

Heating Household Water With A Wood Stove

Water heating is the second largest energy drain for most households. About half the energy consumed for everything other than space heating goes to heat water. If you have a wood stove, however, you may be able to use it to heat household water and thus trim your energy bill.

How does a wood stove water heater work?

Wood stove water heaters use **heat exchangers** to transfer heat from the stove to the water. Exchangers can be mounted inside the stove, in the

stovepipe, or on the outside of the stove. Water circulates through the exchanger whenever a fire is burning, either naturally (**thermosiphon**), which relies on water rising as it's heated, or by means of a pump.

Heat exchangers come in three forms: a serpentine coil of tubing, a boxlike minitank, or a small solar collector-type absorber plate (see figure 1). Most heat exchangers are coils or minitanks mounted inside the stove body.

Savings from wood stove water heating

The typical Pacific Northwest family of four uses 4,800 to 7,200 kilowatt-hours (kWh) of electricity each year to heat water. Annual water heating costs average about \$270, but may range from \$75 to \$400.

Savings from a wood stove water heater depend on how much the family uses its stove, the heat exchanger size and location, and how much hot water the family uses. Most families heat water with wood only during the winter months. Savings vary from about \$25 to \$200 per year.

These savings, however, are offset by the cost of the wood stove water heating system and the value of the additional wood burned. A wood stove consumes about 10 percent more fuel when a water heating device is attached.

Wood stove water heating systems vary widely in cost, depending on the components used. Heat exchanger prices range from \$50 for a simple black iron coil to \$150 for a stainless steel unit. If you need a pump and controller, add at least \$200 more. A commercially installed system with pump usually costs about \$700.

Be sure to consider other factors, including safety requirements and the environmental effects of wood burning (air pollution), when deciding on whether to install a wood stove water heater.



You can lower your water heating bills, whether or not you use your wood stove to heat water, by doing the following:

- Install low flow showerheads.
- Add an insulating wrap to your water tank.
- Set the thermostat on your water heater to 120°F or lower if family use allows. (Some dishwashers require 140°F minimum.)

Safety precautions

Many people have been injured by poorly installed wood stove water heaters in recent years. Any pressurized water heating device can explode if a control failure results in high temperatures and excessive steam pressure. Houses have been destroyed when conventional electric or gas heaters exploded.

Like all water heaters, the wood-fired water heater requires safety precautions to prevent dangerous pressure buildup. A properly installed wood water heater can be operated with no danger to the household. Hundreds are now in routine use in all parts of Oregon.

Before you begin working on your wood stove, obtain the appropriate permits from your Building Department. Follow the instructions given with plumbing details in this publication to ensure safe installation; then have a qualified inspector check for safety hazards.

Materials and types of exchangers

Exchangers are commercially made, built in local shops, or homemade. They can be made from copper, galvanized iron, or stainless steel. However, copper is not a good choice if there is a chance it will be jarred or damaged by hastily loaded firewood; your water may look and taste rusty if you use steel or black iron; and galvanized metals release a toxic gas at high temperatures. Therefore, even though it's the most expensive, stainless steel is the best material for internally mounted heat exchangers.

Because of the extremely high temperatures possible inside the stove, be sure your heat exchanger has no mechanical joints inside the stove body unless they are welded—not soldered or silver soldered.

Flue-type (stovepipe) exchangers are not used in air-tight stoves because they depend on high exhaust gas temperatures to be effective. For Franklin-type stoves which are not air-tight, stovepipe exchangers may be a good choice. The exchanger is composed of an oversized piece of stovepipe surrounding a cylindrical coil through which water circulates. To make your own, bend soft copper tubing to the desired coil diameter by filling it with dry sand to prevent kinking, and then winding it around an appropriate size cylinder. Creosote buildup can be a problem with flue-type exchangers, so check yours frequently.

Externally mounted heat exchangers eliminate the need to make holes in the stove body. The exchanger intercepts radiant energy from the stove body, so its surface area is very important. Normal coils and minitanks do not receive enough radiant energy to be

effective when mounted outside the stove. External heat exchangers have large, flat panels similar to solar absorber plates.

