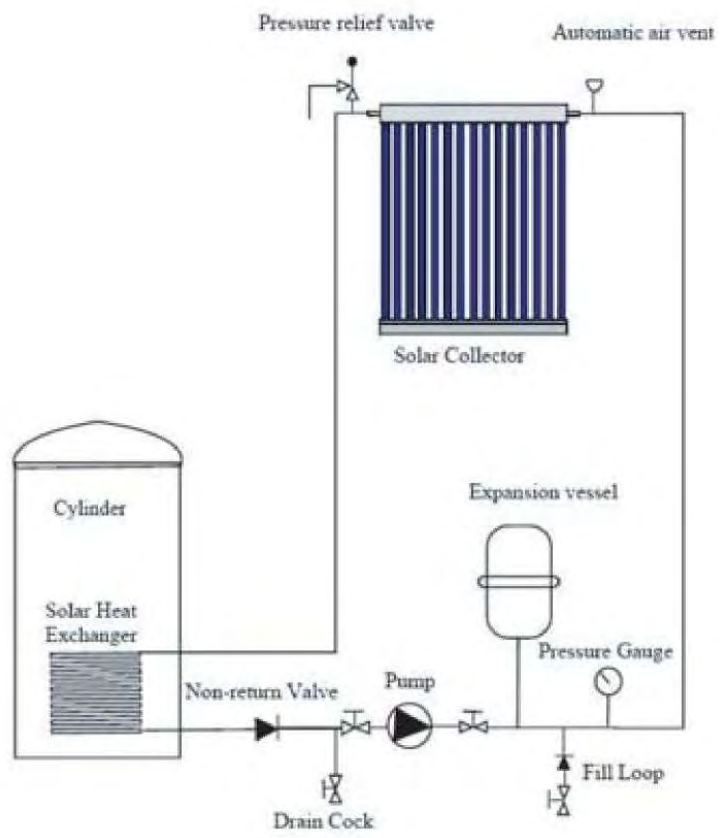

Figure 7: Solar water system plumbing schematic

Plumbing Components:

PUMP, typically a Laing D5, with flow meter attached to monitor flow of water within the system. Pump size may be calculated by using the pressure drop program available at www.freefuelforever.com under "downloads". See also project examples.

NON-RETURN (CHECK) VALVE prevents reverse flow of water when the storage tank temperature is greater than the collector temperature, such as at night. Be sure to install in correct direction.

AN AIR PURGER positioned just before the pump can assist with air elimination.

A TEMPERING VALVE is recommended to control water temperature to the taps. Positioning it alongside the tank will extend the life of the valve and provide a heat trap to stop heat leaking from the tank through the hot water line. This pipe should be well insulated.

EXPANSION VESSEL contains increased water volume in the system due to rise in temperature and hence increased pressure of water.

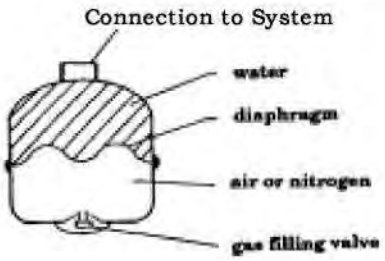

Figure 8: Expansion vessel with diaphragm

A **PRESSURE RELIEF VALVE** and **PRESSURE GAUGE** monitors the pressure of the system and serves as a safety mechanism to avoid over pressuring of the system. Working pressure is generally 3 bar or 45 psi.

An Optional FILLING LOOP, consisting of a flexible hose and stop valve that connects from water mains supply to hose connector and filler valve, with a **DOUBLE CHECK VALVE,** to stop reverse flow of water into cold mains water supply.

Pipe

Pipe Joining

For hot heat transfer fluid pipe, there are not any components connected to this pipe, so it is best to use a single pipe run without any joints with the help of a tube bender. When copper pipe has to be joined, please use Model C copper pipe union joints (both ends for pipe) to connect both ends. If both pipes of the circulation loop have to be joined, keep the two unions a few centimeters apart in order to make insulation more easily.

Figure 9: Joining copper pipe with unions.

Pipe size recommendation:

For a solar installation with pipe work of total length 30 to 50 meters, the following dimensions are recommended for the flow and return pipe work:

Less than 36 tubes 12 mm or ½ inch-possible, but recommend ¾ inch.
Up to 90 tubes 22 mm or ¾ inch

Up to 120 tubes 128 mm or 1 inch
More than 120 tubes – use parallel branches of 1 inch each.

Pipe work should be insulated with ¾ inch minimum high temperature pipe insulation, more insulation in more extreme cold environments. For multiple manifold installations, the recommended maximum number of manifolds that should be connected in series is five 12-tube solar panels. For more panels, use parallel pipe runs.

Collector-Roof Attachments:

Collectors be mounted on any angle roof, but for maximum efficiency, a frame should be made so that the collector angle is about equal to latitude. See the written and pictorial steps below.

Figure 10: Dual collectors on roof

1. Select a suitable location on the roof for the collector. In the northern hemisphere, the collector should face due south, at an angle to the ground equal to the latitude. For example, latitude of 49 degrees would use a collector angle of about 49 degrees, plus 10 degrees to give best heating in winter.
2. Remove roof tiles at the corners of an area large enough to fit the collector.
3. Secure a stainless steel band to a rafter using coach screws and washers.
4. Replace the roof tiles, leaving the band protruding (fig 3-4).
5. Secure the collector frame to the bands, or hooks, as installed.
6. Cover the tubes with a blanket if in direct sun.
7. Connect plumbing and turn on pump.

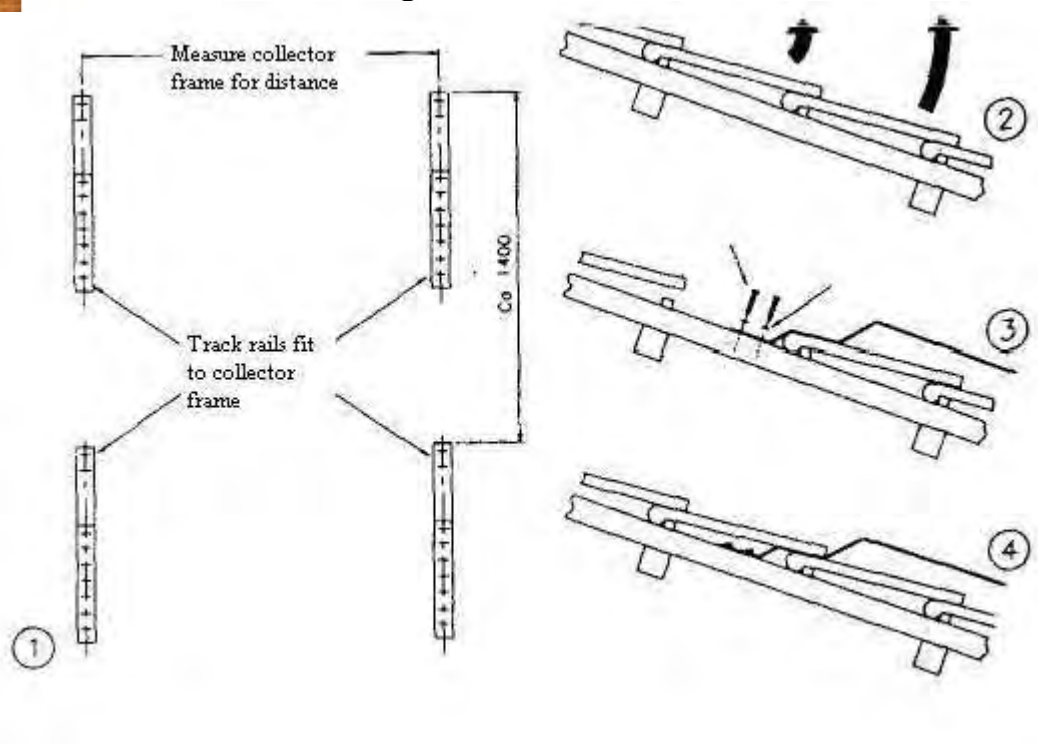

Figure 11: Straps to hold collector on roof.

