SOLAR WATER HEATING – It's time for plumbers to upskill

by Ian Sumner, Director of Energy Conscious Design Limited*

"In this series of articles I will provide an introduction to solar water heating*, ask the hard questions, expose the myths, and provide guidance on various aspects of solar water heating design and installation. This time we look at the different types of solar collectors and hot water cylinders.

Solar Collectors

The two most common types of solar collectors are flat plate collectors and evacuated tube collectors, both of which have their place in the market, and each ideally suited to different circumstances. We will briefly look at how they work and the differences between the two systems.

Flat plate collectors

Flat plate collectors have been around for decades and are by far the most commonly installed type of solar collector. They consist of an absorber plate and pipework contained within an insulated enclosure with a glazed top surface.

Figure 1: A flat plate collector installation

The solar radiation falls upon and warms the dark surfaced absorber plate; this heat is transferred to the heat transfer fluid (water or a glycol/water mix) flowing in copper tubes which are bonded to the absorbers.

In a pumped system when the heat transfer fluid in the collectors is warmer than the bottom of the hot water cylinder, the fluid is pumped back to and heats the water in the hot water cylinder, either by displacement in the case of water, or through a heat exchanger in the case of a glycol mix.

In a thermosiphon system the heat in the absorber rises into the storage container which sits above the collector *(see article Aug/Sept 2006, p.34)*.

Glazed solar collectors are far more efficient than unglazed collectors as they are able to reduce heat losses by trapping the heat in the collector once it has passed through the glazing. Unglazed collectors are only really used where low temperatures are involved, such as for swimming pool heating.

Absorbers in early flat plate collectors were painted black with high temperature paints, however, although matt black is a good absorber it is also good at reflecting this heat back. Modern day collectors have absorbers coated with a selective surface which reduces this radiated heat loss from the collector and are, therefore, far more efficient than early types. High performance collectors also have a low iron casing glass which allows more radiation to pass through the glass, thereby increasing the performance of the collector further.

The absorber plates are generally copper, bonded to copper riser tubes, with flow and return header pipes; although there are some collectors on the market that have aluminium or steel absorber plates.

The level and type of insulation material is also of particular importance and needs to be suitable for, or protected from, the high temperatures experienced by the solar collectors.

Characteristics of flat plate collectors:

- Reliable and historically proven technology
- Generally more efficient than evacuated tube collectors until the water temperature is 45°C warmer than the ambient temperature
- Easy to clean and maintain.

Evacuated tubes

Evacuated tubes have increased their market share in New Zealand in recent years, mainly due to their production in China and other Asian countries, which has resulted in lower priced systems.

1. Selective coated-copper absorber sheet ultrasonically welded to copper riser pipes to optimise collector efficiency
2. Copper header pipes
3. Copper riser pipes
4. Brass outlets brazed to copper header pipes and manifolds
5. Direct-injected polyurethane insulation coated with aluminium foil
6. Aluminium foil-coated mineral wool insulation to protect the polyurethane insulation and to reduce heat loss from the collector
7. Embossed aluminium protective backsheet
8. Tempered low-iron security glass for increased collector performance
9. Powder coated extruded aluminium housing
10. UV resistant 100% EPDM rubber seals and gaskets
11. Ventilation holes
12. M8 threaded inserts for easy mounting on to roof, profile etc

