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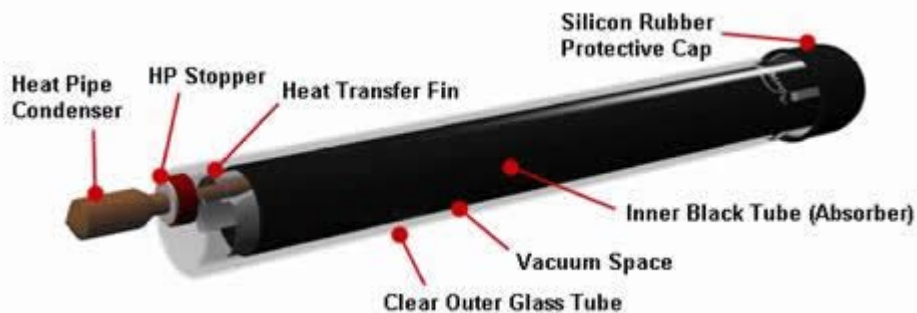
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How Solar Water Heaters Work

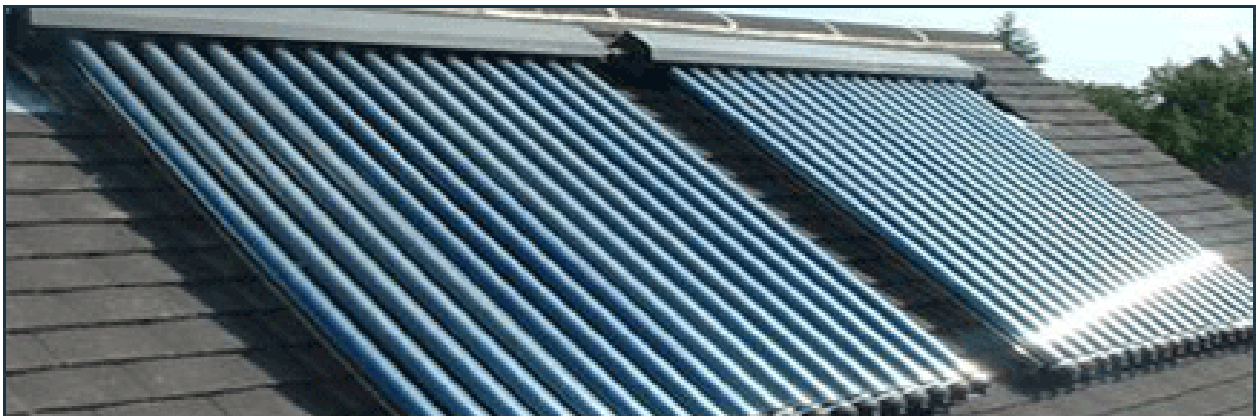
The operation of the solar collector is as follows:

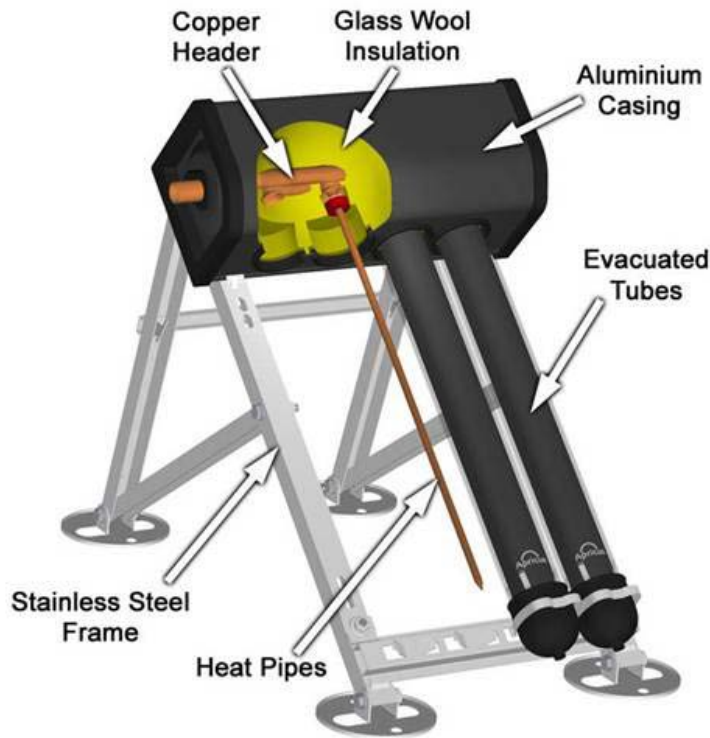
Solar Absorption: Solar thermal energy is absorbed within the evacuated tubes and is converted into usable concentrated heat.

