



FreeFuelForever.com

Solar Water Heaters

Installation Manual

Gravity Solar Water Heater

Evacuated Tube Integrated (Direct) System, unpressurized



Gravity Solar System Installation Manual:

This manual explains how to install a system of evacuated tubes with the collector panels integrated with the storage tank, also referred to as a direct system, which drains by gravity; in other words, the system is unpressurized. Gravity drain integrated systems described here use FreeFuelForever (www.freefuelforever.com) evacuated tube all-glass heat pipe solar water heaters. Gravity drain integrated systems are among the easiest, quickest and simplest to install.

For a general overview of contractor tasks to prepare the site and install a solar water heater, see <http://www.freefuelforever.com/Solar%20Installation%20Tasks.pdf>.



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General System Layout:

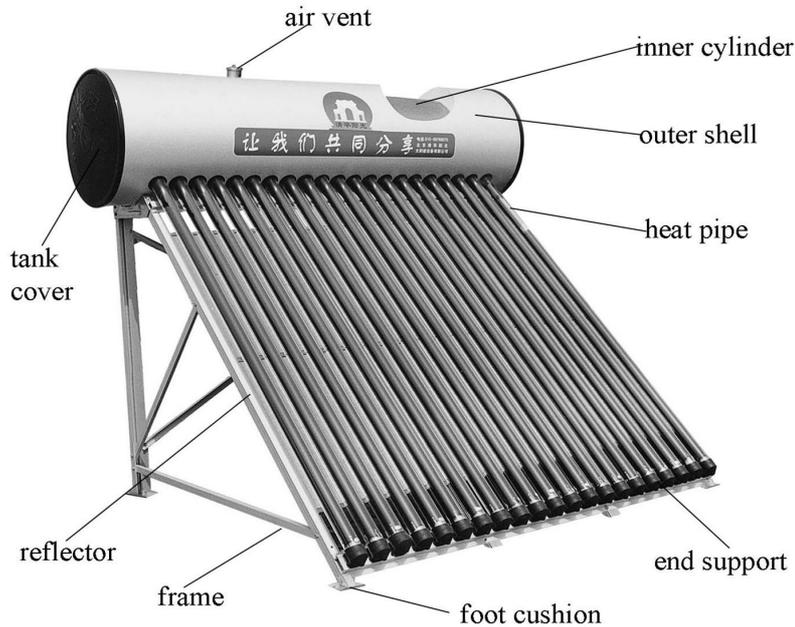


Figure 1: General layout of integrated (direct) gravity solar system

How it works:

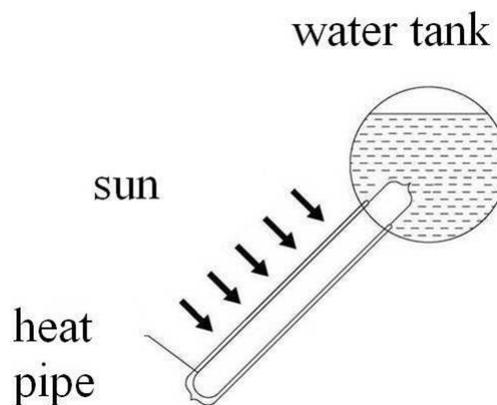


Figure 2: Glass heat pipe inserted into solar water tank.

There are two tricks to the high efficiency of this solar heater. First, a vacuum prevents any conductive or convective heat loss to the environment from the absorber. Second, heat pipes ensure one-way heat transfer from the absorber to the water: the water can



not heat the absorber. The selective coating in the inner cover of the evacuated tubes ensures high energy absorption and low heat radiance losses. The liquid in the inner glass heat pipes changes into vapor which then rises up the heat pipe. When heat is exchanged between the condenser end of the heat pipe and the cold water in the tank, it turns into liquid again, and comes down to the base of the heat pipe. cycle continuously repeats as long as the sun shines. Hot water can be obtained by injecting cold water into the bottom of the tank, with the hot water being forced out the top.

The evacuated tubular collector with heat pipes are quasi-tracking in four seasons, which is to say that as the sun tracks across the sky, about the same absorber area is facing the sun all the time, since the absorber surfaces are cylindrical. The collector will be in operation as long as sun shines. The solar water heater can be in service all year round even in cold climate areas since heat pipes transfer heat in one direction only within the collector and the vacuum prevents convective heat losses.

Unpressurized (Gravity Drain) Solar Water Heater Systems:

All glass heat pipe systems are unpressurized, which means the collector must be on the roof to allow water to drain from the tank by gravity. This means no pump or pressurization is required, nor are any high-pressure fittings required to the solar tank.

Glass heat pipe, unpressurized (gravity) system advantages:

- Lowest cost per liter of water heated
- Glass heat pipes do not corrode
- Can stand freezing temperatures-no water in tube
- No water leaks if bottom of tube broken

Installation Procedure:

Before Assembling Collectors:

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

- ✓ Decide on location of solar hot water system
- ✓ Check access for piping from solar tank to point of use (bathroom tank?)
- ✓ Install pipe runs from solar tank to point of use
- ✓ Pipes should be installed rising slightly to avoid the creation of air pockets
- ✓ Insulate all pipe runs
- ✓ Ensure all valves are open



Unpressurized (Gravity) System Plumbing:



Figure 3: Unpressurized (Gravity) integrated system cutaway schematic.

Unpressurized systems simply drain by gravity. There are several holes in the bottom of the tank: one water inlet (center), a vent, and an overflow, which could either be for hot water out, or for indicating when the tank is full. There are several alternatives on how to use the standpipes and tank, but really only two ways that the system was designed for: manually filling and draining the tank all at once, or using an automatic filler.

1. Automatic Option (most convenient): An economical alternative (\$50) is the automatic filler mechanism. The automatic filler functions in a similar way to a toilet bowl filler, which is unpressurized, but through a float mechanism shuts off the pressurized input water when the tank is full. Pressurized supply water is connected directly to the automatic filler. With the automatic filler, one pipe enters for filling, the hot water out is through overflow hole. The hottest water is on the top of the tank, so this is where the overflow standpipe is located. The other hole is the air inlet vent to allow rapid draining without further water input. Look inside the holes on the bottom of the tank to see which is which-the longest pipe is the vent, the shorter pipe is the overflow, or drain, and the hole without a pipe is the filler, or water input to the bottom of the tank, in the center.
2. Manual Option (most common): With manual filling and draining, plumbing is simple: one pipe. The same pipe is used to fill as to drain the tank. In this case, the overflow vent is used as an indicator. When the tank is full, water comes out the overflow, and water is manually shut off downstairs. A small tube from the overflow vent is run downstairs to show when the tank is full. The water heats up during the day, then the valve downstairs is opened to drain the hot water. This is the best method if all the hot water is required at once, at high flow, as no cold water is added to the tank during use.
3. Not recommended: Some installers use the overflow vent as the hot water outlet and block the air vent, which pressurizes the tank. Hot water flows out whenever cold water is added to the tank. However, the gravity system is not designed for pressure: the rubber seals between the tank and the tubes could leak. (see premium model for a pressurized solar system)

Optional Electric Backup Heater:

An integrated solar water heater requires no plumbing to use as a standalone unit. Simply add water, wait, and use hot water. No electricity, pumps or controls of any kind are required for



basic manual operation. The insulation on the tank is very effective and the heat pipes need only a few hours of sun to keep the water above freezing. This is the most basic and simple configuration. However, hot water temperature will vary.

To use the solar water heater as a year-around hot water supply even in cold climates, install the optional controller and electric heater. In this case, there is no need for a conventional water heater at all. The optional electric controller can function as pump control, electric heating control and time preset. To ensure the cold water supply to the tank does not freeze, insulate the line heavily, or put the bottom of the tank on the warm side of your roof barrier. This configuration is the simplest way to achieve a constant water temperature.