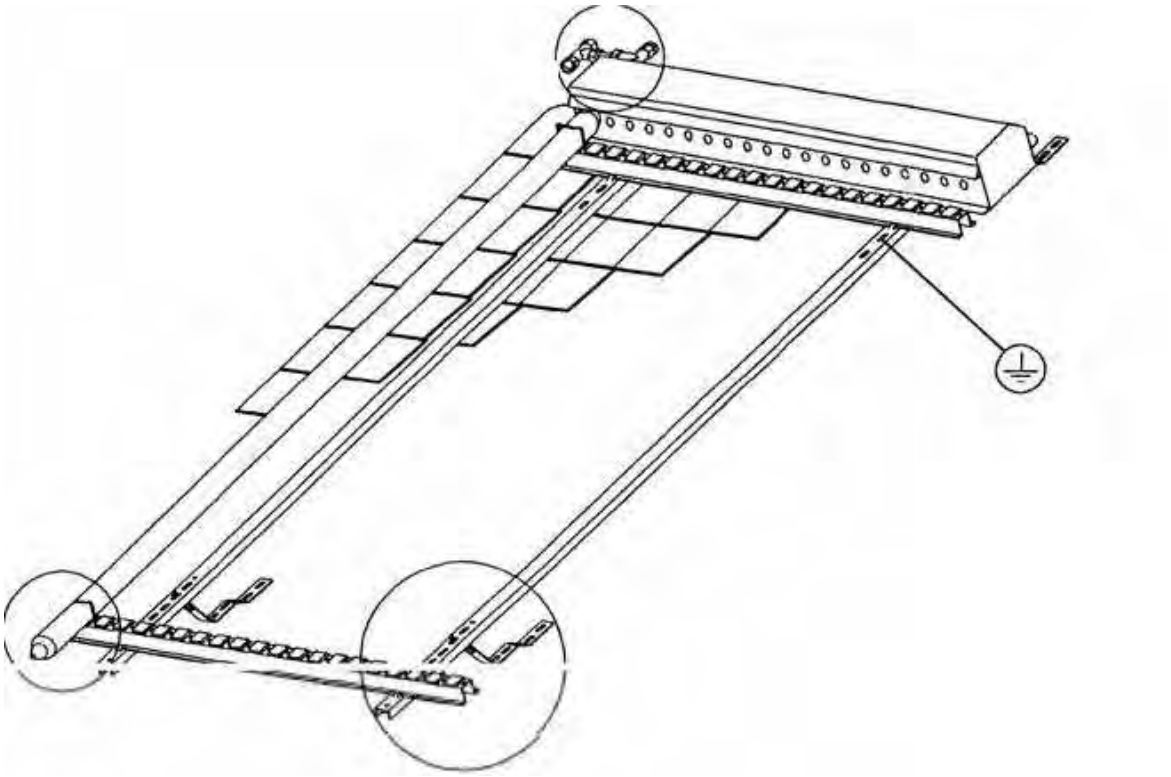

Figure 12: Solar Panel frame installed on sloping roof

Fix the collector on the support frame and leave 60-100 mm distance between two collectors

Pictorial Steps to Install Collector Roof Straps:

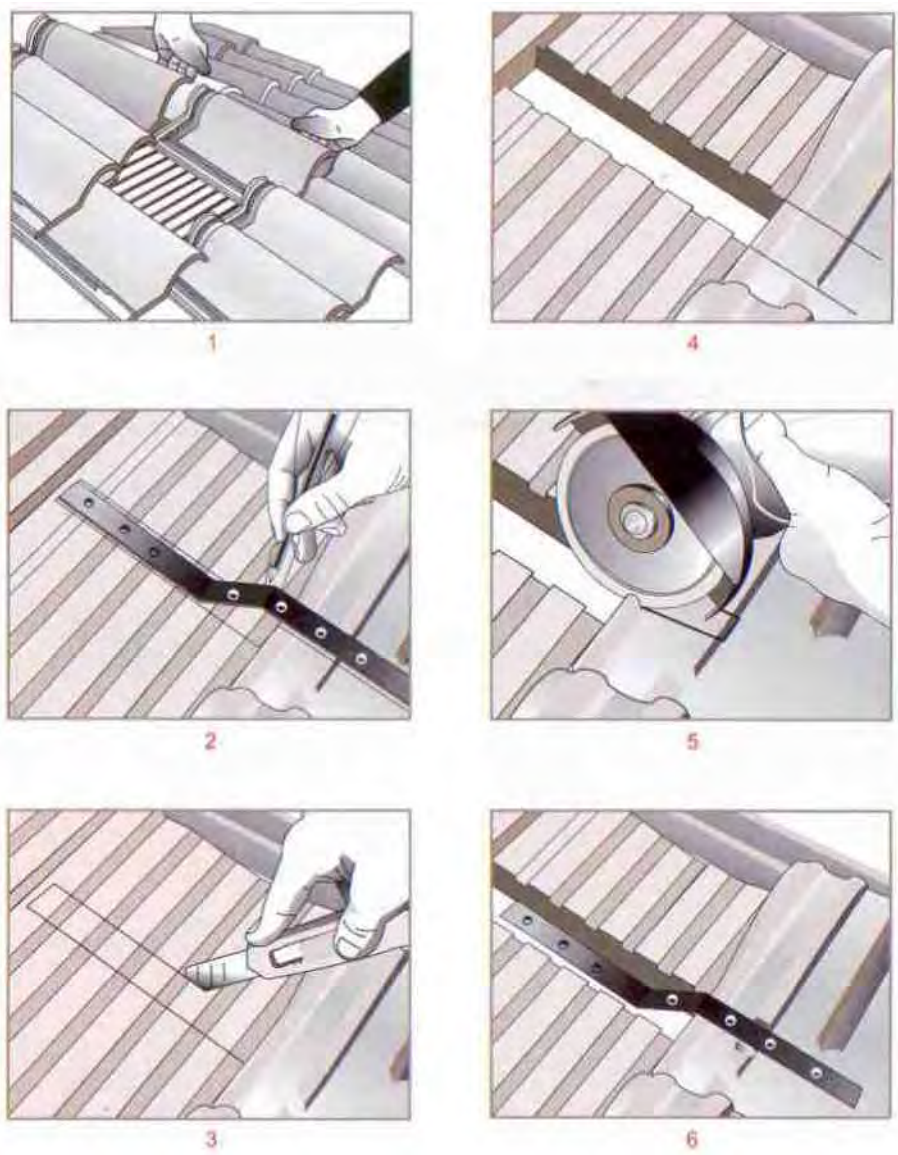

Figure 13: Installing collector straps to roof, steps 1-6

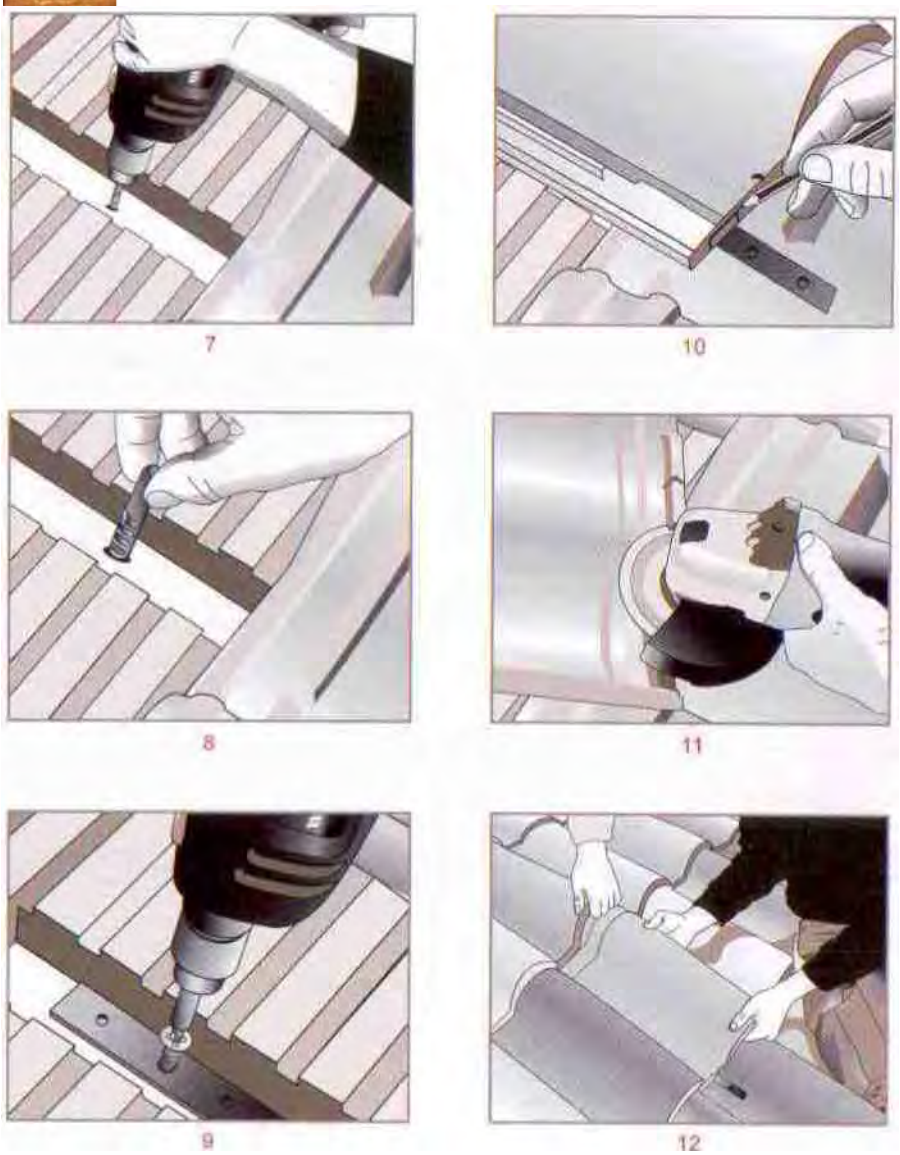

Figure 14: Installing collector straps to roof, steps 7-12

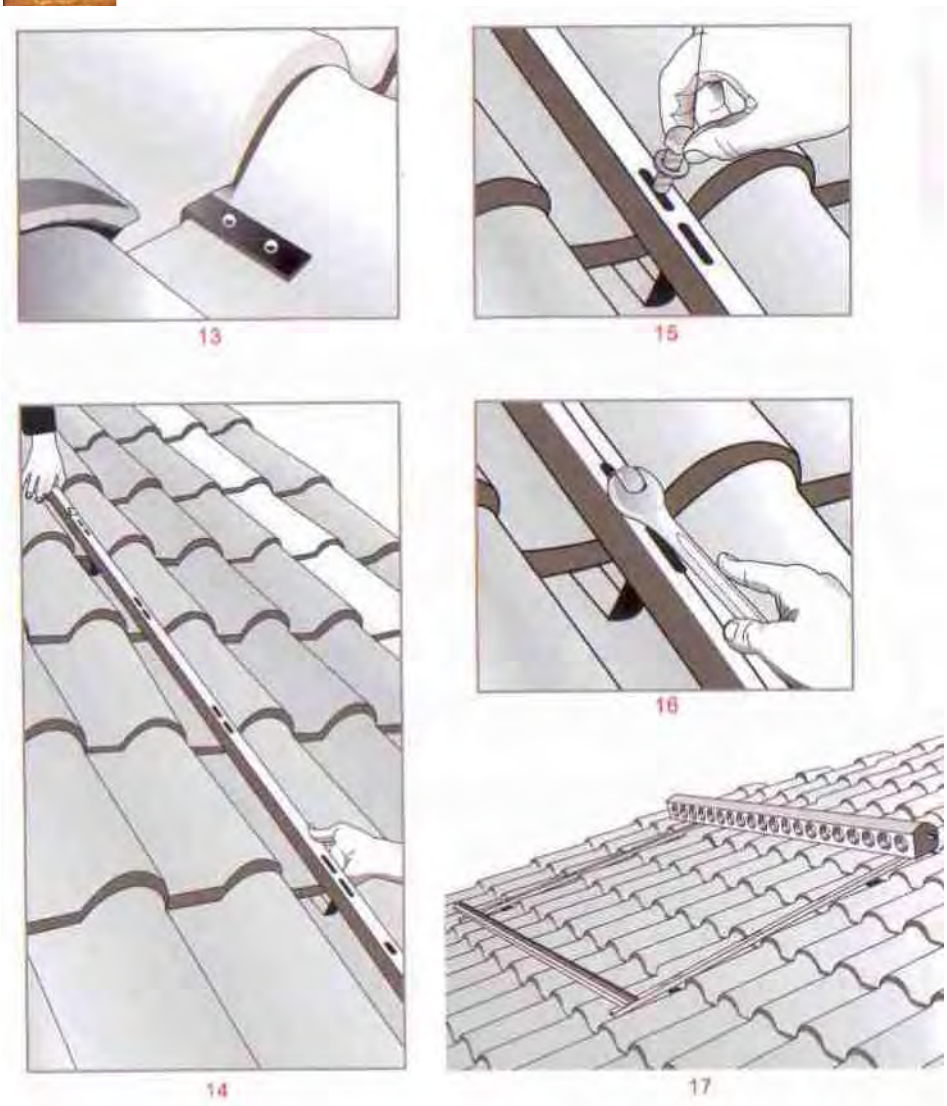

Figure 15: Installing collector straps to roof, steps 13-17

Flat Roof Collector Frame:

A flat roof usually means a frame to hold the collector at an angle is needed. Collector angle should be equal to the latitude, so the only place a flat roof will work without a frame is the equator. Some collectors are supplied with frames.