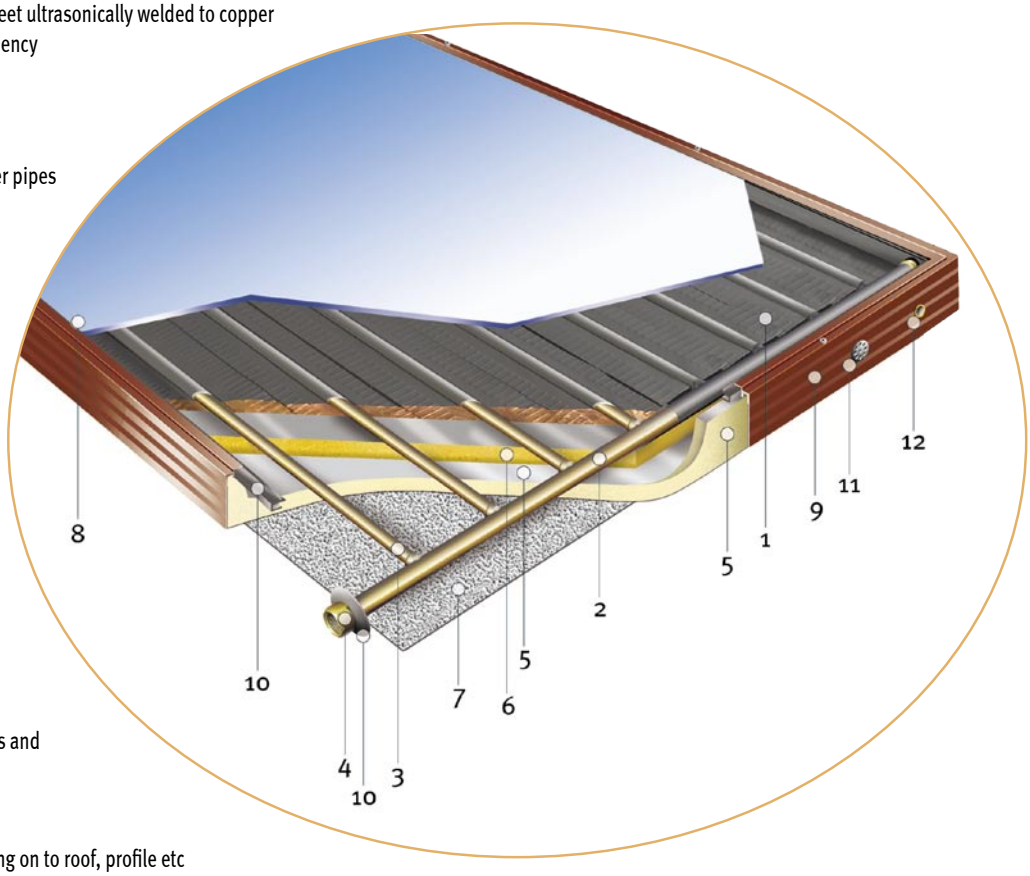

Figure 2: Cut away section of a flat plate collector

Figure 3: An evacuated tube collector installation

Each evacuated tube consists of two concentric glass tubes with a vacuum between. The outer tube is transparent allowing radiation to pass through, the inner tube is coated with a selective coating which absorbs this heat.

The heat is collected by an absorber which could be either a heat pipe or directly heated water tubes.

The heat pipe version has a copper tube passing down the centre of the evacuated tubes to absorb the heat, this heat is transferred up the heat pipe into a header through which colder water passes absorbing the heat from the heat pipe. Directly heated water absorbers have water passing through the centre of the absorber to collect heat.

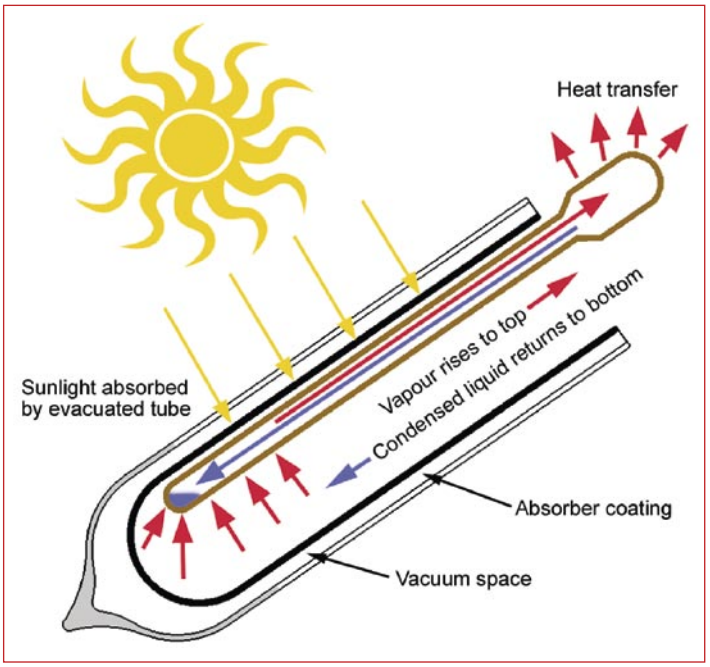

Figure 4: How a heat pipe evacuated tube works

Characteristics of evacuated tube collectors:

- Generally become more efficient than flat plate collectors when the water temperature is 45^{O}C warmer than the ambient temperature
- Generally require more maintenance than flat plate collectors as they can collect tree leaves, and so on
- Some systems can encounter problems with high stagnation temperatures
- Tubes are often broken in transportation to site or during the installation (however, they are easily replaced)
- Requires an enclosure under the tubes to contain broken glass, in the event of tube failure
- Are light and easy to carry onto a roof where they are assembled.

continues on page 45...

Cylinders

There are many options for hot water cylinders.

Low pressure

Low pressure copper cylinders offer a good resiliance to high water temperatures as experienced in solar water heating systems and are historically proven for most areas. There are several areas in New Zealand that suffer from poor water quality and this can result in a significantly reduced life expectancy.

Many households now insist on higher water pressures, and this limits the number of low pressure cylinders being installed.

Medium pressure

Medium pressure copper cylinders offer a good resiliance to high water temperatures as experienced in solar water heating systems and offer increased resiliance to poor quality water than low pressure cylinders. Medium pressure cylinders provide a good reliable cylinder at a lower price than mains pressure cylinders, while offering increased water pressures over low pressure cylinders. In many cases this a good compromise. However, again, many households now insist on higher water pressures, and this limits the number of medium pressure cylinders being installed.

The low and medium pressure cylinder often offer a reduction in water useage, which is becoming increasingly important.

Mains pressure

There are now more options available for purchasers of mains pressure cylinders, including steel-lined and stainless steel cylinders.

Lined steel cylinders are often the lower cost option for mains pressure cylinders. However, care should be taken in their selection for solar water heating systems as many have a relatively low maximum recommended storage temperature. Temperature limitations of between 70 to 85^{O}C are common. Care should also be taken when moving steel cylinders as the internal lining can easily be damaged, which then exposes the steel cylinder to the stored water.

Stainless steel cylinders, especially duplex stainless steel cylinders, have a good resiliance to poor water quality and to the higher water temperatures experienced in solar water heating systems. However their quality, and therefore life expectancy, is very dependent upon the quality and cleanliness of the manufacturing process.

Figure 5: Solar heated cylinder with heat pump backup heating for underfloor heating system

Cylinders with/without heat exchangers

Cylinders can be fabricated with or without internal heat exchangers and there are several configurations available. Unless a heat exchanger is installed, the solar water heating system will operate as a direct (open loop) system, that is, the water contained within the cylinder that is drawn off at the taps is also the water that circulates through the solar collector.

Most existing cylinders do not have an internal heat exchanger and, therefore, if a solar system is being retrofitted onto an existing cylinder, the solar heating system will generally need to operate as a direct system, that is unless an external or retrofit heat exchanger is installed.

If a new cylinder is being specified it is cost-effective to manufacture it with a heat exchanger, and these cylinders are available from several manufacturers in New Zealand.

Cylinder capacity

Domestic solar heated cylinders are generally sized on the basis of 75 litres of water storage per occupant. This commonly results in the installed cylinder being of a greater capacity than would otherwise be installed. This results in several issues:

- Space allocation and structural loading for the cylinder, although many cylinder manufactures can produce cylinders to suit the space available.
- Existing cylinder storage capacity is often only suitable for two to three people and therefore retrofit solar systems, where the solar system utilises the existing hot water cylinder, are only suitable for smaller households. Retrofit systems will be covered in more detail in a future article.

Horizontal versus vertical cylinders

Vertical cylinders are invariably more efficient than horizontal cylinders. However, site limitations may dictate that a horizontal cylinder be installed.

Most thermosiphon systems are designed as a close-coupled package of collector and storage container, with the storage container invariably horizontal for aesethtic reasons as it will be installed on a roof where a horizontal cylinder blends in better than a vertical cylinder.

Although there are issues to manage when designing or installing solar water heating systems, many of the problems encountered in systems that have failed, are easy to resolve in the design process. Surveys undertaken to date have shown that many of the reasons for customer disatisfaction relate to either over-selling the benefits of solar water heating or poor plumbing practice, rather than issues associated specifically with the installation of solar water heating.

The next article will look at system control, frost protection and over-heating, all of which must be well managed to ensure years of trouble free cost effective savings. Future articles will cover maintenance, safety precautions and system handover, as well as training and Government funding."

*Ian Sumner of Energy Conscious Design Limited previously worked as a plumber. He subsequently completed a degree in building services design and his thesis sought to get solar hot water to be cost effective in the UK. He also has extensive building services consultancy experience in New Zealand.

Ian says that: "This series of articles is intended to be an introduction to solar water heating only and I do not intend to provide specific design advice." He adds that for more detailed information ask for a free copy of the latest Ecosolar solar hot water installation guide, and/or send any questions or requests for topics you would like him to cover, to ian@ecosolar.co.nz or telephone 0800 ECOSOLAR (0800 32676527).