SECTION 2:
END USES OF THE SOLAR ENERGY

by Radiantec Company

In Section 1, we discussed the construction of the solar loop. At the solar collector, the sun's energy is turned into heat in the form of a hot antifreeze solution.

In this section we will dicuss construction of systems that will transform this energy into something that is useful to us. This usually involves the use of a ***heat exchanger.***

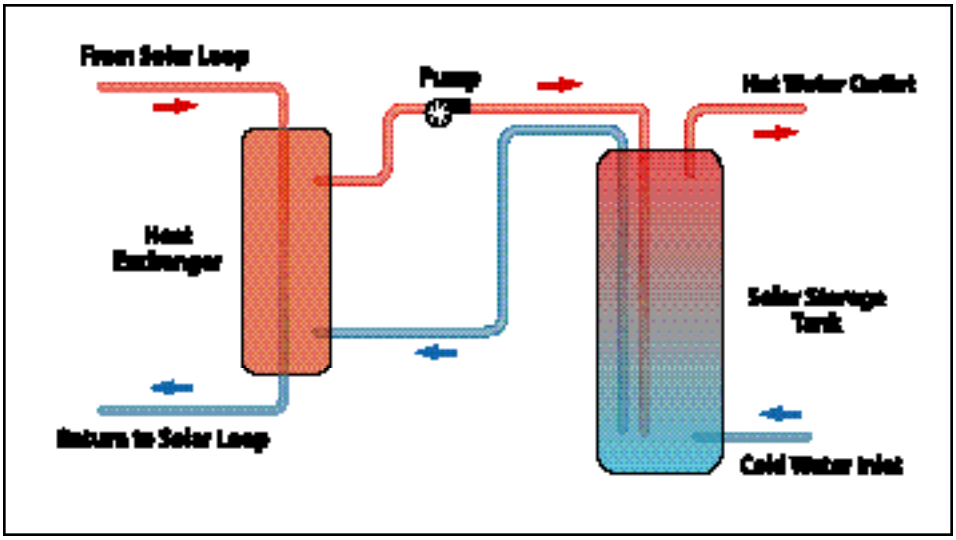
The FUNDAMENTALS publication has additional information about heat exchangers. In this section, we define a heat exchanger as **a device that exchanges the heat within one material (or fluid) to another material (or fluid) without a mixing of the materials.**

DOMESTIC HOT WATER

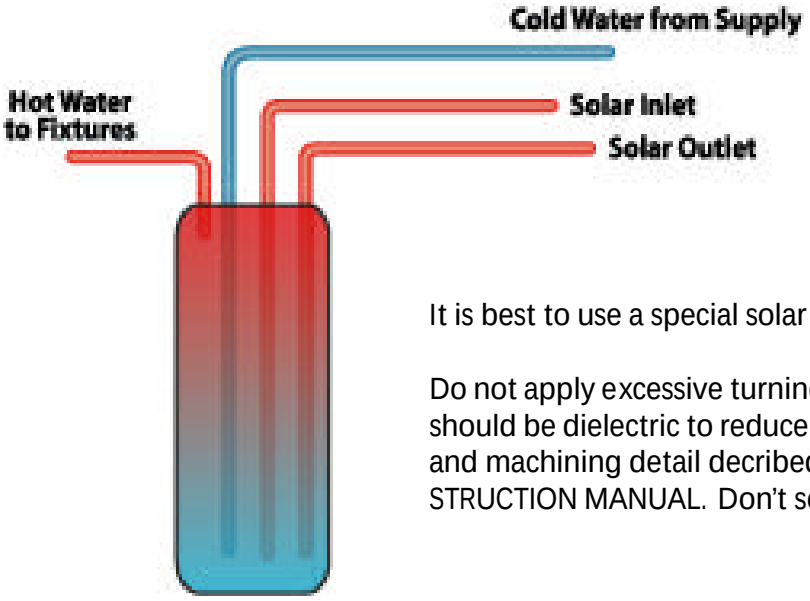
In general,there are three common ways to make domestic hot water with the heated antifreeze solution that the solar loop will provide. They are:

1. **An external heat exchanger**
2. **A wrap-around type**
3. **An immersion type**

External Heat Exchange



Heat exchangers



Solar storage tank with extra dip tubes

It is best to use a special solar tank with extra dip tubes.

Do not apply excessive turning pressure to the fittings which should be dielectric to reduce corrosion.Instead, use the mating and machining detail decribed on page 12 of the SOLAR CONSTRUCTION MANUAL. Don't solder directly to them.

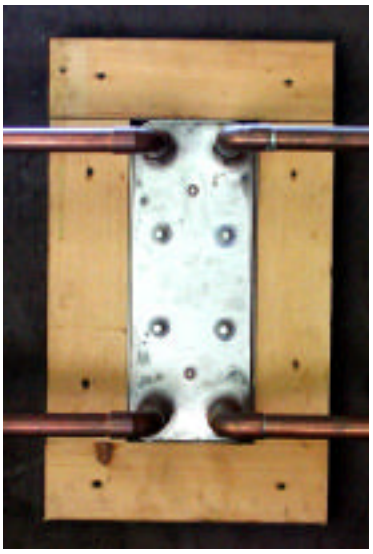
This is a safe and efficient way to mount a stainless steel, plate-type heat exchanger.

Mount a piece of foam insulation board to the wall with glue. Make a sturdy wooden frame for the heat exchanger. Screw the frame to the wall (through the foam board) with long lag bolts. Attach the pipes to the heat exchanger and cover with another piece of foam insulation.

The domestic hot water storage tank will have two extra dip tubes. It may also have an auxiliary electric element.

The advantage of this approach is the separation of components. If one component fails, it does not disable the other. There is more flexibility in design.