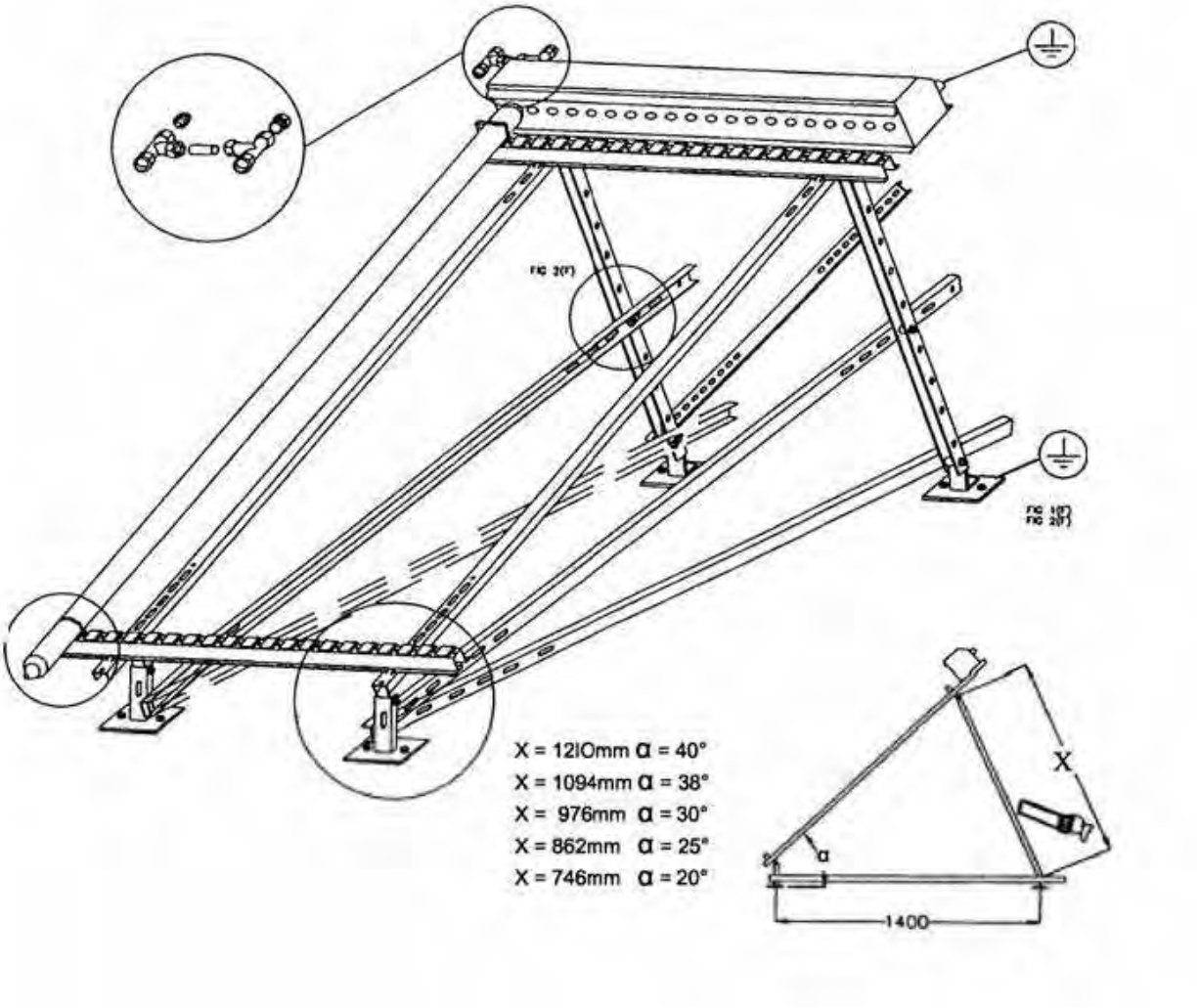

Figure 16: Solar Collector Frame for flat roof.

To make a frame from angled aluminum, take measurements from your collector and follow the schematic below, or purchase a frame kit for your location.

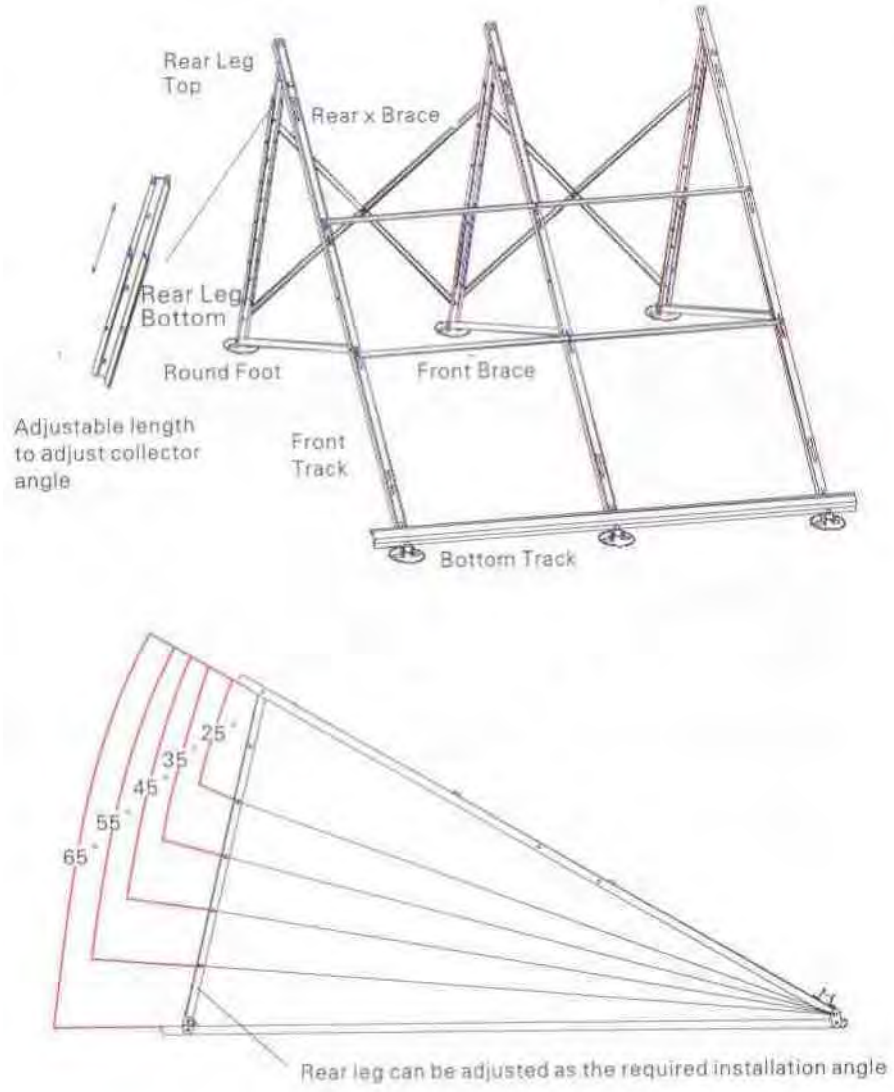

Figure 17: Flat roof frame construction.

Low Sloping Roof Collector Frame

A suitable frame can be made to the required angle for the roof and latitude. Inventive installers will also tilt the frames' rear legs to make the collector azimuth face towards the equator (due south in North Hemisphere) while the collector lies flat on a sloping roof. Rear legs of the frame can be made different lengths so that the collector is facing the equator at an angle to the horizontal equal to latitude, while the frame lies flat on a sloping roof. Of course, this is only necessary if the roof is not already facing due geographic (not magnetic) south already. If the roof is already facing geographic south, then all rear legs can be the same length, with that length being enough to make the collector angle equal to the latitude.