To add the solar water heater to an existing hot water system, such as electric, oil or gas, connect the cold water supply to the solar heater and connect the outlet from the solar heater to where the cold water would normally enter your existing hot water heater. To preserve the option of removing the solar heater from the system for maintenance, use two T-fittings and two valves, so that cold water can either be routed through the solar heater before going to the conventional heater, or directly to the conventional heater. In this way, the solar tank can be drained and the conventional system continues to operate. Using an in-line, on demand water heater, such as a gas unit is efficient, simple and suitable for off-grid living applications.

Pipe work and plumbing:

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

Frame Attachment to 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.
2. Remove roof tiles at the corners of an area large enough to fit the collector (2).
3. Secure a stainless steel band to a rafter using coach screws and washers (3).
4. Replace the roof tiles, leaving the band protruding (4).
5. Secure the collector frame to the bands.

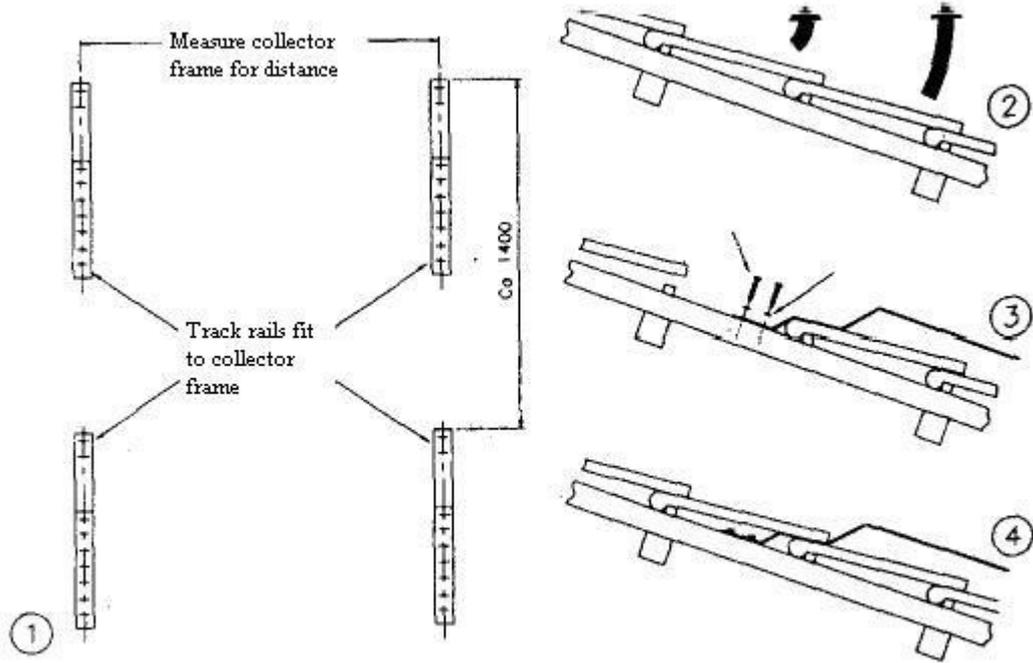


Figure 4: Straps to hold collector on roof.

Complete Solar Water Heater Assembly

All fittings are included in package. Open tube box and check for breakage by observing bottom of tube is silver, not cloudy, which indicates pressure loss. Not all gravity systems have reflectors.



Figure 5: Box of evacuated solar tubes



Assembly Diagram:

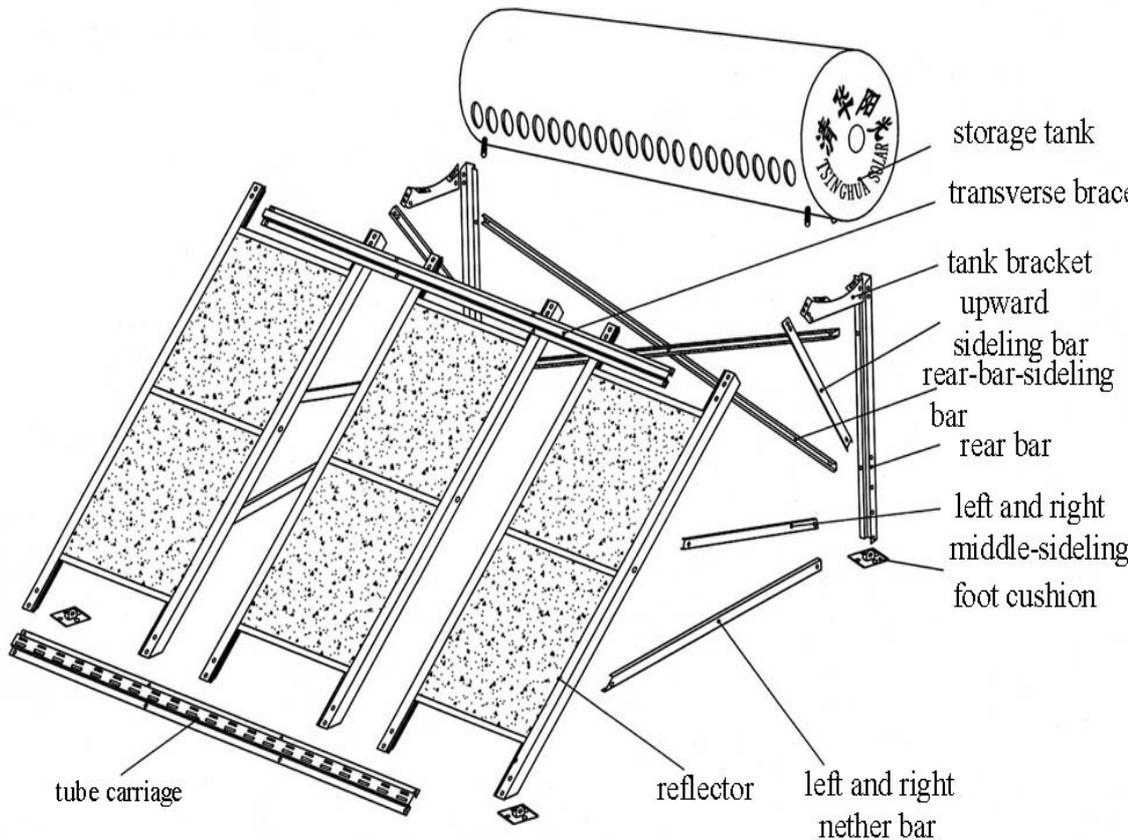


Figure 6: Reflector (optional) and frame assembly

Base Assembly:

Not all models have reflector; skip this step or make your own reflector if your system does not include a reflector. A clean reflector can increase efficiency, but also can collect snow, twigs, dust and debris, depending on the environment.

1. Place the module-type reflectors in parallel;
2. Overlap the holes in the tube carriage (the larger holes facing outside) with the slots in the triangular joint of reflector bar, and then connect them with bolts.
2. Overlap the slots in the transverse braces (the shorter side of transverse brace facing outside) with the slots in the other end of reflector bar, and then connect them with bolts.
4. Cross-connect the rear brace bars with the rear bars using bolts.
5. Make up a level base for the frame as required; facing due south.



Figure 7: Level base for solar heater frame.

Frame Assembly:

1. Push the triangular joint of the stainless steel tank brackets into the gap between transverse braces and horizontal bar, and then attach the braces, brackets and the horizontal bars with bolts; connect the other joint of the brackets with the rear bars.

2. Connect the brace bars and lower braces (tilt angle 45°).

Connect the upward, middle brace bars and lower braces (tilt angle 30°).

3. Fix the foot cushion.

NOTE: Assembly of the unit is not finished; do not fit all the nuts tight until the tubes are installed.

Storage tank assembly:

Lift the storage tank into position on the frame. Two persons make the job easier, and a strap around the tank makes adjusting the position easier.



Figure 8: Lifting the tank into position



Rotate the tank and lower on to the frame. Bolts on the cylinder fit into the slots of the frame brackets. Fit nuts finger tight. Make sure the holes for the tubes are facing forward, with the water connections facing down on the bottom.