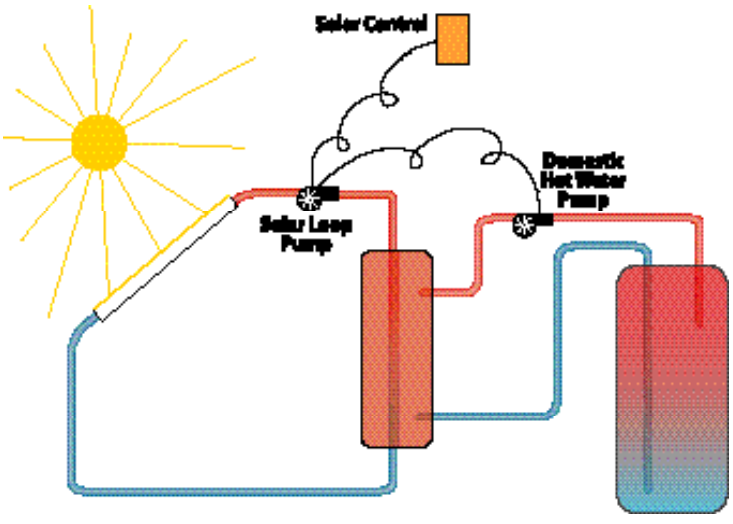
A disadvantage is the somewhat higher cost and the complexity of a second pump.



Deatil of mounted heat exchanger

CONTROL OF THE DOMESTIC HOT WATER PRODUCTION

Connect the pump for the domestic hot water directly to the solar loop pump so that the solar controller will turn them both on and off at the same time.



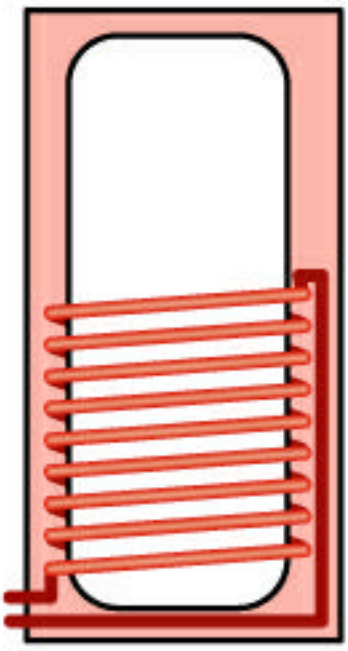
USING A WRAP-AROUND HEAT EXCHANGER

The advantage of this approach is that the solar antifreeze solution is highly unlikely to contaminate the potable domestic hot water heater (double wall, vented separation). There is simplicity and mechanical elegance in the avoidance of the second pump.

The disadvantage is that if one component fails, it will disable the other component with it, and there will be somewhat less flexibility in design. At present, when you buy the tank, you get whatever heat exchanger comes with it.

Use the same precautions as above when attaching the fittings. The hot solar fluid should come in at the top attachment to the wrap-around heat exchanger and exit at the bottom for a little extra efficiency.

CONTROL OF THE HEATING PROCESS— Fluid from the Solar Loop should flow to the domestic hot water heat exchanger whenever the Solar Loop is operating. There is no need for a separate domestic hot water pump because the heat is transferred from the solar fluid to the tank directly by conduction.



Wrap-around type

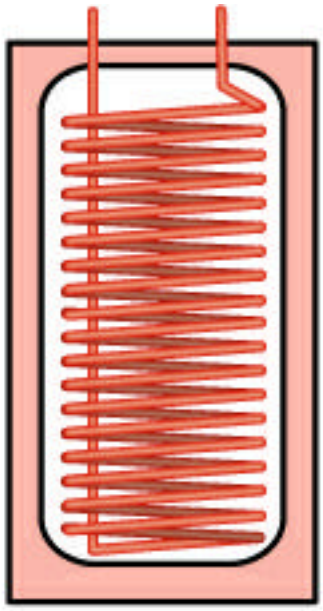
USING AN IMMERSION HEAT EXCHANGER

The domestic hot water heater with an immersion type of heat exchanger is mechanically identical to the wrap-around type with the exception that the heat exchanger is within the heated fluid. Extra precaution must be taken to avoid contamination of the potable domestic hot water.

Higher efficiency and performance are possible because of immersion of the whole heat exchanger and often, higher storage capacities are available.

The same cautions about attaching to fittings apply.

CONTROL OF THE HEATING PROCESS— Same as with the wrap-around type.



Immersion type

HEAT DUMP

The solar heating system should have a good way to deal with potential overheating, particularly in the summer when space heating is not needed. At Radiantec, we design the domestic hot water use to always be "on", even if everything else is "off". This is because solar collectors should not stagnate in the sun with nothing to do. Because domestic hot water is a year around use, we design the heat dump into the domestic hot water.

Control of overheating is achieved in several ways.

1. If the solar panels are set at an angle that directly faces the winter sun, they will be set considerably off the direct angle in mid-summer. This orientation will greatly lower summer performance at high temperatures. Some designers specify a lower efficiency heat exchanger for the domestic hot water heater on the theory that during the winter, the space heating will pick up any heat that the hot water heater misses, and in the summer, a high efficiency heat exchanger will only cause overheating.

2. A simple shut off. Many solar controllers deal with potential overheating in this manner. Solar collectors must be able to withstand stagnation conditions because it can happen as a result of power failure or mechanical failure. Some medium temperature flat plate solar collectors can rise in temperature to 275° F if they stagnate in the direct sunlight. An antifreeze solution will also raise the boiling point of the solar fluid. Certification standards specify that the solar collectors must be able to stagnate for a period of 30 days without damage or loss of efficiency. Nevertheless, Radiantec does not recommend stagnation as the primary control strategy although it can be retained as a backup.

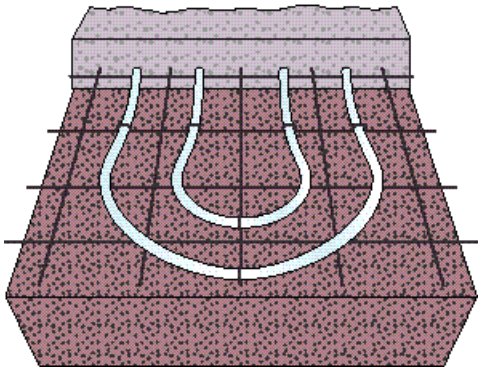
3. Operation of the "Temperature and Pressure Relief Valve". Every domestic hot water tank is required to have a relief valve that will open at 200° F. But this is only intended to be a last ditch emergency device. While reassuring, this valve is not designed to operate frequently, and will start to leak eventually if it is used often. It can also dump the entire contents of the tank instead of just a little.

4. The heat dump. The heat dump is a reliable, effective, and low cost way to control excess temperatures. It is our preferred method for controlling excess temperatures. When a sensor detects unwanted high temperatures, a control will open a solenoid valve and dump a small amount of hot water down the drain. (See the Appendix section for a detailed discussion of control issues, and see the Control section for detailed wiring suggestions.)

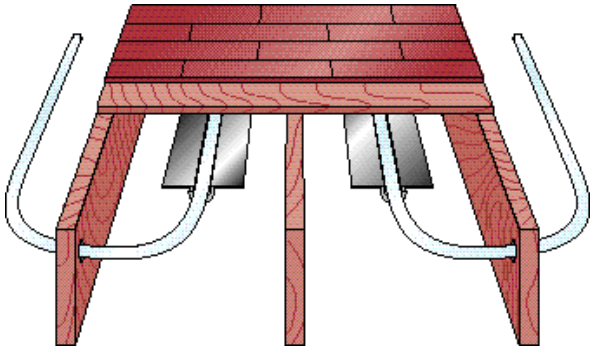
Controller

The Heat Dump Valve can be located on any hot water supply pipe. A laundry room placement is convenient because the washing machine drain can be used.

SPACE HEATING USING SOLAR ENERGY



Concrete installation



Floor joist installation

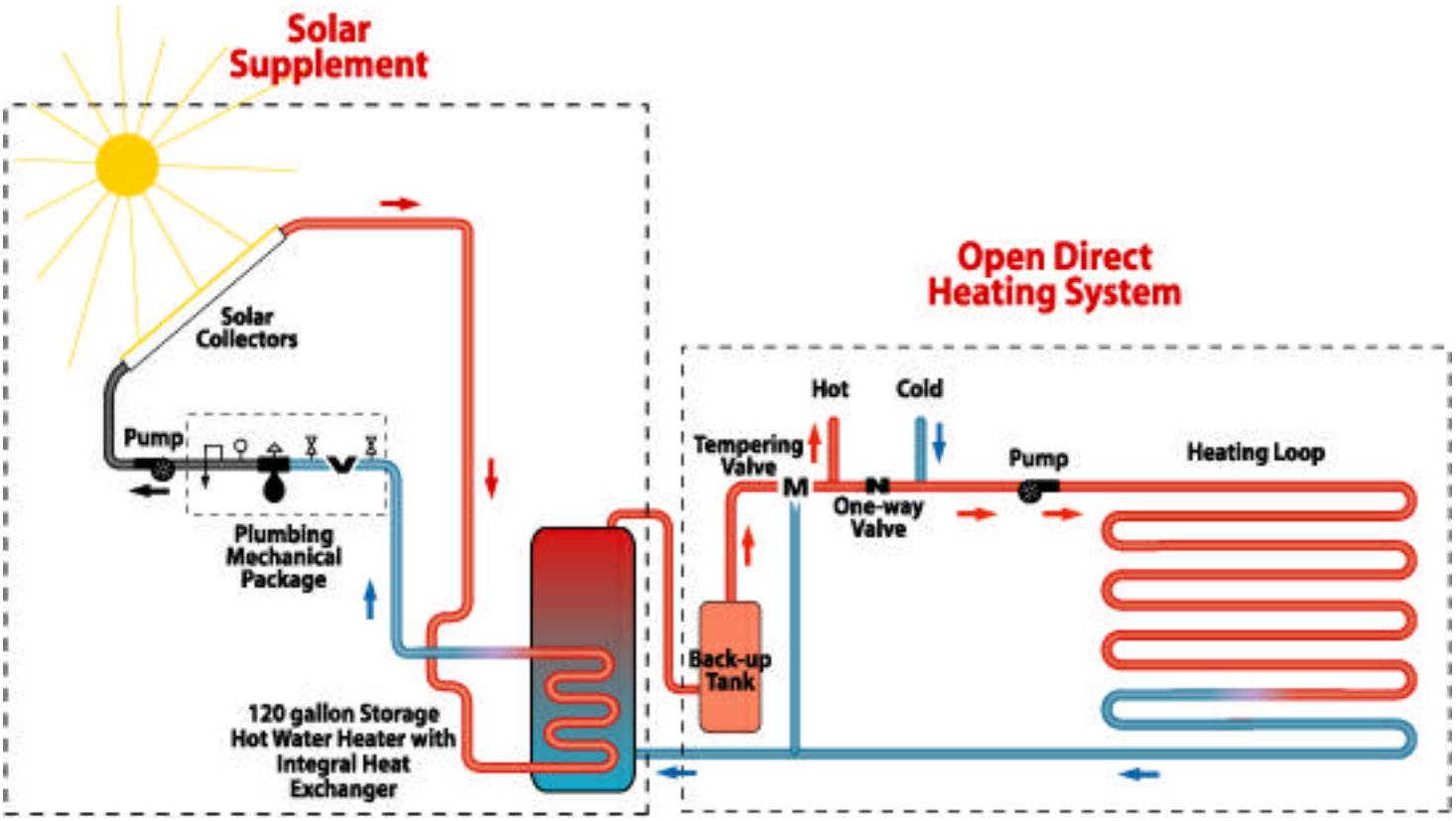
When solar energy in combined with underfloor radiant heating, the result is high efficiency and excellent comfort. The solar energy harvest is efficient because of the relatively low operating temperature of underfloor heat.

Radiantec Company offers a DESIGN AND CONSTRUCTION MANUAL in PDF format which is available at **radiantec.com/next.htm**. This manual will provide the details for installing underfloor radiant heat.

One limitation of conventional building styles is their ability to store heat for use on cloudy days and at night when the sun did not shine.

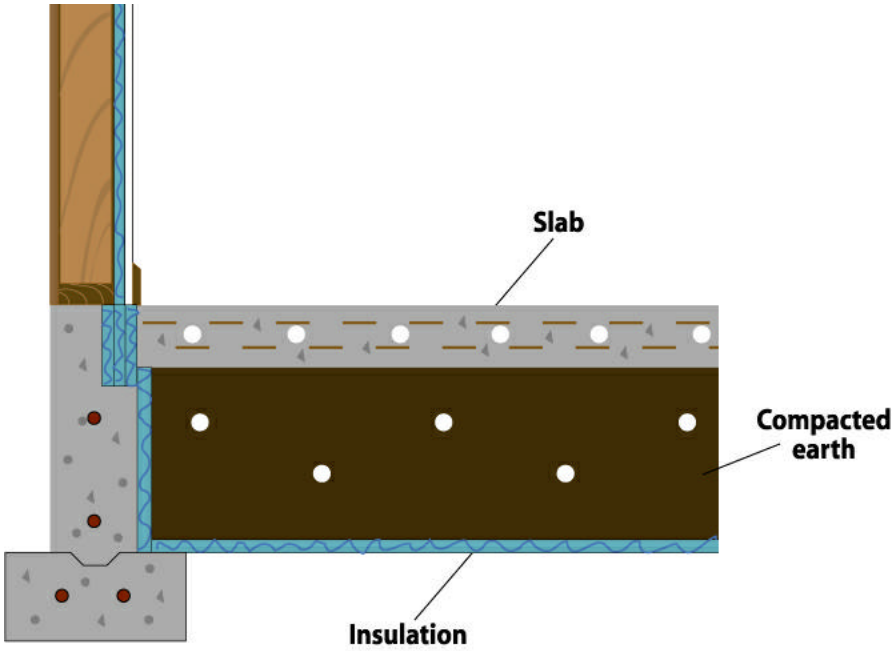
Earlier building styles were able to store heat because of the materials that they were made of.

The Solar Option 2 stores solar energy in both domestic hot water tanks and in the building itself.

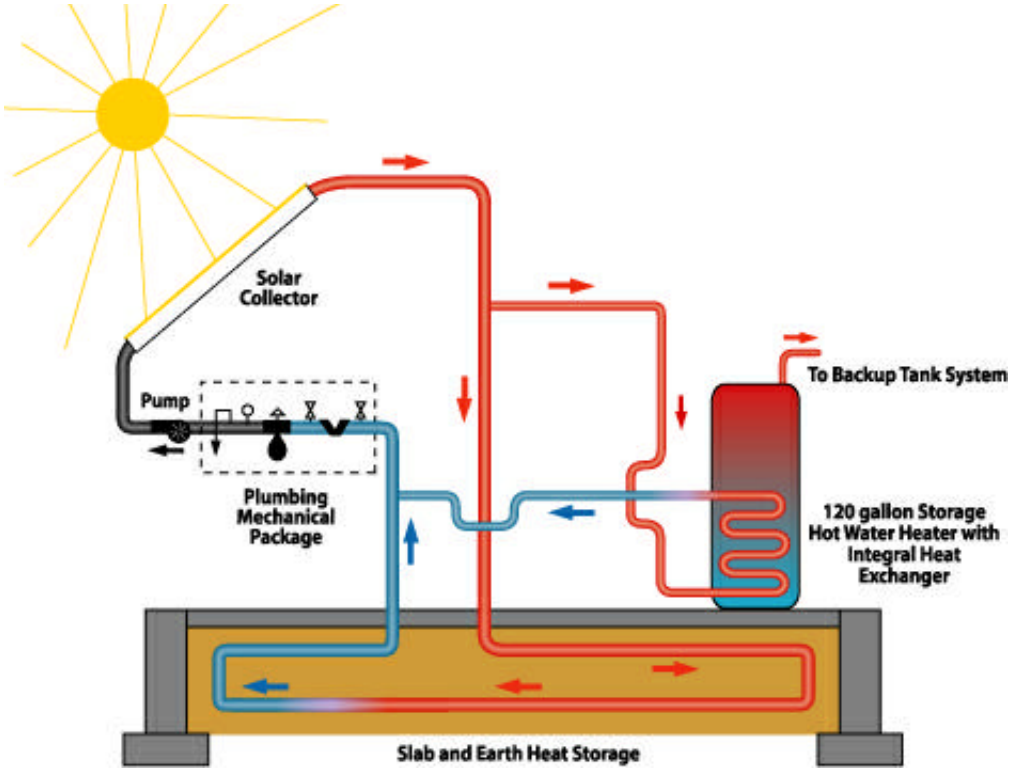


LONG TERM PASSIVE HEAT STORAGE

Figure 1



Studies have shown that the passive heat storage detail shown above can store enough heat to enable high solar heating percentages in all areas of the continental United States



The Solar Option One Heating System stores solar energy for a longer time.

CONSTRUCTION OF A SLAB EARTH BOX

The slab earth box is the storage mass for the Solar Option One heating system. Solar energy is put into the slab earth box by means of the solar panels and plastic heat exchanger pipes that are cast into the slab and/or buried in the earth box. These heat exchanger pipes are later connected to the solar collectors and other mechanicals.

SIZE AND DEPTH—The slab earth box varies in size, depth, and pipe location. These variables are specified by the designer and depend upon the characteristics of the building and upon the local weather conditions. It is common to use a 5 1/2" slab and a two-foot thick earth bed.

INSULATION OF THE SLAB EARTH BOX—The slab earth box is insulated on all sides and the bottom with ***extruded polystyrene***. This is the blue board or pink board or equivalent. ***Urethane or the white beadboard is the WRONG material.*** These materials tend to absorb moisture, which deteriorates their performance. Three inches of extruded polystyrene is usually called for where the concrete wall is exposed to the outside air. Two inches is usually used along the sides and one inch along the bottom. (See figure one).

The purpose of the ledge or shelf at the top of the frost wall is to bring the insulation inward so that it does not interfere with the flooring and to allow three inches of insulation at the slab perimeter. It is constructed by casting two 2"X6" boards into the top of the wall and then tearing them out when the forms are removed. It is important that the slab earth insulation be planned so that it is compatible with the building's insulation system and that there is no clear path for heat loss out of the building. The wall insulation detail shown in figure one is recommended for frame type buildings using The Radiantec heating system. This detail provides a tight building that is free from moisture problems because the studs are insulated as well as the wall cavities.

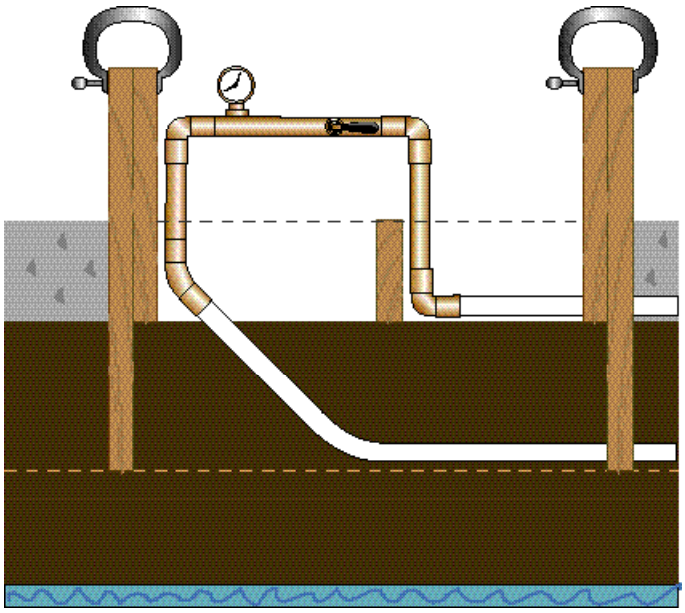
FILLING THE EARTH BOX—The earth box is filled with clean fill that contains no topsoil or organic matter that might cause the slab to settle. Clean sand or gravel is ideal. The following is a list of "Non-problem" soils.

SOIL TYPE	SOIL DESCRIPTION
GW,GP	Gravels or sandy gravels :little or no fines
GM,GC	Gravels or sandy gravels with sand or silt
SW, SP	Sand with little or no fines
ML	Fine sand with silt or clay
MH	Inorganic clay or silt

CAUTION: Do not spend extra money on stone. It will not store more heat. Do not use fill with sharp stones as they could damage the pipes. Do not use crushed rock or cinders in the vicinity of the pipes.

COMPACTION—The earth box is heavily compacted during the fill. Good compaction is important with any slab to prevent settling and cracking from differential settling of the fill. Compaction is performed with a mechanical compactor on 6" lifts (layers) of soil. Compaction continues until the soil feels ***very*** solid (90-95% of optimum dry density).

PLACEMENT OF THE MANIFOLD BOX—The manifold box is the place where the plastic pipe coming from the slab earth box connects to the copper pipe in the rest of the system. The manifold box should contain equipment for air testing the slab earth heat exchanger to ensure there are no leaks in the pipe. The solar fluid will come down from the solar panels by way of a copper pipe and then branch off into several plastic tubing heat exchanger pipes. The solar fluid is cooled by the slab and then returns to the solar collectors.

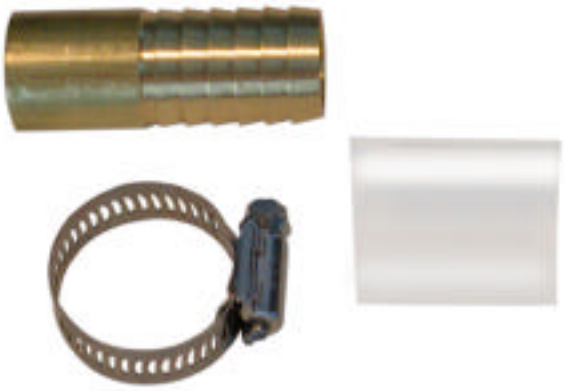


The manifold box as supplied by Radiantec Company contains the manifold, pressure gauge, air stem, air vent and a valve. It has been pre tested at the factory. This equipment comes in a sturdy plywood box that protects the components from shipping damage, and is also used for protection during the remainder of the building construction.

Partly disassemble the manifold box by removing the top, the bottom and the upper half of the sides. This will permit access to the manifold for connection to the plastic heat exchanger tubing.

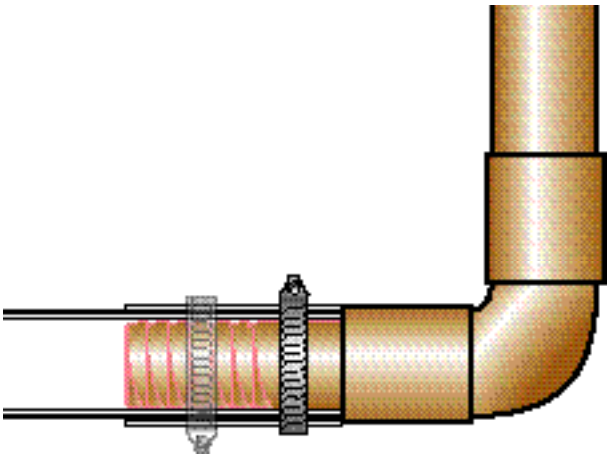
Locate and level the box in the place called for in the plans. If tubing is to be placed within the earth box as well as in the slab, it will be necessary to set the manifold box upon stilts in order to level it in the proper location. An easy way to do this is with large C clamps and four short pieces of 2"X4" boards. ***It is important to note that the manifold box must be secured well. If the manifold box becomes crooked during the earth filling, it may not be practical to straighten it later. It will look unsightly and spoil the overall professional appearance of the work.***

The manifold box is now ready to be connected to the polyethylene heat exchanger tubing. Designate one side to be the supply and the other to be the return.



Put the stainless steel clamp on the pipe, insert the adaptor into the pipe as far as it will go and tighten the clamp behind the serrations on the adaptor. These insert adaptors fit more snugly into the tubing than other types and will require more force, and perhaps some gentle heat from a heat gun. The vinyl sleeve is needed to distribute the clamping force evenly. When double clamping, the hubs should be opposite each other.

The tubing should come straight into the manifold box to avoid strain on the fitting. Too much strain on the fitting may cause it to leak.



1/2" PEX TUBING WITH A COMPRESSION FITTING TO 3/4"TUBING

Tighten the nut onto the threaded fitting with the compression ring in between. There is no need to tighten the fitting excessively.

PLACEMENT OF THE PIPE

1. Use only the pipe specified for the job. Check the pipe carefully for shipping damage. The pipe should come to the job site in a shipping car ton to help spot damage. Inspect the pipe continuously when working with it. We recommend that you order an extra coil of tubing and either use it later or send it back. Radiantec will not charge a restocking fee.

2. Considerations in pipe selection include temperature and pressure resistances, solubility with antifreeze solutions, durability over time, appropriate flow characteristics, proper rate of heat transfer and other important factors. Do not substitute tubing without considering what the change will mean. A slab heat exchanger constructed from the proper material will outlast the building in which it is installed.

3. Pipes may be concentrated somewhat in areas such as bathrooms where more heat and air circulation is wanted.

4. Do not go over the pipe with wheelbarrows. Do not drop heavy equipment on the pipes or otherwise abuse them. Pipes will withstand the ***ordinary*** conditions of a concrete pour. Make sure that ***each person*** doing the earth filling or concrete work knows this.

5. During earth fill, pipes may be held in place with construction boards or with wire mesh.

6. It is not unusual to have to discard a small amount of tubing in order to get good arrangement. It will not make much difference

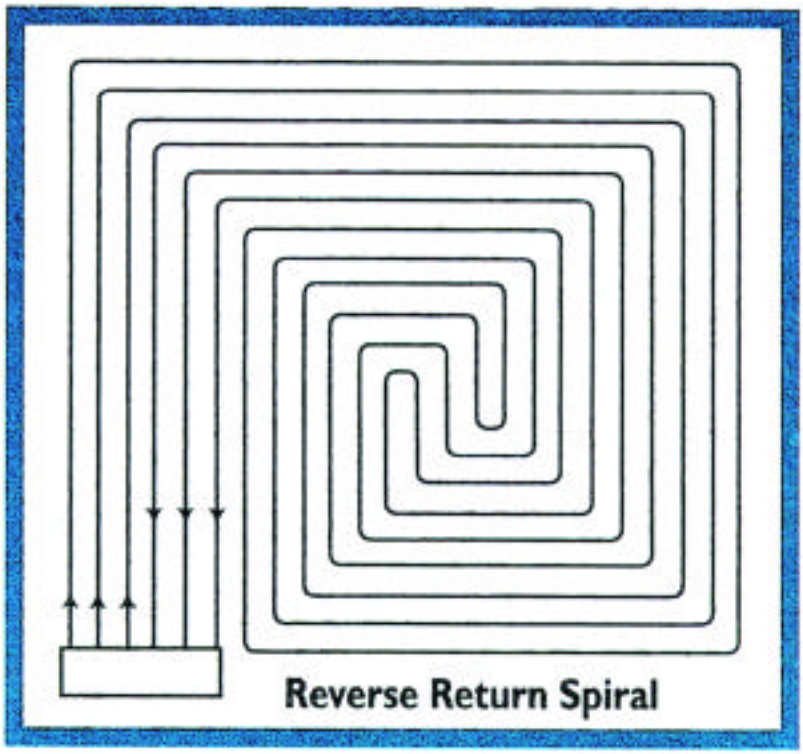
PLACEMENT OF THE PIPE IN SLABS

The **reverse return spiral** is ordinarily the easiest and best way to place tubing within a slab. Place the manifold at any convenient place along the perimeter of the slab. Start by running the tubing around the perimeter of the proposed slab and then inward towards the center. At the center, turn 180 degrees and spiral back to the manifold. The spiral is **flexible and convenient**. If there is too much tubing left over when you get back to the manifold, simply tighten up the spiral and the excess tubing will be taken up. If you have the opposite problem and you cannot get back to the manifold, simply relax the spiral and more tubing will be freed up. Use **multiple parallel circuits** instead of just one long one. Multiple circuits require less pump work and the fluid will not cool off too much. Because additional circuits run parallel to the first, they will be easy to do once the first circuit is in place and arranged properly.

IMPORTANT POINTS:

1. Put in the linear amount of tubing that is required.
2. Space out the tubing reasonably well.
3. Do not kink the tubing.

Absolute precision is not necessary. An exact and perfect arrangement is a waste of time and can also waste tubing. It is acceptable if the tubes cross one another as long as the concrete has adequate thickness. Tubing may be concentrated somewhat in bathrooms and in other areas where more heat is desired. Tubing may also be concentrated somewhat in high heat loss areas such as bay windows, patio doors, entryways,, etc.



HINT: Cut a piece of thin wire to plan length and maneuver it on the blueprint until a good arrangement is found.

THE PRESSURE TEST—Before burying pipe, pressure test the assembly with 50 psi of air for at least 4 hours, and preferably overnight. Use a soap suds solution and check for bubbles. Any leaks are most likely right at the manifold. There should be no loss of pressure. Schedule the work so you are not rushed at this time. Maintain working pressure (20 psi) while the pipe is being buried or cast into the concrete. If tubes are to be installed within the earth bed as well as within the slab, it will be necessary to pressure test the earth loops before the slab loops are in place. The use of two separate manifolds is the easiest way to do this.

CONCRETE RECOMMENDATIONS—(these are general recommendations and what Radiantec considers good practice. However, Radiantec does not accept responsibility for the design of any particular project.)

1. Foundation walls with footings should be provided to bear the weight of the building. Carryover slabs, thickened edge slabs, etc. are often structurally inadequate and cannot be insulated well. When used, they must be professionally designed.

2. Slabs should not bear on the foundation walls but should bear upon the compacted fill.

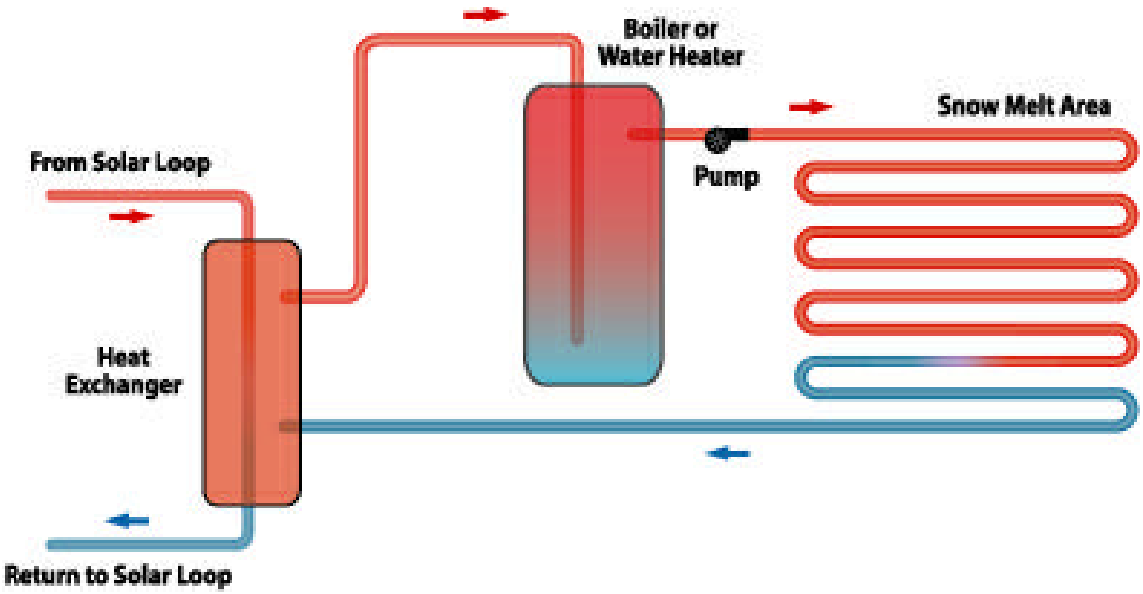
3. Floor slabs should be 5" thick,minimum. No length or width of the slab should exceed 75 feet without an isolation joint. Control joints should be placed every 15 to 20 feet. Odd shapes should be divided into rectangles with control joints or isolation joint.

4. The concrete mix for a floor slab should be a 6 bag mix with 3,500 psi compressive strength. It should contain 6 gallons of water per sack and should have a slump of 2-4". This mixture will be quite stiff and not as easy to work with as a soupy mixture. It is however, a lot stronger and more resistant to cracking. A vibrator is handy when placing stiff concrete. Water may be added if absolutely necessary.

5. Use a moist cure method of curing the concrete. The work should be kept moist with coverings for at least 3 days after the pour. No load should be placed on the slab during this time. It is never beneficial to cause a slab to dry out quickly.

Very heavy objects such as fireplaces, chimneys, etc. should be footed separately from the slab and pipes. Hot water heaters should have their own pad that is isolated from the slab. Places that will bear interior partitions should be made stronger with extra concrete and more steel. The manifold box should be reconstructed with the boards that were removed in order to protect the manifold from accidents during the remainder of the building construction.

SNOW MELT



An advantage of the snow melting application is that it can use low-grade sunshine that is not useful for anything else because of its very low operating temperature.

A supplemental boiler is often used if all weather operation is needed. For efficiency, the boiler is used in conjunction with strong sunlight in order to get the job over with quickly, so the heat can be turned off.

Use 1/2" PEX for high strength and durability. Its thicker walls and lower efficiency are less important because of the large temperature difference between the heating fluid and the ground. Typical spacing is 12" on center. Scraps of wire mesh, left over from concrete work, can be used for tying and managing the tubing.

The tubing should be placed in the earth about 6"- 8" beneath the surface.

Pressurize the tubing when work is being done above it.

Run cold water through the tubing if asphalt is being placed.

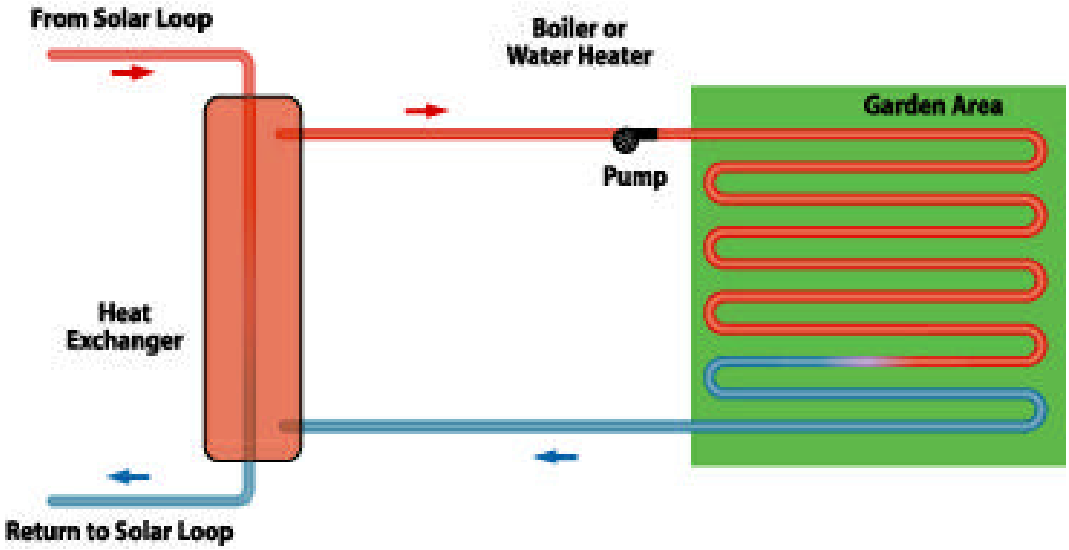
In general,do not insulate under the snowmelt area. The ground beneath is usually warmer than 32° F.

SOLAR ENERGY CAN BE FUN. A HIGH PERFORMING SOLAR HEATING SYSTEM WILL MAKE MORE HEAT THAN YOU REALLY NEED FOR HEATING AND DOMESTIC HOT WATER AT CERTAIN TIMES.

YOU CAN USE THE EXCESS HEAT IN FUN AND IMAGINATIVE WAYS THAT YOU MIGHT NOT CONSIDER IF YOU HAD TO USE FOSSIL FUELS

GO AHEAD, IT'S FREE!

GARDENS



Studies in greenhouses show that root zone heating can be highly effective. Root zone heating can extend the season on both ends. It can make it possible to grow plants that would not otherwise grow in your zone.

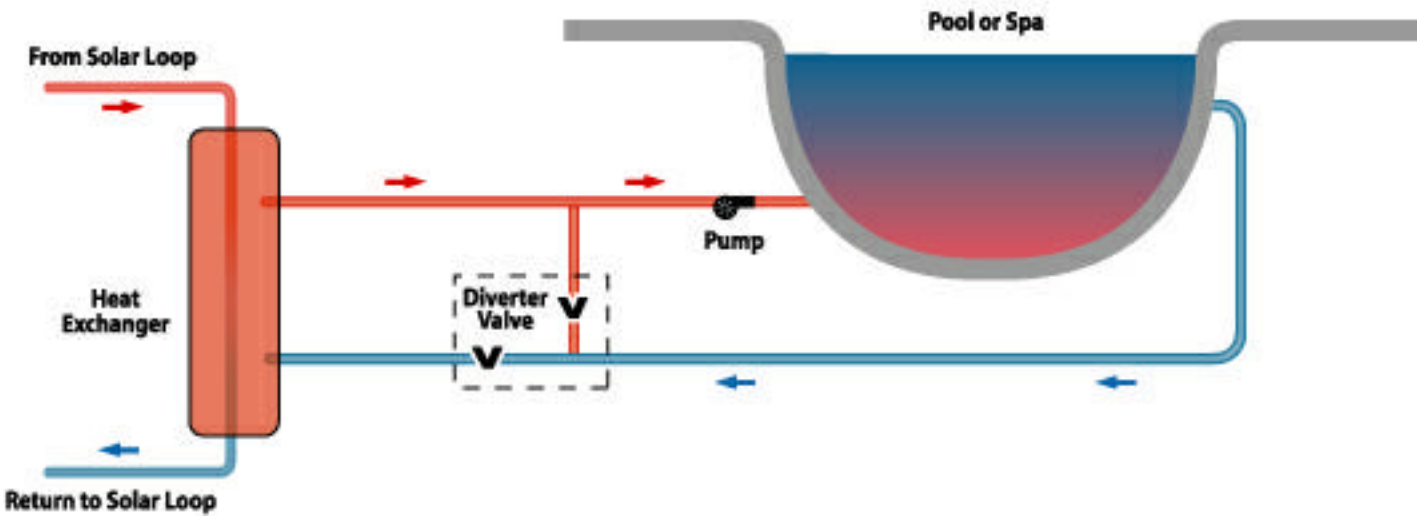
This is another good use for low-grade solar energy that is not useful for higher temperature applications. It also makes a good heat dump.

The work is basically ditch digging, but a bulldozer or excavator can be used in new construction. This is the ideal time to work organic matter deep into the soil.

Tubes should be placed about 1 foot below the surface and below rototiller depth.

Tubing layout is about the same as for snow melting and the mechanicals are the same as well . It is possible to use the same mechanicals as the snowmelt system, and isolate the uses with valves.

POOLS & SPAS



It is important to use a stainless steel heat exchanger because of corrosive chemicals in pool and spa water.

It is often possible to use the filtration pump. Just construct a bypass to the solar loop heat exchanger such that turning a bypass will start the heating process.

It is said that hot tubbing in the sun plumps and tans the skin, while giving highlights to the hair. If so, you can indulge yourself in the knowledge that your energy consumption is renewable.