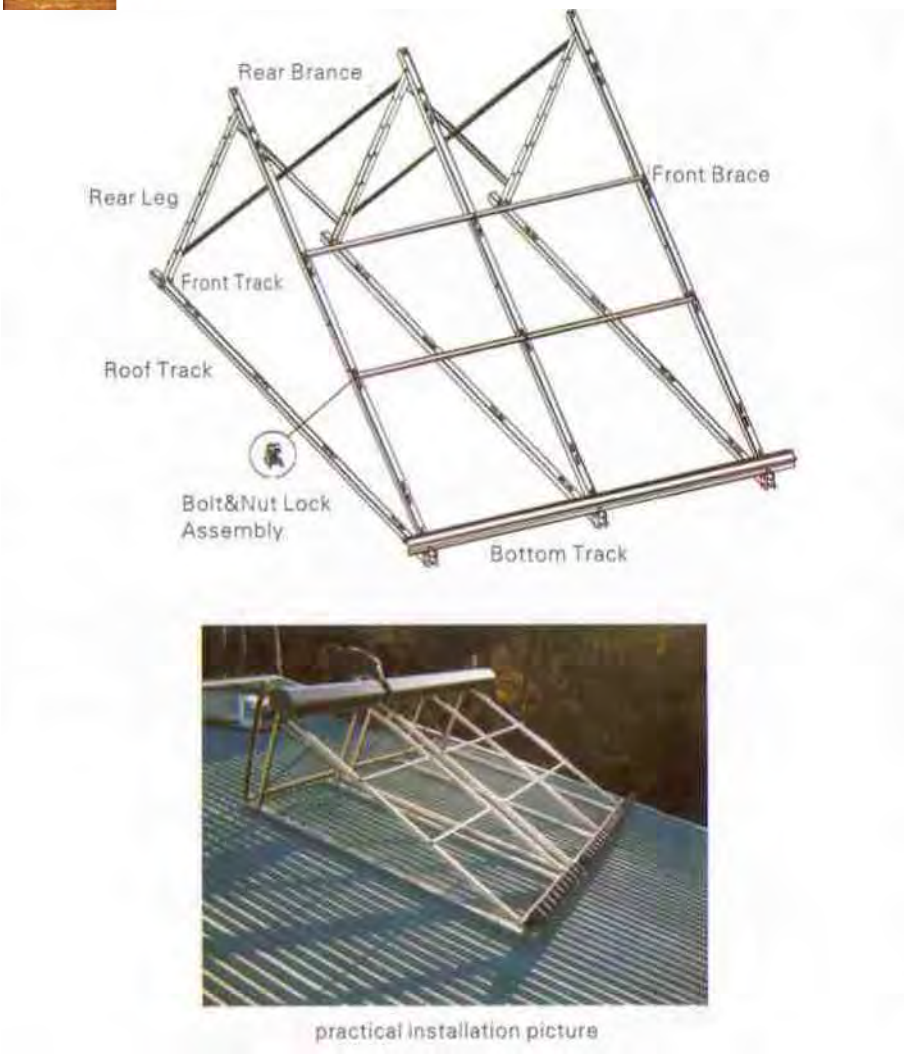

Figure 18: Solar Collector frame assembly for low-slope roof.

Temperature sensors

On installations that use an electronic controller to turn on the circulation pump, there must be temperature sensors to determine if the collector has useful heat.

Collector: On the right cover plate of the collector, there is a hole for the temperature sensor. Push the temperature sensor into the hole and seal it from the rain. The sensor should be outside of the insulation in order to be replaced easily in case of damage. The temperature at the collector (T1) is displayed on the controller screen, at the bottom.

Temperature sensors inside the tank: there are two sensors (T2 and T3) inside the tank. T2 is placed in the middle of the tank; T3 is at the bottom of the tank. T2 is displayed at the upper part of the controller screen, and T3 at the right of the under part of the controller screen. The circulation of the collector loop is controlled by the temperature difference between T1 and T3 if the standard electronic controller is used.

Controller Installation

Push the temperature sensor into the hole on the collector cover and connect it with

temperature sensor connection wire in the tank by STP. Connect the pump with the black wire of tank. Connect the power wire to the power supply. Refer to the controller installation manual for full instructions on setup (www.freefuelforever.com, downloads)

Connecting multiple collectors

Figure 19: Two collector headers joined.

Seals and gaskets are a potential source of leakage. Selecting good quality is quite critical. At the collectors, pressures and temperatures may be quite high. Seals and gaskets used shall be high-temperature resistant. Silicate rubber gaskets are highly recommended and are provided with some products.

Storage tanks

Figure 20: Solar Water Storage tank with plumbing

Place the storage tank in a position that is easy to connect with the water supply and also a position that is easy to supply hot water for the different rooms. On the top of the tank, there is a connection for an air eliminator, or one-way vent valve. On the back side of the standard system tank, there are four inlet and outlets. Connections, in order from top to bottom, are: hot water outlet, circulation loop inlet (warm heat transfer fluid), circulation loop outlet (colder heat transfer fluid), and cold water inlet. On the bottom of the tank, the connection is for drainage.

These inlets/outlets shall be connected as following:

1. Connect the air eliminator with the connection on the top;
2. Connect a brass bend with each inlet/outlet connection on the back side of the tank. The bend connected to the hot water outlet shall be installed upward, the bend connected with circulation loop inlet/outlets shall bend left (or right), the bend connected with cold water shall bend downward, and the bend connected with drainage shall bend left or (right);
3. Connect a ball valve with drainage
4. Connect connection pipes with the four inlet/outlet connections on the back side of the tank. Connections are for the hot water outlet, the circulation loop inlet (warmer heat transfer fluid), circulation loop outlet (colder heat transfer fluid), and cold water inlet;

Adjust the final position the storage tank. Ensure that the tank is 150mm away from the wall and all connection pipes run parallel with the wall.

Note: the drain hole at the bottom of the tank has to be installed with a ball valve. The globe valve can be connected with a 300mm connection pipe for easy installation. The valve shall be blocked to prevent the valve being opened by accident, which will cause the drainage of water.

Multiple Tanks:

Solar water system tanks may be connected in series, where hot water flows through each tank in turn, or in parallel, where the tank that the water flows through is controlled by motorized 3-way valves.

