

U.S. Department of Energy - Energy Efficiency and Renewable Energy Energy Savers

Heat Exchangers for Solar Water Heating Systems

Solar water heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid or air used to heat water or a space.

Heat exchangers can be made of steel, copper, bronze, stainless steel, aluminum, or cast iron. Solar heating systems usually use copper, because it is a good thermal conductor and has greater resistance to corrosion.

Types of Heat Exchangers

Solar water heating systems use three types of heat exchangers:

- **Liquid-to-liquid**

This heat exchanger uses a [heat-transfer fluid](#) that circulates through the solar collector, absorbs heat, and then flows through a heat exchanger to transfer its heat to water in a storage tank. Heat-transfer fluids, such as antifreeze, protect the solar collector from freezing in cold weather. Liquid-to-liquid heat exchangers have either one or two barriers (single wall or double wall) between the heat-transfer fluid and the domestic water supply.

A single-wall heat exchanger is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water. Double-wall heat exchangers have two walls between the two fluids. Two walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol (antifreeze). Double walls are often required as a safety measure in case of leaks, helping ensure that the antifreeze does not mix with the potable water supply. An example of a double-wall, liquid-to-liquid heat exchanger is the "wrap-around heat exchanger," in which a tube is wrapped around and bonded to the outside of a hot water tank. The tube must be adequately insulated to reduce heat losses.

While double-wall heat exchangers increase safety, they are less efficient because heat must transfer through two surfaces rather than one. To transfer the same amount of heat, a double-wall heat exchanger must be larger than a single-wall exchanger.

- **Air-to-liquid**

Solar heating systems with air heater collectors usually do not need a heat exchanger between the solar collector and the air distribution system. Those systems with air heater collectors that heat water use air-to-liquid heat exchangers, which are similar to liquid-to-air heat exchangers.

Heat Exchanger Designs

There are many heat exchanger designs. Here are some common ones:

- **Coil-in-tank**

The heat exchanger is a coil of tubing in the storage tank. It can be a single tube (single-wall heat exchanger) or the thickness of two tubes (double-wall heat exchanger). A less efficient alternative is to place the coil on the outside of the collector tank with a cover of insulation.

- **Shell-and-tube**

The heat exchanger is separate from (external to) the storage tank. It has two separate fluid loops inside a case or shell. The fluids flow in opposite directions to each other through the heat exchanger, maximizing heat transfer. In one loop, the fluid to be heated (such as potable water) circulates through the inner tubes. In the second loop, the heat-transfer fluid flows between the shell and the tubes of water. The tubes and shell should be made of the same material. When the collector or heat-transfer fluid is toxic, double-wall tubes are used, and a non-toxic intermediary transfer fluid is placed between the outer and inner walls of the tubes.

- **Tube-in-tube**

In this very efficient design, the tubes of water and the heat-transfer fluid are in direct thermal contact with each other. The water and the heat-transfer fluid flow in opposite directions to each other. This type of heat exchanger has two loops similar to those described in the shell-and-tube heat exchanger.

Sizing

A heat exchanger must be sized correctly to be effective. There are many factors to consider for proper sizing, including the following:

- Type of heat exchanger
- Characteristics of the heat-transfer fluid (specific heat, viscosity, and density)
- Flow rate
- Inlet and outlet temperatures for each fluid.

Usually, manufacturers will supply heat transfer ratings for their heat exchangers (in Btu/hour) for various fluid temperatures and flow rates. Also, the size of a heat exchanger's surface area affects its speed and efficiency: a large surface area transfers heat faster and more efficiently.

Installation

For the best performance, always follow the manufacturer's installation recommendations for the heat exchanger. Be sure to choose a heat-transfer fluid that is compatible with the type of heat exchanger you will be using. If you want to build your own heat exchanger, be aware that using different metals in heat exchanger construction may cause corrosion. Also, because dissimilar metals have different thermal expansion and contraction characteristics, leaks or cracks may develop. Either of these conditions may reduce the life span of your heat exchanger.

For more information about residential solar water heating systems, see:

- [Solar Water Heaters](#)
- [Heat-Transfer Fluids for Solar Water Heating Systems](#)

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