Since the amount of water heated is determined by use of the stove, the optimum heat exchanger size depends on three things:

- Fire size
- Fire frequency
- Household water use.

Typical installations use coils of $\frac{1}{2}$ inch or $\frac{3}{4}$ inch diameter, 8 to 12 feet in total length, mounted in the firebox (50 percent longer if located in the stovepipe). Minitanks usually have 70 to 200 square inches of surface area exposed to the fire. External absorber plate exchangers are often 250 square inches or larger and are sized to cover the back of the stove.

• Interpretation of the Building Code and Mechanical Code by officials in some areas does not permit internally mounted exchangers, so check to see if they're allowed in your area. Remember that holes cut in the stove may void the manufacturer's warranty and laboratory listing. Check with your insurance company to see if modifying the stove affects your homeowner's coverage.

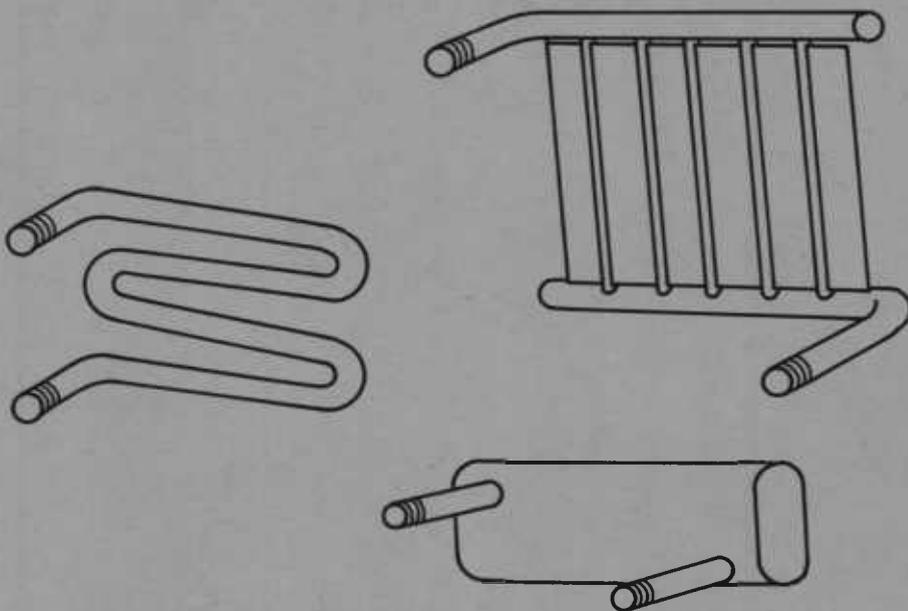


Figure 1. Woodstove heat exchangers

Circulation

To prevent boiling, water must circulate through the heat exchanger whenever the stove is used. Use thermosiphon circulation if your water storage tank is located near the stove and is higher than the heat exchanger. You will need to purchase a circulating pump for all other cases. Thermosiphon systems are better than pumped systems because a power outage which stops pump circulation could result in overheating of the water in the heat exchanger.

Thermosiphon system

Figures 2 and 4 show typical thermosiphon plumbing details. As water is heated, air dissolved in it is released as bubbles. Pockets of air in the piping prevent circulation and must be avoided. Figure 3 shows common problem areas. A water tank with an opening in the side, as shown in figure 4, is the best way to prevent air

pockets. An air vent like that shown in figure 2 will eliminate air pockets, but must be located where any dripping from the vent will not cause problems.

You could connect the heat exchanger return line with a tee (T) to the hot water supply line to the house, but cool water would then be drawn through the stove whenever a tap was turned on, even when no fire was burning. It is better to connect the hot water from the stove through a different tank opening than that used to supply the house.

Plan to direct the exchanger outlet line upwards immediately behind the stove. This helps initiate water flow when you start a new fire.

If you ever need to remove the stove, you'll find it easier if you have a valve on the cold circulation line. Before stove removal, drain water to the level of the hot return connection on the tank to prevent flow back through the line. By doing this, you'll eliminate the

need to install a valve in the hot water line (see Plumbing for Safety).

Thermosiphon systems normally use $\frac{3}{4}$ inch or larger water line to minimize flow resistance. As a general rule, the horizontal distance from the stove to the tank should be no more than twice the vertical distance from the heat exchanger outlet to the top of the tank. Check valves will prevent flow and should not be used in a thermosiphon circulation loop. Make sure the bottom of the tank is above the heat exchanger so that no "back-siphoning" can occur when there is no fire, and so that all of the water in the tank can be heated.

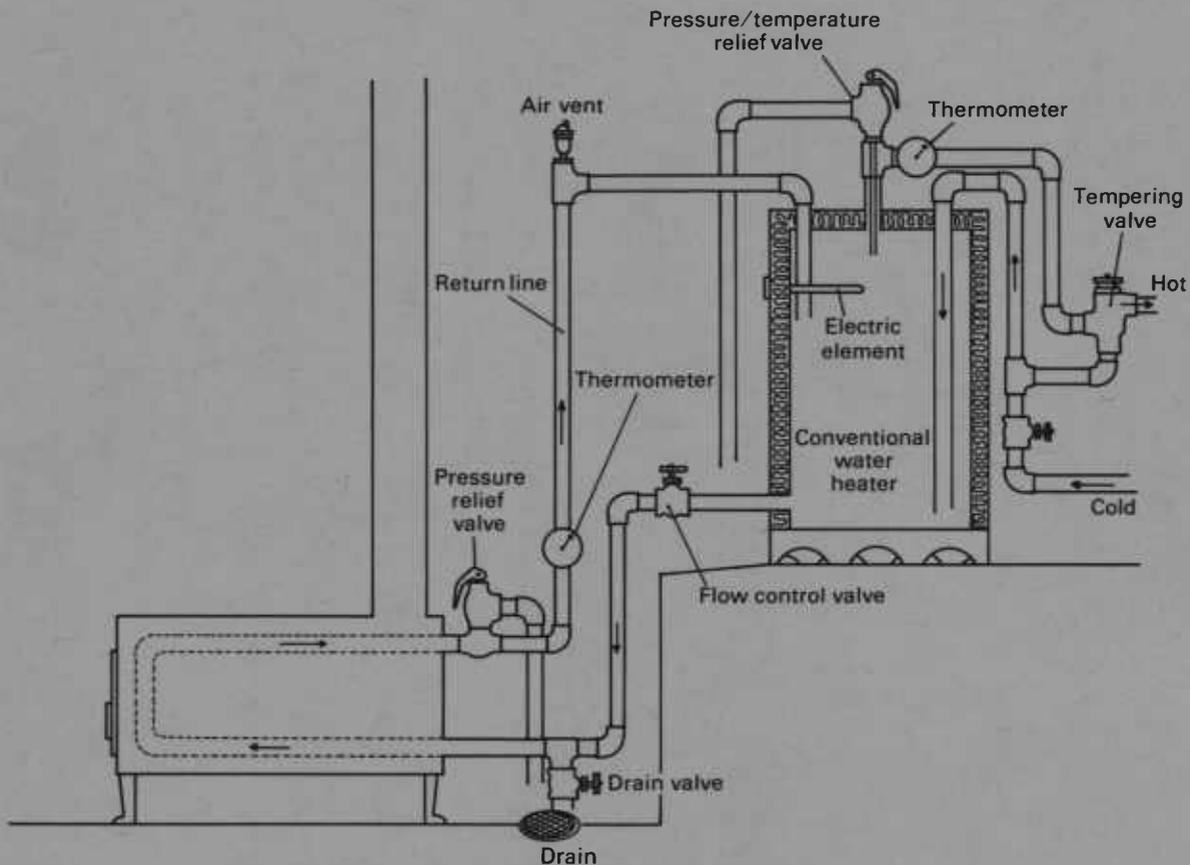


Figure 2. Thermosiphon single-tank system

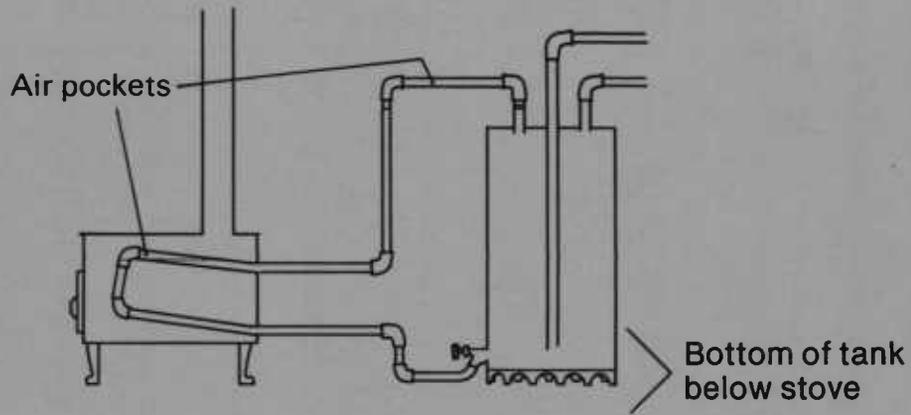


Figure 3. Thermosiphon PROBLEM AREAS

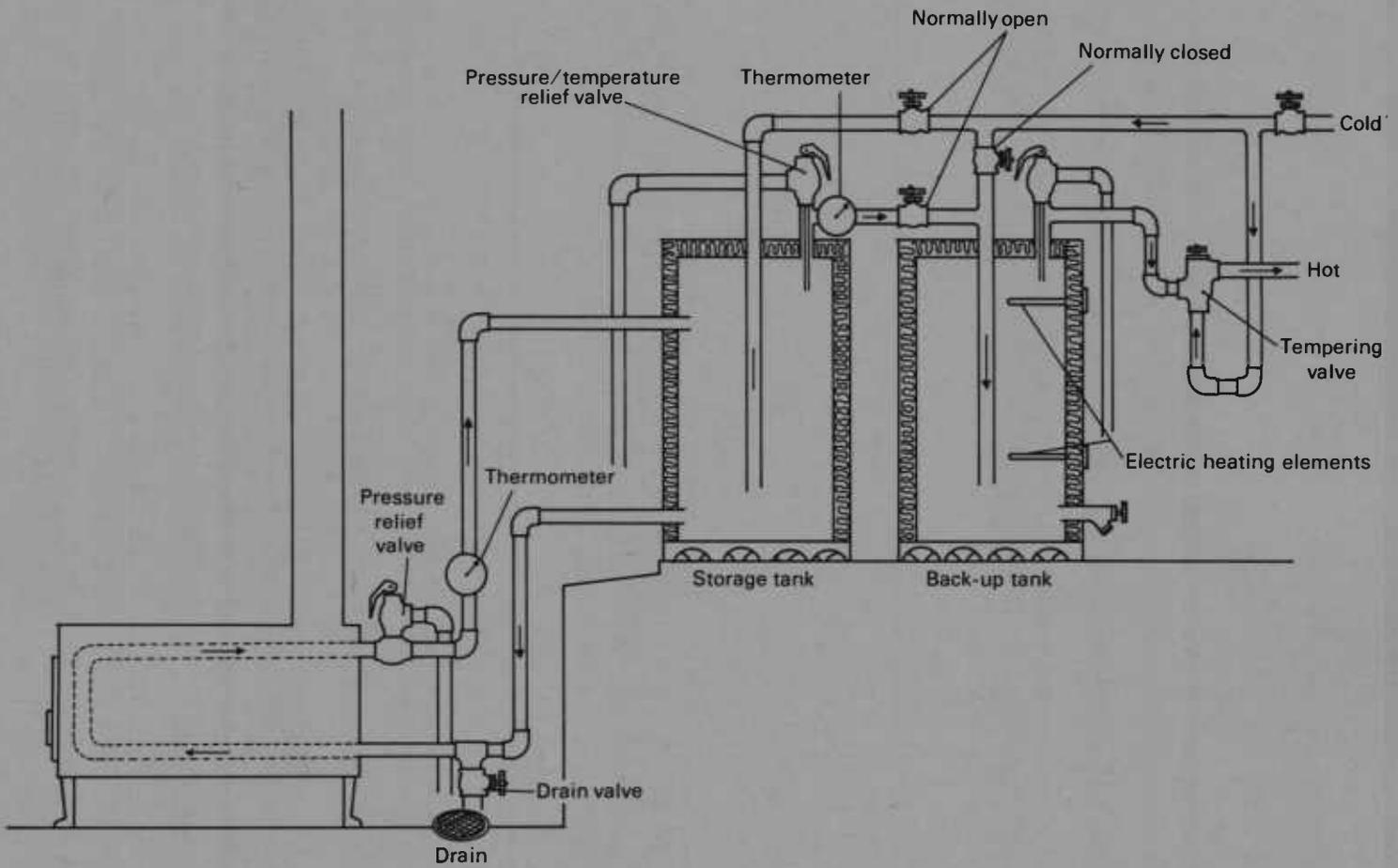


Figure 4. Thermosiphon double-tank system

Pumped system

You'll need a pump to circulate water through the stove loop if you can't position the tank where required for thermosiphon flow. A pump will push water past air pockets and through any length of pipe.

Pumped systems require little power to maintain flow. Circulation pumps are usually smaller than 1/20 horsepower and draw little electrical current, usually less than 150 watts. In open systems where fresh water is routinely introduced, submerged pump components must be stainless steel or bronze. Don't use cast iron pumps; they won't be guaranteed by the manufacturer for this use.

Figure 5 shows plumbing details for a typical pumped system. A check valve prevents hot water from rising to the stove from the tank when there is no fire and the pump is off.

If a power or pump failure occurs, water in the heat exchanger will quickly boil. A pressure/temperature relief valve at the heat exchanger outlet will vent off steam as long as there is water pressure to continue filling the exchanger with water. You can also use a water level limit control with manual reset to prevent pump restart until the stove cools, thus eliminating any chance of heat exchanger damage or a steam flash when the heat exchanger refills.

The pump must have a control to switch it off when there is no fire. Snap disc switches, fan controls, and aquastats have been used with only limited success. A better, but more expensive choice is a solar proportional differential controller. It electronically compares the temperatures of sensors at the tank and exchanger outlet and adjusts pump speed accordingly.

An on-off differential controller can be used but will result in pump cycling during medium and low fires. Intermittent boiling noises sometimes occur because of system cycling.

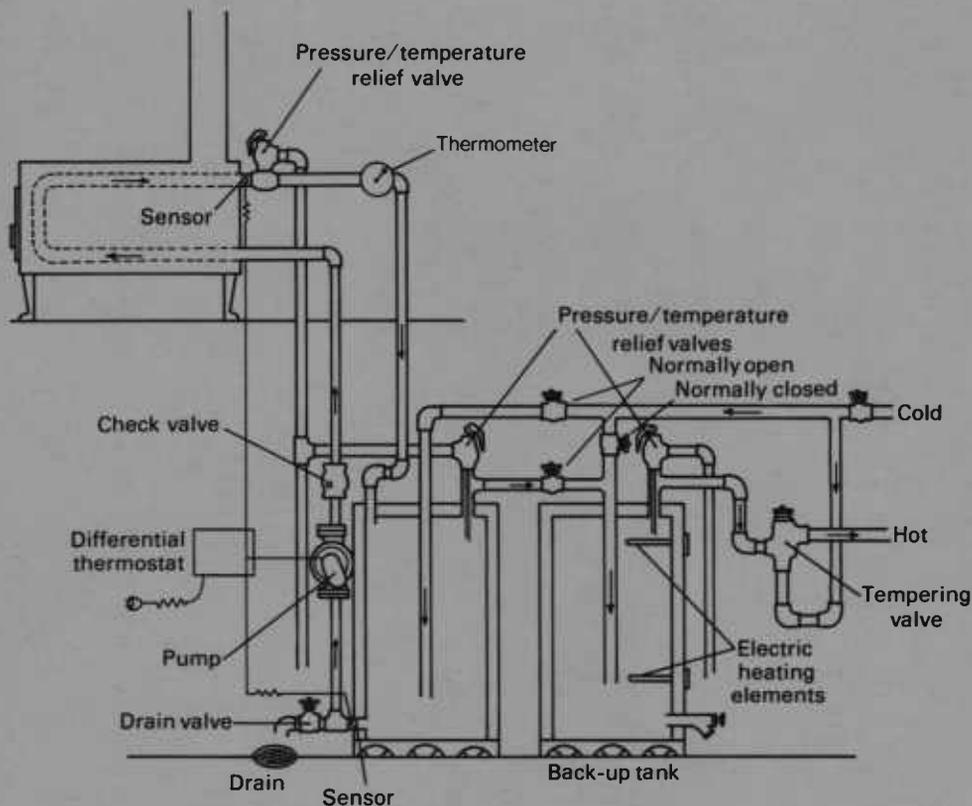


Figure 5. Pumped double-tank system

Single or double tank?

You might want to add an extra tank to store wood-heated water (figures 4 and 5). A conventional water heater will heat the water from the storage tank to final desired temperature. Temperature in the storage tank can vary from 50°F to 180°F.

In some cases a single tank accomplishes both functions. Don't use your wood stove to heat water for an electric tank with both elements operating (or a gas water heater) because you can only overheat the water to a temperature higher than the thermostat set point. Instead, you should disconnect the lower element of an electric water heater to allow the bottom half of the tank to store wood-heated water at intermediate, fluctuating temperatures. When you use the upper element only, however, the amount of electrically heated water on standby will be limited to that quantity stored above the upper element; therefore, you may want to use a larger tank. You should find greater energy savings with a single tank system, but you may also have to cope with occasional delays while the backup recovers.

In a single-tank system, it's important that water from the wood stove not return to the top of the tank at a lower temperature than the backup thermostat setting because that would turn on the backup power. The flow control valve shown in figure 2 can reduce flow in a thermosiphon system so that the heat exchanger will raise the water temperature more. In a pumped system with a single tank, the water from the stove should be returned through a dip tube to slightly below the upper electric element.

You can purchase a thermostatic valve for two-tank systems which will direct water from the stove to the backup tank after water in the storage

tank has reached a certain temperature. The valve allows the wood-heated water to offset heat losses from the backup tank. Heat losses from the water tank to its surroundings often account for 20 percent of the energy a water heater uses.

A timer attached to a small single tank

can signal it to operate as a backup at times when household hot water use is heavy. The tank at other times can store lower temperature water that is being heated by the wood stove. It is better, however, to use a larger tank which can store a full day's supply of water.

Plumbing for safety

A standard pressure/temperature relief valve on each tank releases water or steam if for any reason the pressure or temperature exceeds preset limits, usually 125 pounds per square inch or 210°F. A pressure relief valve at the stove will provide protection against high pressures which could result from obstructions in the lines between stove and tank. This relief valve **must** be installed on the stove side of any shut-off valves if such valves are installed on both circulation lines.

The stem on the pressure/temperature valve senses water temperature. It should extend into the storage tank. If a tee (T) is used at the tank outlet, purchase a special relief valve with an

extra long stem which can reach through the tee into the tank (see figure 2).

Prepare for the possibility of the tank overheating. Direct all relief valve outlets to a safe area of good drainage where the line cannot freeze, such as a floor drain away from people or a crawl space.

Use a tempering or mixing valve on all systems. The valve mixes hot and cold water when necessary to insure that water comes out of the faucet no hotter than a chosen temperature. In some plumbing arrangements, a check valve may be required on the cold water line which supplies the tempering valve so that no backflow of hot water can occur. As shown in the illustrations, the tempering valve should be mounted below the top of the tank to prolong thermostat life.

Safety checklist

- Provide complete water circulation loops in all installations
- Install pressure/temperature relief valves on all tanks.
- Install at least one pressure relief valve no further than 6 inches from the heat exchanger at the stove.
- If shut-off valves are installed in the circulation loop, remove the handles to prevent inadvertent shut-off.
- Install a mixing valve between the hot water tank and house faucets.
- Never fill a hot heat exchanger with cold water.

General tips

- Insulate all hot water lines which are farther than three feet from the stove. You can insulate lines inside house walls economically by using fiberglass batt-type insulation when the house is under construction. