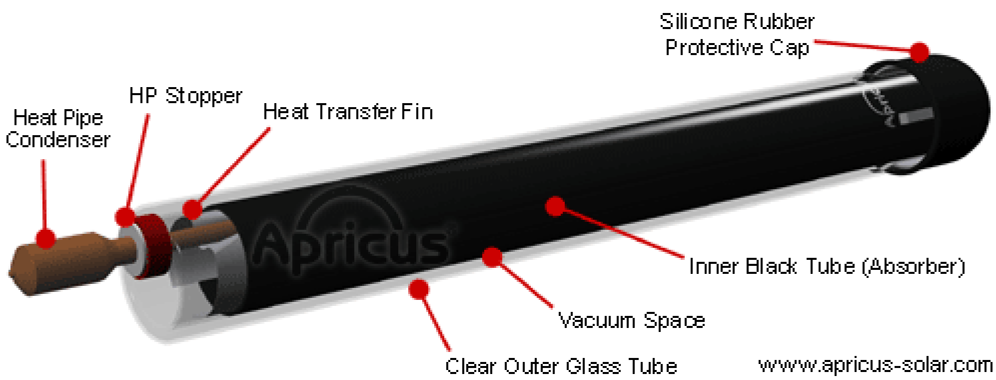
The Apricus solar collector design incorporates 6 main components:

1. Evacuated Tubes
2. Copper Heat Pipes
3. Copper Header Pipe
4. Glass Wool Insulation
5. Manifold Casing
6. Mounting Frame

Evacuated Tube & Heat Pipe



The heat pipe, heat transfer fin and evacuated tube shown above form the heat absorption and transfer portion of the solar collector. Unlike some other evacuated tube heat pipe designs, Apricus evacuated tubes and heat pipes are not joined or fused together. This allows the two components to move independently, allowing for building movement and the expansion and contraction that occurs daily in a solar system. For more information about evacuated tubes click here, heat pipes click here.

Copper Header Pipe

The AP solar collector's header is designed to providing excellent heat transfer and corrosion resistance while using a simple "plug in" installation method.

The key features are as follows

1. Heat pipe ports provide simple plug in installation while still ensuring tight contact with the heat pipes for optimal heat transfer. Thermal heat conduction grease is applied to the heat pipes condenser prior to insertion to further enhance heat transfer. Given the high temperatures that the manifold is exposed to, the expansion of the heat pipe condenser and "setting" of the heat conduction paste results in the heat pipe being firmly held in place. This ensures excellent heat transfer for the life of the solar collector. As the heat pipe is extremely reliable and durable, there is no need to ever remove or replace the heat pipe, even if changing a solar tube.
2. The twin header pipes are molded to match the shape of the heat pipe ports in order to maximize contact area. In addition, the heat pipe ports are brazed to the twin header pipes providing a direct metallic connection.
3. The "contoured" header pipe design produces turbulent water flow enhancing heat transfer.
4. The header pipes are brazed using Ag45CuZn, lead free brazing rods, which are suitable for potable water and provide a strong, quality joint.
5. Available in rear port or end port inlet/outlet configuration.
6. 8mm ID copper temperatures sensor ports at both the inlet and outlet which are brazed directly to the header pipe for accurate temperature measurements.

Glass Wool Insulation

Glass wool is a very popular insulation material, used throughout the world in many high temperature insulation applications. Glass wool is also non-flammable, and so an excellent choice for a high temperature solar thermal solar collector. One key advantage of glass wool is that it can be molded into any shape. Via a process similar to baking a cake, the glass wool is "cooked" at high temperatures matching perfectly the shape of the header and the evacuated tubes.

Glass wool is:
- An excellent insulator K = 0.043W/mK
- Non-flammable (can withstand temperatures up to 300°C / 572°F)
- Made from 90% recycled glass
- Very Lightweight (~70kg/m^3 density - 4.36p/ft^3)

Manifold Casing

The manifold casing serves two main purposes, protecting the header and glass wool insulation from the elements, and making the collector attractive and neat. The casing is made from corrosion resistant grade aluminum and is available in a matt black or silver finish.

Mounting Frame

The Apricus Solar Collector can be installed on most roof surfaces, and a full range of roof angles. A standard frame is provided with all collectors, and additional frame kits are available to suit most common installations. The various frame components can also be used to install on most other non-standard surfaces.

The frames are designed to withstand high speed winds; the tubes provide minimal resistance due to the round shape. Attachment points must also be strong enough to withstand significant pull forces that will occur during strong winds.

Standard Frame

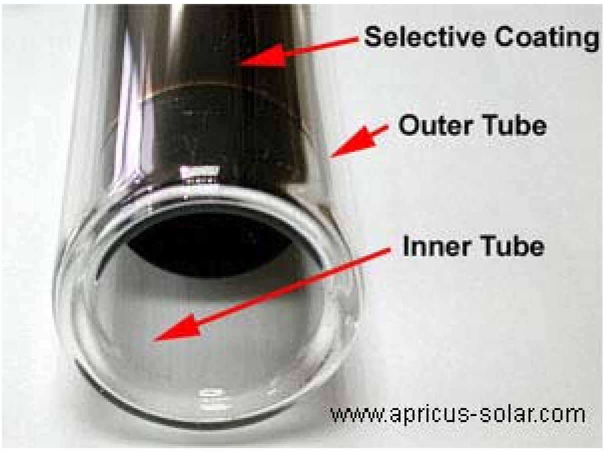
For flush installation on a pitched roof, the standard mounting frame is used. The front tracks are secured to a tiled roof using the stainless steels straps, rubber pads or round feet, depending on the roof's surface.

Low, Mid & High Angle Roof Frames

Frame kits are available which increase the angle of the solar collector, from as little as 12° to as high as 53°, allowing the collector to be installed at an optimal angle. The frames kits even allow mounting on a wall.

Evacuated Tube

Evacuated tubes are the absorber of the solar water heater. They absorb solar energy converting it into heat for use in water heating. Evacuated tubes have already been used for years in Germany, Canada, China and the UK. 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, performance and low manufacturing cost.



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.
Please
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 150°C / 304°F, 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 (during high Delta-T conditions).

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, CO_2, N_2, O_2, H_2O and H_2 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 colored 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.

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

Left Tube = Vacuum Present
Right Tube = Faulty

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.

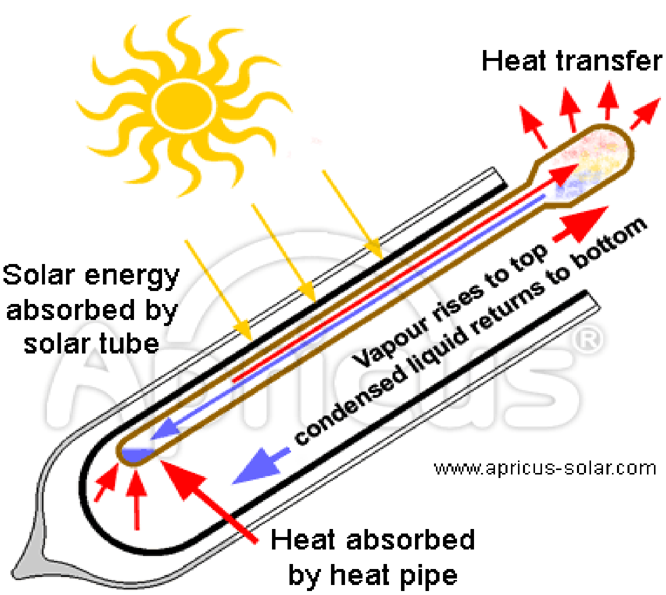
The efficiency of an evacuated water heater is dependent upon a number of factors, one important one being the level of evacuated radiation (insolation) in your region. To learn more about insolation and the average values for your area click here.

