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

by Ian Sumner, Director of Energy Conscious Design Limited*

This series of articles provides an introduction to solar water heating, asks the hard questions, exposes the myths, and provides guidance on various aspects of solar water heating design and installation. This time Ian Sumner looks at solar system control.

System control overview

"A well designed system will include a level of control that maximises energy savings while allowing the end user to manage the system, supplies hot water on demand and minimises the risks associated with Legionella forming in the cylinder. The level of control is dependent on the user requirements and the type of system installed.

Thermosyphon systems

Thermosyphon systems by their very nature require less control than pumped systems. If there is sufficient solar gain to heat the water contained in the solar collector, the water will rise into the cylinder to be replaced by colder water from the cylinder. Thermosyphon systems should incorporate a control system that is able to inform the user of the cylinder temperature, both at the top and bottom of the cylinder, and allow the backup heating, such as the electric element, to be easily managed.

Pumped systems

In addition to the control requirements of the thermosyphon systems, pumped solar systems also need a differential temperature controller to only turn on the ciculating pump when there is heat to be recovered from the collector, that is, when the water temperature in the collector is warmer than that of the water in the bottom of the cylinder.

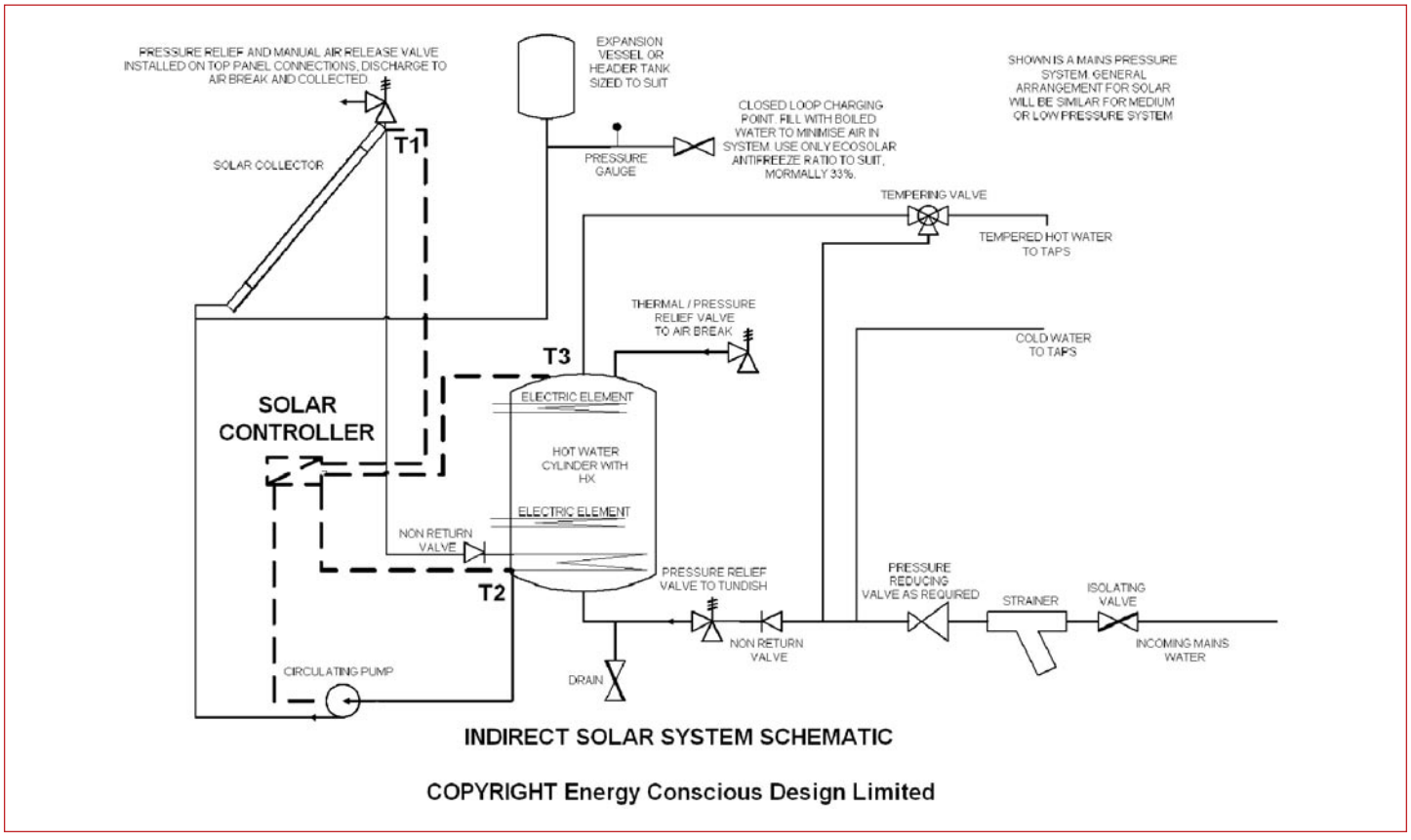

Figure 1: Closed loop solar system showing the placement of the temperature sensors, T1, T2 and T3, in the top of the collector, bottom and top of the cylinder respectively.

Temperature sensor installation

Temperature sensors should be installed so that they monitor the water temperature and are not influenced too greatly by their surroundings. Sensors are often installed in dry pockets and attached to the surface of the actual water cylinder vessel. A heat transfer paste should be used to improve heat transfer between the surface being measured and the temperature sensor. The sensor should also be adequately insulated from the ambient conditions.