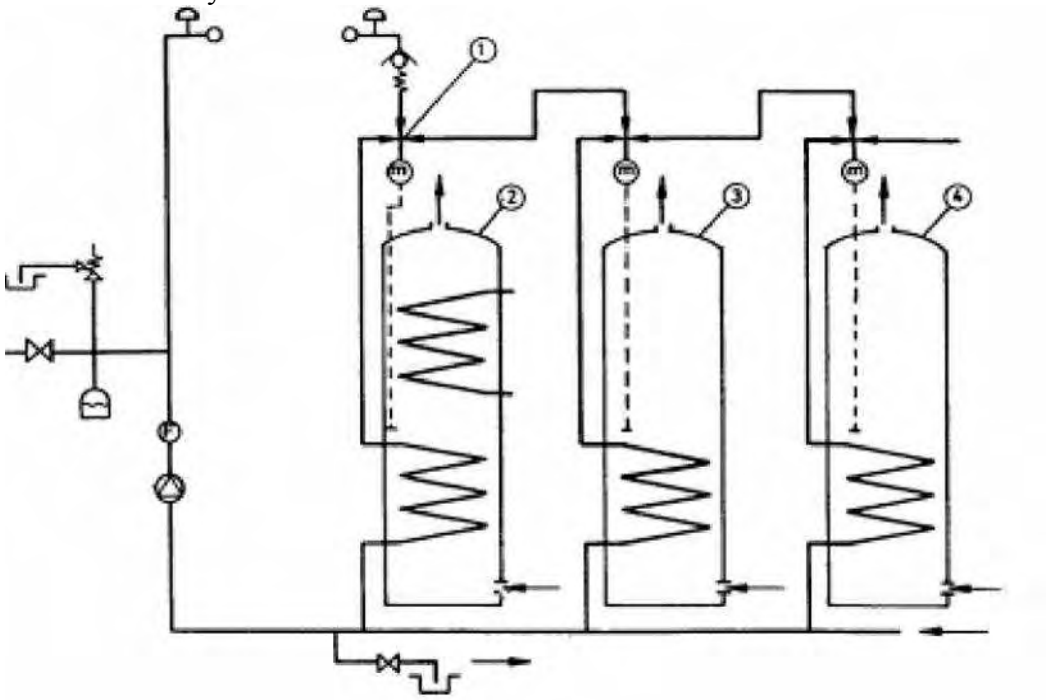

Figure 21: Parallel solar water storage tanks

Parallel Tanks:

A number of storage tanks may be connected in parallel to the collector system for very large scale applications such hotels, hospitals, multi-storey buildings. When the water temperature in Tank 1 reaches a set temperature, the water from the collector is directed via a motorized 3-way valve, controlled by a temperature sensor at Tank 1, to Tank 2. If the temperature in Tank 1 falls below set temperature, the water from the collector is redirected through its heating coil.

Series Tanks:

For large installations two or more tanks may be connected to the solar system in series, in a preheat arrangement. Water passes through each tank, being heated more with each additional tank. Motorized three-way valves control the flow of water.

Figure 22: Parallel tank for large scale solar water systems

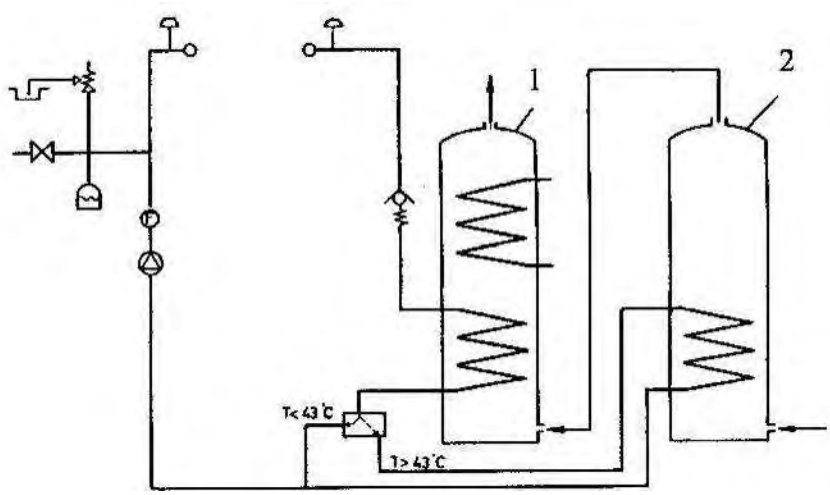

Figure 23: Solar tanks in series.

Circulation loop

During normal operation, the temperature inside the circulation loop rises to 100 C. Under stagnation circumstances, the temperature will be much higher. Hence, all the seals in this loop shall be able to withstand high temperature and high pressure. The following sealing methods are recommended:

Copper pipe joints: requires a resilient seal. Connect a Model A union joint directly with the copper pipe after using a reamer to flare the end. The copper pipe should be malleable enough to compress for the seal. Non-copper pipes: seal with silicon tape and pipe seal compound.

Heat Exchanger Recommendation

In areas where local water is known to be hard or aggressive, a heat exchanger must be used and the use of water softener is recommended, otherwise regular cleaning of the system will be required. A heat exchanger will avoid the problems of corrosion and deposits building up inside the solar collectors. Any kind of liquid may be heated by the heat exchanger. In areas where chloride ion concentration is greater than 40 ppm a heat exchanger must be used in hot water storage tank. The solar system should be filled with distilled or de-chlorinated water, or another clean fluid such as glycol.

Circulation Pump:

Connect the following pump components:

1. Model A union joint with circulation loop inlet
2. Copper pipe
3. Model A union joint
4. Back flow preventer valve
5. Standard male thread union joint (3/4”)

6. Converter (1” to 3/4”)
7. Grunfos pump (UPS25-80)
8. Converter (1” to 3/4”)
9. Model A union joint
10. Model A union joint with connection to cross junction manifold

Cross manifold

Connect the cross manifold components as the following figure shows

1. Model A union joint nuts
2. Copper pipe
3. Safety valve (5 bar)
4. Brass union (1/2” male thread)
5. Model A union joint (male thread)
6. Model A union joint nuts
7. Manometer
8. Manometer gaskets
9. Cross manifold
10. Silicate rubber seal
11. 600 mm bellow for expansion vessel
12. Silicate rubber seal
13. Expansion vessel