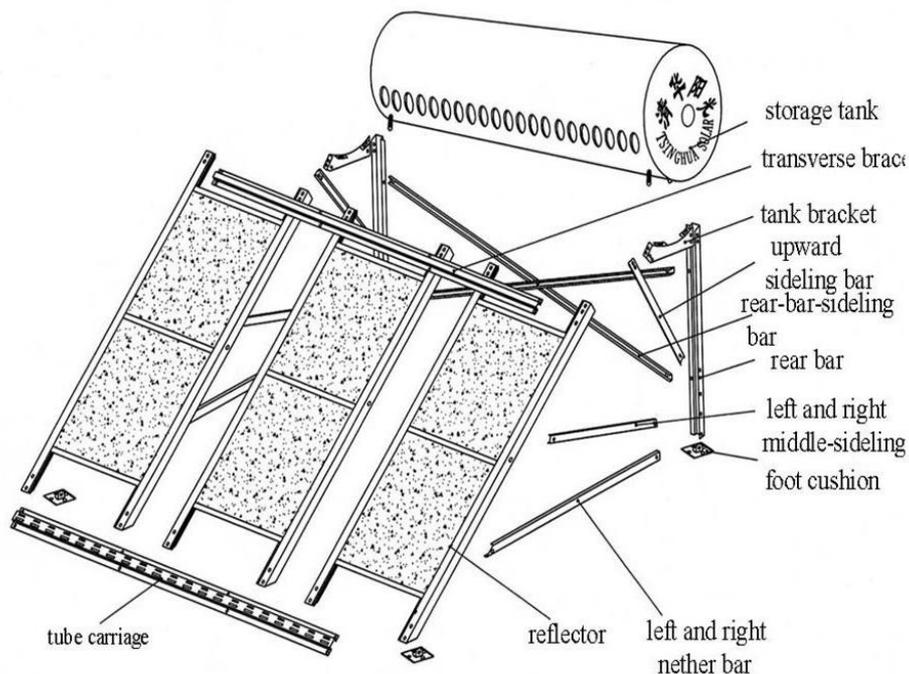


Figure 9: Tank and frame assembly

Push the tube into the locating hole; avoid excessive twisting of the tube to avoid damaging the inner cover of the tube. Do not use any petroleum based lubrication in contact with the silicon seals, as petroleum based lubricants can degrade the seals, leading to leaks. Use vegetable oil or water based lubricants if needed.



Figure 10: Tube inserted in tank.

Insert tube bottom into the plastic end cap protector, then fix the protector into the shorter holes in the bottom tube carriage brace, as well as the left/right flexible fasteners into the longer holes.

Slide the black rubber wind- blocking seals up the tube until its outside edge fits well with the cylinder.

Insert one tube on each side of the tank to achieve alignment of the tank and the frame before proceeding with others.

Fix all the frame nuts tight after all the tubes are assembled to the tank.



All-Glass Heat Pipes:



Figure 11: All glass heat pipe condenser end

All glass heat pipe tubes come pre-assembled and need only be inserted into the water tank.

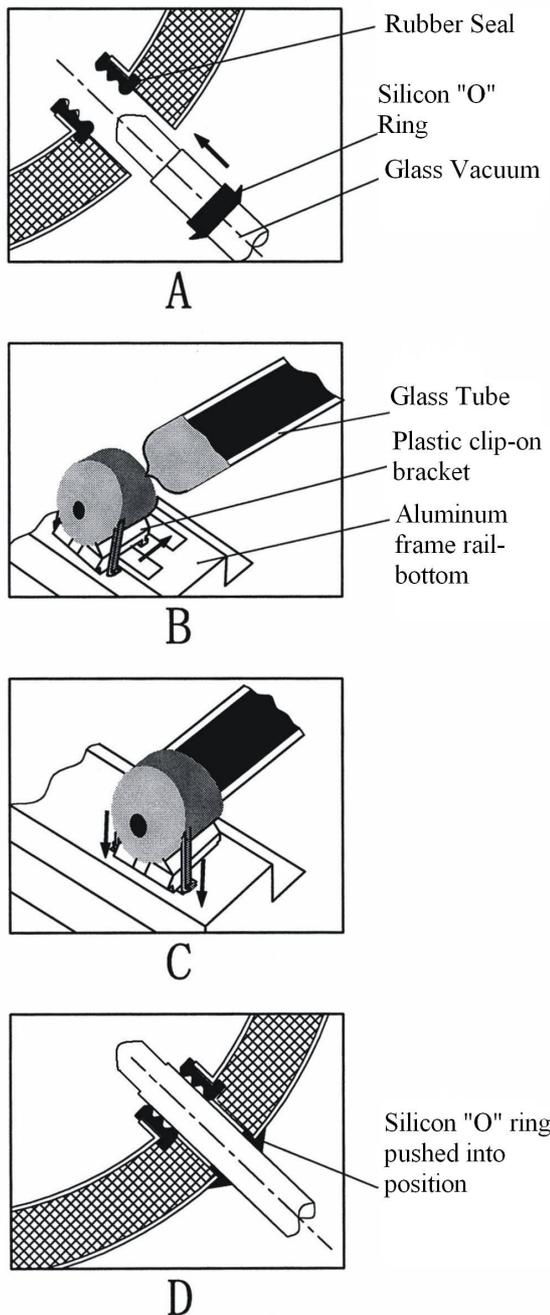


Figure 12: Insertion of glass heat pipes into tank.

Glass heat pipes with rubber collars are used with unpressurized systems. Glass heat pipes, being pre-assembled, need no preparation other than carefully sliding them into the tank after the tank and frame are assembled. The plastic bottom cap (Picture C, Figure 12) snaps into the bottom rail to hold the tube in place. Rubber O-ring seals keep dust out. Do not use petroleum lubricant on silicon seals inside the tank.



Cover the solar tubes to prevent overheating if there is no water in the tank and the tubes are in full sun.



Figure 13: Complete solar heater covered to avoid overheat.

Connect the cold water line in and hot water line out to the bottom of the tank. Insulate all water lines. For the unpressurized (gravity) glass heat pipe system, an automatic water filler shutoff valve can be installed on the bottom of the tank. This 10 cm cylinder-shaped valve allows cold water to flow in until the tank is full. When hot water is used, the valve opens again to keep the tank full, much like a float valve keeps the toilet bowl full of water, but unpressurized. Without an automatic shutoff valve, cold water filling the tank must be shut off manually when the tank is full. Water spills out of the overflow vent when the unpressurized tank is full. A tube attached to the overflow vent leading downstairs can be used as a quick indicator of when the tank is full.

If the optional electric backup heater was purchased, install it now on the bottom of the tank, in the purpose-built mount. See the controller manual download for presetting the desired water temperature. For the unpressurized system, greater water pressures are obtained by placing the solar collector higher than the point of water use, with gravity water pressure from a two story roof being higher than from a one-story roof.



Inspection Checklist:

1. After joining the heat pipes to the tank, check to see if there are any leaks between them. Adjust the connection to ensure there are no leaks.
2. The non-pressurized (gravity) system with glass heat pipes is filled with water, which spills out the overflow vent when the tank is full. Ensure no leaks.
3. A lightening arrester should be considered if you live where thunderstorms are common and the heater is installed at the highest point on your roof.
4. Water piping systems used with solar heating should be of high quality and capable of high temperature operation [100 degrees Celcius]
5. Whatever is supporting the frame (your roof) should be strong enough to avoid damage-remember that water is heavy.
6. All exposed piping should be insulated properly to prevent heat loss and provide freezing protection. In the areas with ambient temperature under -5 Celsius, pipes need freeze protection. The solar water heater will not freeze, but the pipes connected to it also need freeze protection, best accomplished by heavy insulation and keeping the pipes inside the warm envelope of the building for as long as possible. Avoid long outside pipe runs in freezing climates.



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. Leaving tubes exposed to full sun for long periods without water in the tank will eventually degrade performance.
5. Do not use any petroleum based lubricants in contact with silicon seals, as petroleum can degrade silicon; use vegetable or water based lubricants.