Evacuated Tubes: Are the most efficient thermal collectors on the market, the glass tubes absorb solar thermal energy for use in water heating. The tubes have a double wall, the area between the inner and outer layers of the wall are evacuated (a vacuum). This acts as a thermos to keep heat from escaping into the atmosphere.

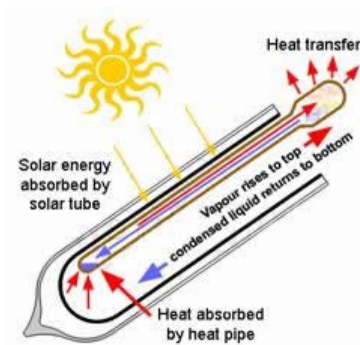


The evacuated tubes are glass tubes manufactured from strengthened borosilicate glass. The tubes have a double outer layer; the outer layer is fully transparent to allow solar energy to pass through unimpeded. The inner layer is treated with a selective optical coating which causes energy absorption without reflection. The inner and outer layers are fused at high temperatures at the end leaving an empty space between the inner and outer layers. All air is pumped out of the space between the two layers (evacuation process) creating the thermos effect which stops conductive and convective transfer of heat which might otherwise escape into the atmosphere. Heat loss is further reduced by the low-emissivity nature of the type of glass that is used.





Heat Pipe: Inside the glass tube is the copper heat pipe. It is a sealed hollow copper tube that contains a small amount of proprietary liquid, which under low pressure boils at a very low temperature. In fact the liquid contained in the heat pipe boils at only 86 oF (30 oC).

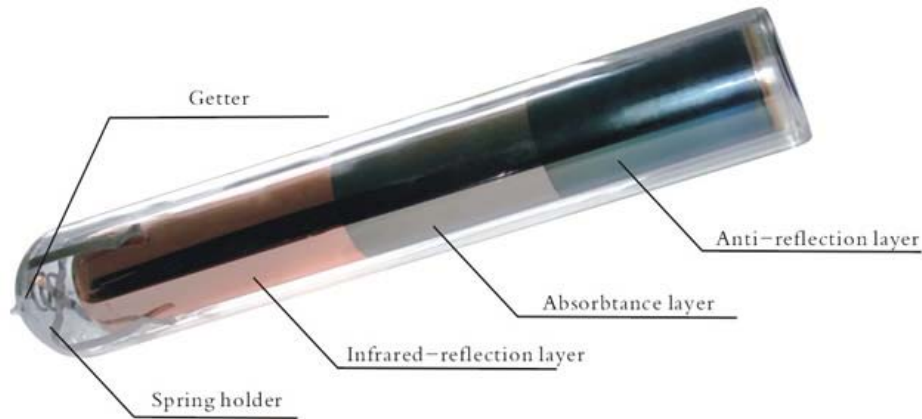


The header is enclosed in the manifold (above).

This heat pipe rapidly and efficiently transfers the captured thermal energy through the evacuated tube and delivers it to the manifold (header) as the liquid boils and rises. As the heat is removed from the heat pipe by the copper header, the liquid condenses and gravity returns it to the base of the heat pipe so that the process is continually repeated.