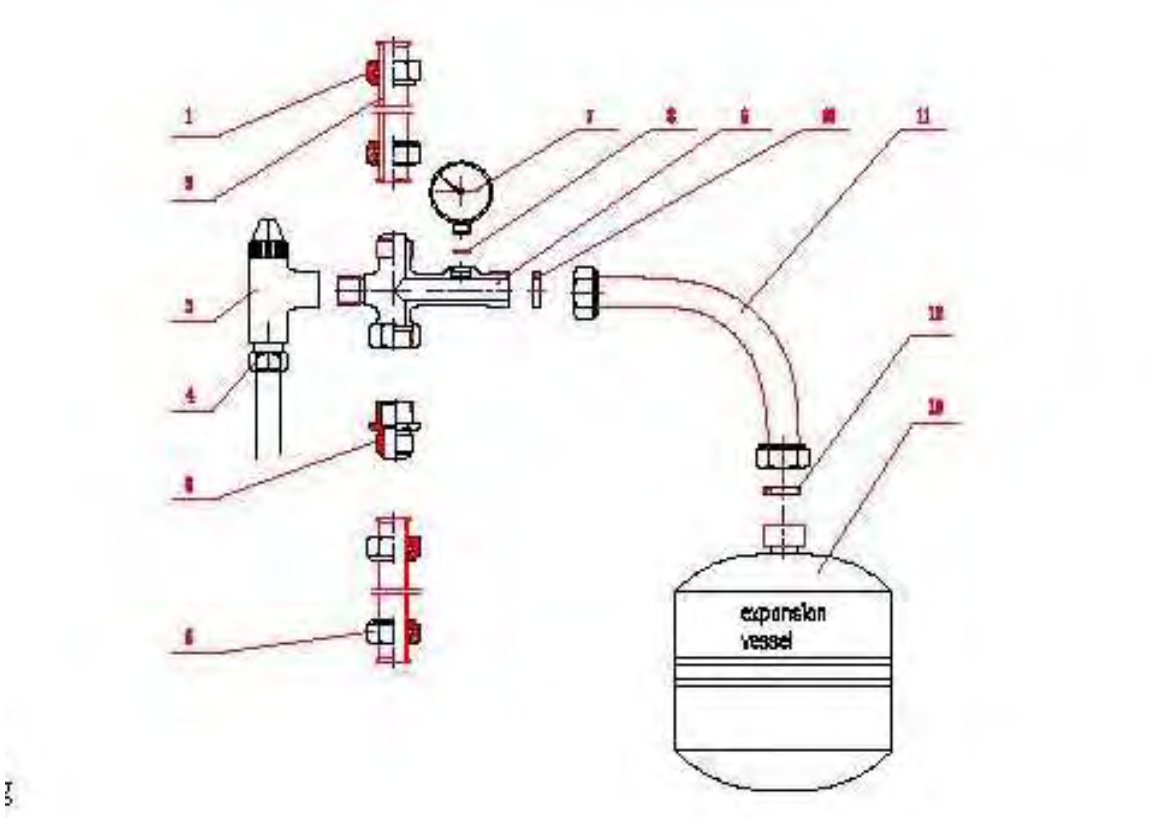

Figure 24: Cross manifold plumbing

1. Fasten the circulation copper pipes with pipes support by 4 M6 expanding bolts, 500mm away from the valve manifold;
2. Fasten the expansion vessel with its specified support.

Note: all the components in the circulation loop (pump, expansion vessel, manometer, and valve) shall be installed on the cold water copper pipe which is connected with the most left inlet of the collector array

Valves manifold

Connect the valves manifold components as the following figure shows

1. Model A union joint nuts, under cross manifold.
2. Copper pipe
3. Model A union joint (male thread)
4. Valves manifold
5. 330 mm tank connection pipe
6. Brass union (1/2" may not be included)
7. Pump for filling heat transfer fluid (with 30mm pump trap)

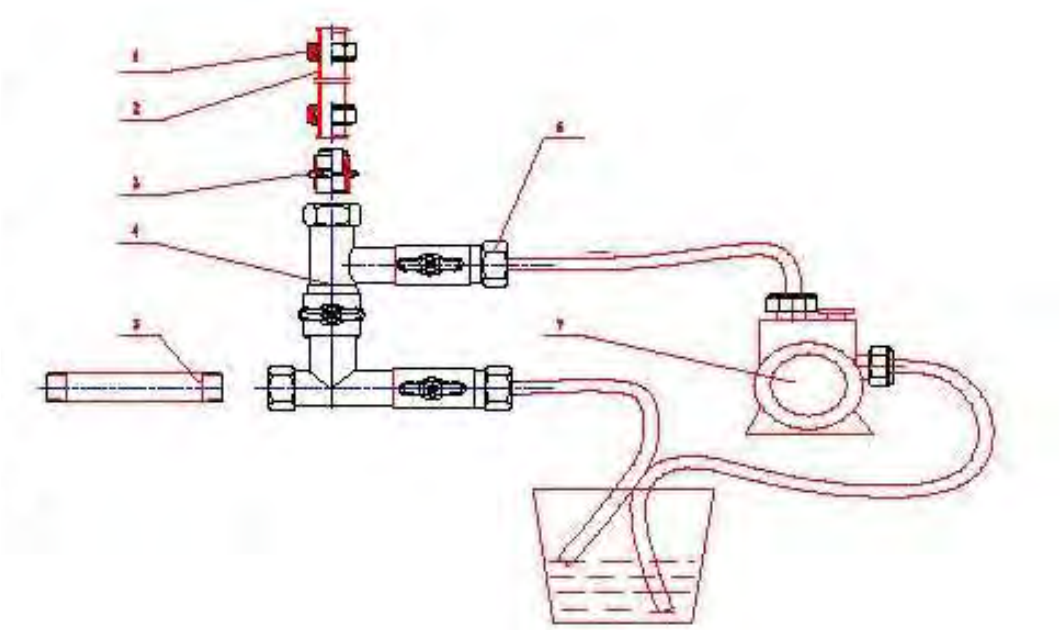

Figure 25: Valves manifold plumbing arrangement

Water loop

Cold water pipe: connect the union joint, ball valve, pressure-relief valve, pressure-reducing valve, reducing-tee, back flow prevention valve, ball valve, and then connect with city cold water supply. One outlet of the tee should be outward and connect with a plug.
Hot water pipe: connect bend, tank connection pipe (alternative), union joint, ball valve, and then connect to hot water supply network.

Testing

The solar water system shall be checked for integrity and operation after installation. This is a very critical procedure.

Storage tank cleaning and checking

Open the cold water ball valve, close the hot water outlet ball valve, and start supply water into the tank until it is fully filled. Check if any leakage occurs in the cold water pipe and the drain pipe. If no leakage occurs, close the cold water ball valve and open the drain valve. Seal the drain valve with a plug after the tank is empty.
Check the hot water pipe for leaks. Supply cold water again and open the water outlet ball valve to check for leaks.

Circulation loop and collector cleaning

Connect test equipment (pump, hose, barrel and other necessary equipment for testing) to the valves manifold. Connect the hose with pump to valve k1, another hose to k2, and

ensure the hoses are screwed tight without any leaks. Open k1 and k2, close k3. Remove air from the circulation loop by pumping water. This procedure shall be stopped when the water coming out from k2 is clean water. Then place the k2 hose into the barrel, open k3 for several seconds and then close it.

Note： A pump with 30mm pump trap is recommended to use here.

Circulation loop leak check

Check the circulation loop for leaks while cleaning the loop and collector. Close valve k1 and k2 slowly when there are no bubbles coming out from k2 hose; adjust the system pressure to 2.2 bar (displayed in manometer). Then open valve k3. Check if the system pressure has become lower after a period of time (ca. 3 hours). If the pressure is lower than 2.2 bar it shows that there is a leak in the circulation loop.

Filling/flushing heat transfer liquid

The flow must be strong enough to carry all the air bubbles away and leave as much heat transfer liquid as possible inside the circulation loop.
Replace the water barrel with a barrel of anti-freezing liquid and start filling the heat transfer liquid into the circulation loop. Close valve k3 and open the test ball valve to maximum, start the pump, open valve k1 and k2. When anti-freezing liquid comes out from k2 hose, place the hose into the barrel and adjust the ball valve to make the flow smaller, ensuring that no air bubbles occur in the barrel. Keep the flow running for several minutes, and then make the system build up the pressure as 2.2 bar through controlling valve k1, k2 slowly. Open valve k3. See the filling and flushing procedure figure for a graphical illustration.

Uncover the collector. Pronounce system operational.

Heat transfer fluid maintenance

Please check the heat transfer fluid on-site in one year intervals. Evaluate the fluid by its appearance and concentration.

General Appearance:
Is the fluid still clear? Or turbid, stained by foreign matter like copper scale, dirt, rust (sometimes sealing materials)? The worst: Does the appearance indicate thermal overload - dark brown color, pungent odor, degradation products that are not soluble in the fluid? In this case the fluid must be replaced.