System controllers

In addition to the minimum control requirements outlined above, good modern controllers, while being user and installer-friendly and looking good, are able to:

- Continually display system temperatures in the collector, bottom and top of the cylinder.
- Monitor the control system and sensors and provide fault diagnosis.
- Provide an indication of the heating output from the solar collector and record the quantity of heat recived from the solar collector.
- Provide a collector defrost function, turning on the pump to circulate water from the cylinder to the collector to raise the collector temperature if the collector temperature has dropped to a point where there is a potential of freezing. *(See also future article on frost control.)*
- Manage the water temperature to provide sufficient hot water and to control the risk of Legionella.
- Limit the maximum water temperature in the cylinder to within the manufacturer's guidelines. Many cylinders have to have the maximum water temperature limited in order to prevent damage to the cylinder, including any internal lining.

More advanced control is also cost-effectively available to provide:

- Control of multiple systems thereby allowing a single bank of solar collectors to heat multiple hot water cylinders, swimming or spa pools. This is especially beneficial in larger homes that often have more than one domestic hot water cylinder. Historically, multiple cylinders have required multiple arrays of solar collectors; however, modern controllers can heat several cylinders from one array of solar collectors. It's also possible to control multiple arrays of solar collectors in different locations, such as when collectors cannot be installed facing north and are instead installed facing east and west. Each array is monitored, and the pump turned on, only when there is heat to recover from that particular array.
- Backup heating controllers to allow the user to manually turn on the backup heating. 'One Shot' controllers allow the user to choose if the backup heating should be turned on and initiate the heating once only, that is, the controller will automatically turn off the heating once the water is up to temperature, and will not turn it on again when the water temperature drops. These cost effective backup heating controllers will save considerable energy as, in the past, if a solar system was unable to provide sufficient hot water the backup heating was manually turned on, but often the user forgot to turn it back off again, resulting in considerable energy use.
- Daily timers which are able to control multiple outputs. This function is often used to automate the backup heating. The controller will determine if there is sufficient hot water available at a predetermined time of day and automatically turn on and off the heating as required.
- Water temperature management for Legionella control. Solar systems incorporate a larger cylinder than is the norm in conventional domestic hot water systems. These larger cylinders often have multiple elements to allow cost effective water temperature boosting using the high level element, and the low level element can be periodically initiated to limit the risk of Legionella.
- Additional sensor inputs. Larger and more complex solar systems require additional temperature sensors either for monitoring or to log data.
- Data logging. Some modern controllers are able to provide full data logging facilities, such as the Ecosolar UVR61 shown below. This controller is able to provide data logging of up to six inputs, including solar radiation, water and ambient temperatures and water flow rates to provide a picture of the system performance. A USB interface allows for easy connection to a normal computer to provide daily data graphs of the monitored sensors and system performance, and this data can also be exported to Microsoft Excel.

Figure 2: Modern user-friendly solar controller with clear to read LCD display to show system temperatures, fault diagnosis and heat outputs.

Figure 3: An advanced modern controller provides more advanced system control and data logging to satisfy even the most demanding of system requirements.

Controlling existing HWC heating source

Once the solar hot water system is installed the existing hot water heating source needs to be managed to minimise the energy consumed heating water; maximise the use of the solar heating system; and minimise the risk of Legionella forming within the hot water cylinder and system.

Under normal circumstances the heating source is turned off, and is only turned on when additional hot water is required or to minimise the risk of Legionella. There are several options to manage the heating source, manually or automatically.

The first and most popular method is for the occupants to monitor the temperature within the hot water cylinder, using the controller, to make sure there's sufficient hot water for their

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requirements. The temperature below which additional hot water is required will vary from household to household, and the occupants will determine this temperature over time. If additional hot water is needed the backup heating should be able to be turned on, and once the water is up to temperature should be automatically turned off. This manual control, providing the heating is automatically turned off, should result in the backup heating being on the least amount of time and provide the greatest savings.

Figure 4: 'One Shot' backup heating controller allows manual control of the backup heating. The heating is manually turned on and will be automatically turned off, maximising the savings from the solar system.

Modern controllers are able to automate the process by determining if there is sufficient hot water in the cylinder at the end of the day once the solar radiation obtained from the sun has been maximised, and automatically turn on and off the heating as required.

Some systems rely upon a large cylinder with two or more immersion heaters, the ones at high level being permanently switched on. Although this provides a continual supply of hot water, its operation increases the amount of energy consumed and reduces the amount of energy savings the user is likely to achieve. Another option, although having a greater capital cost, is to install a preheating solar system. *(These options will be discussed in greater detail in a future article.)*

For maximum savings when installing solar onto gas heated cylinders a solenoid valve is installed on the main gas burner line to hold off the main burner, the solenoid is then initiated by a timer. *(This will also be covered later in this series of articles.)*

Legionella

Unless the hot water cylinder is being heated regularly to greater than 60^{o}C, there's a risk of Legionella establishing itself in the hot water cylinder. Experts in Legionella recommend that the water be heated to 60^{o}C once a week. This function can be manually managed by the user, or automatically by some modern controllers. If this function is being managed manually, it is recommended that if the water needs additional heating that it be heated at the same time each week, this way the management will hopefully become habitual. If the cylinder has two immersion heaters the lower one should be initiated for Legionella control to maximise the amount of water heated.

Note that the above will limit, but not prevent, Legionella from establishing itself in the hot water cylinder or elsewhere in the water system.

In the next issue we look at frost protection, and how making the right choice early on will minimise the risk of the collectors freezing and maximise the savings for the user. Further articles look at different solar installations and pipework configurations, maintenance, safety precautions and system handover, as well as training and Government funding. We will also look at the common problems and errors made when designing and installing systems."

*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 are 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).