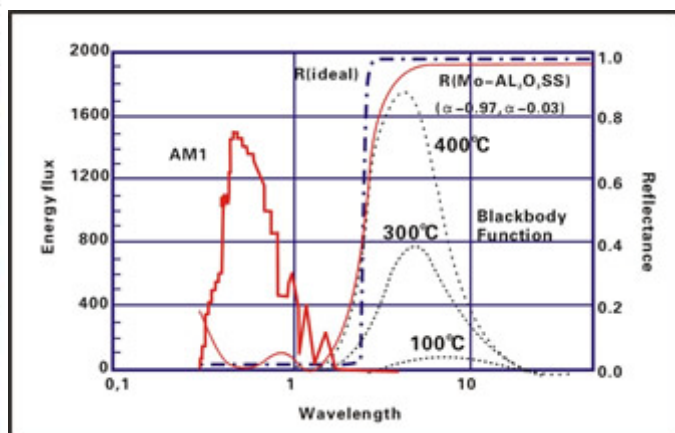
Because the evacuated tubes are round, they serve as a passive tracking solar collector maximizing their performance.

Evacuated tubes are the absorber of the solar water heater. They absorb solar energy converting it into heat for use in water heating. There are several types of evacuated tubes in use in the solar industry. Apricus collectors use the most common "twin-glass tube". This type of tube is chosen for its reliability and performance.



Each evacuated tube consists of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent allowing light rays to pass through with minimal reflection. The inner tube is coated with a special selective coating (Al-N/Al) which features excellent solar radiation absorption and minimal reflection properties. The top of the two tubes are fused together and the air contained in the space between the two layers of glass is pumped out while exposing the tube to high temperatures. This "evacuation" of the gasses forms a vacuum, which is an important factor in the performance of the evacuated tubes.

Why a vacuum? As you would know if you have used a glass lined thermos flask, a vacuum is an excellent insulator. This is important because once the evacuated tube absorbs the radiation from the sun and converts it to heat; we don't want to lose it! The vacuum helps to achieve this. The insulation properties are so good that while the inside of the tube may be 150oC / 304oF, the outer tube is cold to touch. This means that evacuated tube water heaters can perform well even in cold weather when flat plate collectors perform poorly due to heat loss.



In order to maintain the vacuum between the two glass layers, a barium getter is used (the same as in television tubes). During manufacture of the evacuated tube this getter is exposed to high temperatures which cause the bottom of the evacuated tube to be coated with a pure layer of barium. This barium layer actively absorbs any CO, CO₂, N₂, O₂, H₂O and H₂ out-gassed from the evacuated tube during storage and operation, thus helping to maintaining the vacuum. The barium layer also provides a clear visual indicator of the vacuum status. The silver coloured barium layer will turn white if the vacuum is ever lost. This makes it easy to determine whether or not a tube is in good condition. See picture below.



Left Tube = Vacuum Present
Right Tube = Faulty

The Getter is located at the bottom of the evacuated tube.

Evacuated tubes are aligned in parallel; the angle of mounting depends upon the latitude of your location. In a North South orientation the tubes can passively track heat from the sun all day. In an East West orientation they can track the sun all year round.

The efficiency of a evacuated water heater is dependent upon a number of factors, one important one being the level of evacuated radiation (insolation) in your region.

Evacuated Tube Basic Specifications

Length (nominal)	1500mm /1800mm
Outer tube diameter	58mm
Inner tube diameter	47mm
Glass thickness	1.6mm
Thermal expansion	3.3×10^{-6} oC
Material	Borosilicate Glass 3.3
Absorptive Coating	Graded Al-N/Al
Absorptance	>92% (AM1.5)
Emittance	<8% (80oC)
Vacuum	$P < 5 \times 10^{-3}$ Pa
Stagnation Temperature	>200oC
Heat Loss	<0.8W/ (m ² oC)
Maximum Strength	0.8MPa

Types of Solar Water Heating Systems

Solar water heating systems (SWHS) can be either active or passive. An active system uses an electric pump to circulate the fluid through the collector; a passive system has no pump and relies on thermo-siphoning to circulate water. The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, installation angle and orientation. SWHS are also characterized as open loop (also called "direct") or closed loop (also called "indirect"). An open-loop system circulates household (potable) water through the collector. A closed-loop system uses a heat-transfer fluid (water or diluted antifreeze) to collect heat and a heat exchanger to transfer the heat to the household water. A disadvantage of closed looped system is that efficiency is lost during the heat exchange process.

Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. They are usually more expensive than passive systems but generally more efficient. Active systems are often easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors. If installed using a PV panel to operate the pump, an active system can operate even during a power outage.

Open-Loop Active Systems

Open-loop active systems use pumps to circulate household potable water through the collectors. This design is efficient and lowers operating costs but is not appropriate if water is hard or acidic because scale and corrosion will gradually disable the system. Open-loop active systems are popular in regions that do not experience subzero temperatures. Flat plate open-loop systems should never be installed in climates that experience sustained periods of subzero temperatures. The ApricusTM AP solar water heater can be installed in an open loop in areas that experience sub-zero temperatures as long as the solar controller has a low temperature function.

Closed-Loop Active Systems

These systems pump heat-transfer fluids (usually a glycol-water antifreeze mixture) through the solar water heater. Heat exchangers transfer the heat from the fluid to the water that is stored in tanks. Double-walled heat exchangers or twin coil solar tanks prevent contamination of household water. Some standards require double walls when the heat-transfer fluid is anything other than household water. Closed-loop glycol systems are popular in areas subject to extended subzero temperatures because they offer good freeze protection. However, glycol antifreeze systems are more expensive to purchase and install and the glycol must be checked each year and changed every few years, depending on glycol quality and system temperatures.

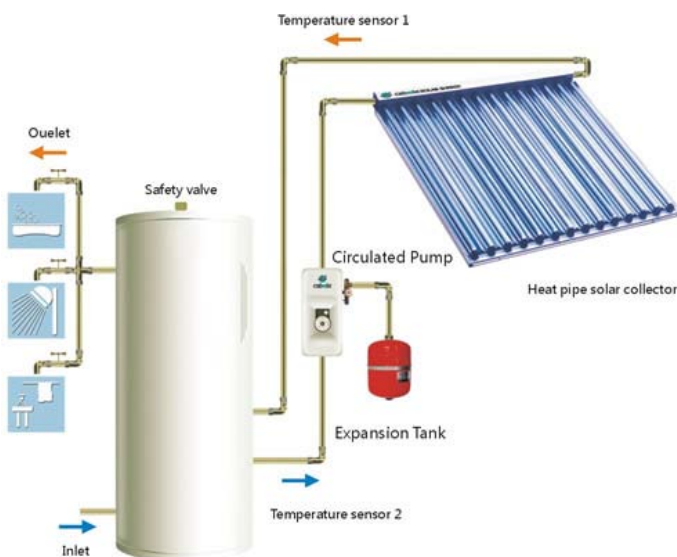
Drain back systems use water as the heat-transfer fluid in the collector loop. A pump circulates the water through the solar water heater. When the pump is turned off, the solar water heater drains off water, which ensures freeze protection and also allows the system to turn off if the water in the storage tank becomes too hot. A problem with drain back systems is that the solar water heater installation and plumbing must be carefully positioned to allow complete drainage. The pump must also have sufficient head pressure to pump the water up to the collector each time the pump starts. Electricity usage is therefore slightly higher than a sealed closed or open loop.

Passive Systems

Passive systems move household water or a heat-transfer fluid through the system without pumps. Passive systems have the advantage that electricity outage and electric pump breakdown are not issues. This makes passive systems generally more reliable, easier to maintain, and possibly longer lasting than active systems. Passive systems are often less expensive than active systems, but are also generally less efficient due to slower water flow rates through the system.

Thermosiphon Systems

A thermosiphon system relies on warm water rising, a phenomenon known as natural convection, to circulate water through the solar absorber and to the tank. In this type of installation, the tank must be located above the absorber tubes/panel. As water in the absorber heats, it becomes lighter and naturally rises into the tank above. Meanwhile, cooler water in the tank flows downwards into the absorber, thus causing circulation throughout the system. This system is widely used with both flat plate and evacuated tube absorbers. The disadvantages of this design are the poor aesthetics of having a large tank on the roof and the issues with structural integrity of the roof. Often the roof must be reinforced to cope with the weight of the tank.



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