Concentration: The water used to dilute anti-freezing liquid must be distilled water. Mix the two fluids in the ratio of 43/57 (w/w). If too high glycol concentrations are observed by measurement of density or refractive index, this is sometimes due to small leaks in "hot areas", e. g. where the collector is connected to the system. Water may evaporate there preferably due to its much lower boiling point compared to propylene glycol (fractional distillation). However, most cases of too high glycol concentration are due to flush dilution. The heat transfer fluid was diluted by water remaining from cleaning or pressure testing. Dilute the heat transfer fluid with distilled water as required.

PH value:

The pH value can be used as a general tool to evaluate the state of the corrosion protection of the fluid. The pH value of un-used diluted fluid (43/57) is about 10. Main factors that shift pH to lower values are thermal load, oxygen, dissolved metal and dirt. If a pH value lower than 7 is measured, corrosion protection will be insufficient, and the fluid has to be replaced.
Please replace the heat transfer fluid under the circumstances described above.

Disposal of heat transfer fluid

Propylene glycol / water mixtures are readily biodegradable when accidentally released into the environment (i.e. water, soil). The mixtures can be directly released into the sewer system. However, if the fluid is severely overheated, it should be incinerated.

Filling and flushing of fluid loop:

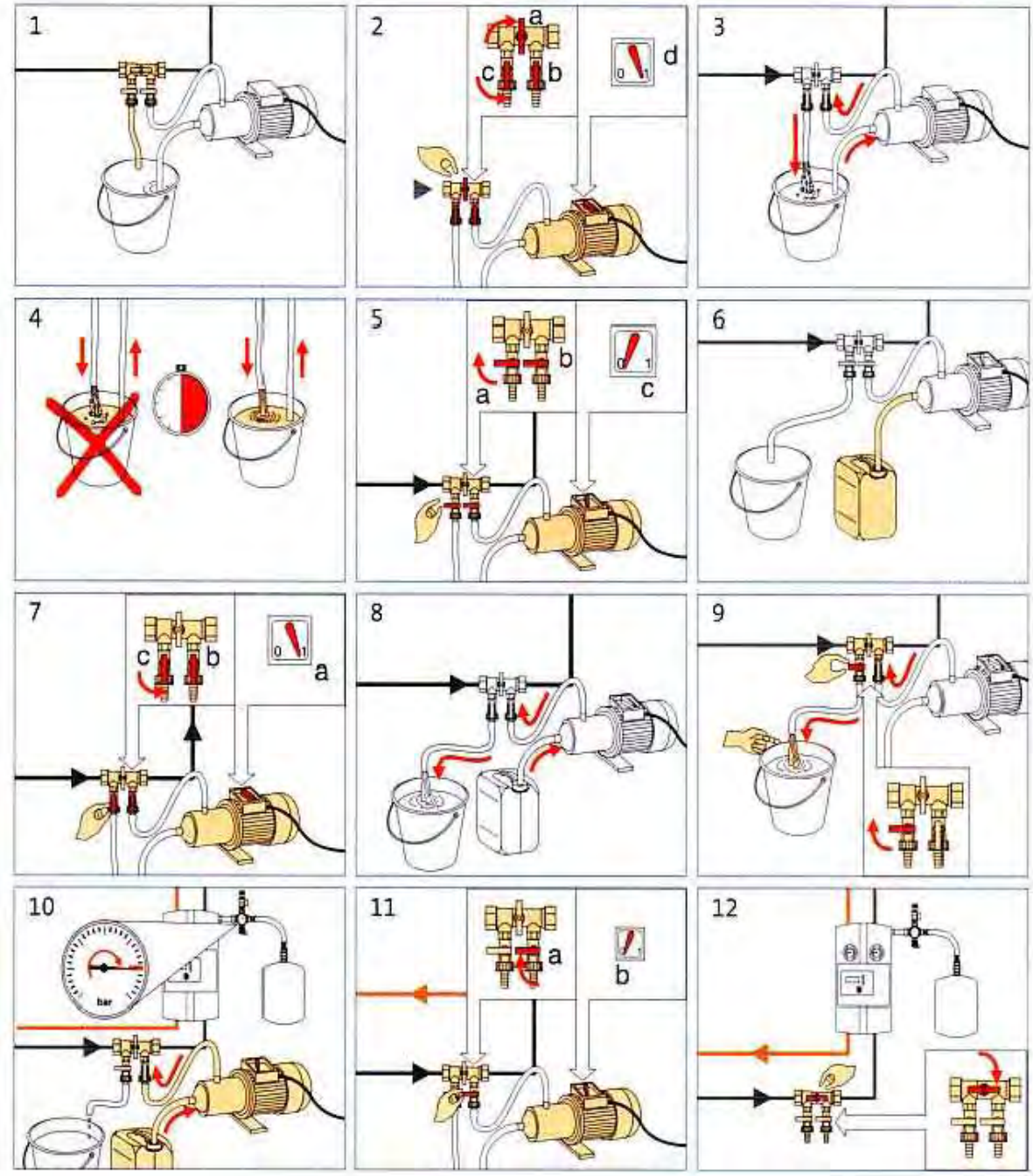

Figure 26: Sequence of steps for filling and testing fluid loop.

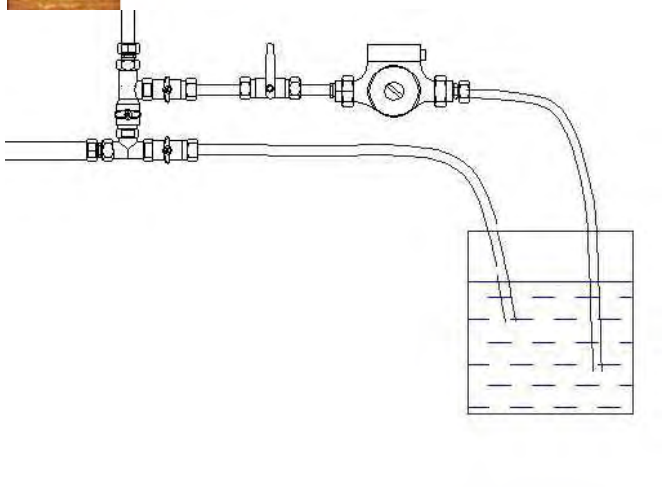

Figure 27: circulation loop cleaning and filling apparatus.

Insulation

Check the system after it has been operated for 24 hours. Remove testing equipment when the system runs well, without leaks or huge pressure changes, and then plug the test holes. Fix piping insulation only after leakage has been checked. Fix the heat preservation material on the pipes. 30mm thick rubber or polyethylene insulation is recommended. The thickness can be adjusted according to the ambient temperature in your area. For pipes exposed to sunshine, bind with anti-ultraviolet radiation material such as aluminum foil adhesive tapes, asbestos belts or asphalt belts.

Cautions:

1. Gloves and eye protection must be used when handling glass tubes
2. avoid scratching or any sudden shock to tubes
3. unpack and install tubes after all pipe work has been completed
4. run the pump to cool the tubes rather than letting them overheat in direct sun
5. In hot water applications, a heat exchanger should be used between the collector and the hot water storage tank if the water has any impurities at all, such as calcium, as deposits can build up inside the tubes.
6. Maximum system pressure is 6 bar (90 psi) with copper u-pipe units, so a suitable pressure relief valve should be used.
7. Leaving tubes exposed to full sun for long periods without running the pump will result in boiling water and reduced system life.
8. Water in tube models are for zero-pressure installations, so can not be used with closed loop systems where pressure may be high.