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} °C
Material	Borosilicate Glass 3.3
Absorptive Coating	Graded Al-N/Al
Absorptance	>92% (AM1.5)
Emittance	<8% (80°C)
Vacuum	$P<5\times10^{-3}$ Pa
Stagnation Temperature	>200°C
Heat Loss	<0.8W/ (m2°C)
Maximum Strength	0.8MPa

Heat Pipe

Heat pipes might seem like a new concept, but you are probably using them everyday and don't even know it. Laptop computers often using small heat pipes to conduct heat away from the CPU, and air-conditioning system commonly use heat pipes for heat conduction.
The principle behind heat pipe's operation is actually very simple.



Structure and Principle

The heat pipe is hollow with the space inside evacuated, much the same as the solar tube. In this case insulation is not the goal, but rather to alter the state of the liquid inside. Inside the heat pipe is a small quantity of purified water and some special additives. At sea level water boils at 100°C (212°F), but if you climb to the top of a mountain the boiling temperature will be less that 100°C (212°F). This is due to the difference in air pressure.

Based on this principle of water boiling at a lower temperature with decreased air pressure, by evacuating the heat pipe, we can achieve the same result. The heat pipes used in AP solar collectors have a boiling point of only 30°C (86°F). So when the heat pipe is heated above 30°C (86°F) the water vaporizes. This vapor rapidly rises to the top of the heat pipe transferring heat. As the heat is lost at the condenser (top), the vapor condenses to form a liquid (water) and returns to the bottom of the heat pipe to once again repeat the process.

At room temperature the water forms a small ball, much like mercury does when poured out on a flat surface at room temperature. When the heat pipe is shaken, the ball of water can be heard rattling inside. Although it is just water, it sounds like a piece of metal rattling inside.

This explanation makes heat pipes sound very simple. A hollow copper pipe with a little bit of water inside, and the air sucked out! Correct, but in order to achieve this result more than 20 manufacturing procedures are required and with strict quality control.

Quality Control

Material quality and cleaning is extremely important to the creation of a good quality heat pipe. If there are any impurities inside the heat pipe it will affect the performance. The purity of the copper itself must also be very high, containing only trace amounts of oxygen and other elements. If the copper contains too much oxygen or other elements, they will leach out into the vacuum forming a pocket of air in the top of the heat pipe. This has the effect of moving the heat pipe's hottest point (of the heat condenser end) downward away from the condenser. This is obviously detrimental to performance, hence the need to use only very high purity copper.

Often heat pipes use a wick or capillary system to aid the flow of the liquid, but for the heat pipes used in Apricus solar collectors no such system is required as the interior surface of the copper is extremely smooth, allowing efficient flow of the liquid back to the bottom. Also Apricus heat pipes are not installed horizontally. Heat pipes can be designed to transfer heat horizontally, but the cost is much higher.

The heat pipe used in Apricus solar collectors comprises two copper components, the shaft and the condenser. Prior to evacuation, the condenser is brazed to the shaft. Note that the condenser has a much larger diameter than the shaft; this is to provide a large surface area over which heat transfer to the header can occur. The copper used is oxygen free copper, thus ensuring excellent life span and performance.

Each heat pipe is tested for heat transfer performance and exposed to 250°C (482°F) temperatures prior to being approved for use. For this reason the copper heat pipes are relatively soft. Heat pipes that are very stiff have not been exposed to such stringent quality testing, and may form an air pocket in the top over time, thus greatly reducing heat transfer performance.

Freeze Protection

Even though the heat pipe is a vacuum and the boiling point has been reduced to only 25-30°C (86°F), the freezing point is still the same as water at sea level, 0°C (32°F). Because the heat pipe is located within the evacuated glass tube, brief overnight temperatures as low as -20°C (14°F) will not cause the heat pipe to freeze. Plain water heat pipes will be damaged by repeated freezing. The water used in Apricus heat pipes still freezes in cold conditions, but it freezes in a controlled way that does not cause swelling of the copper pipe.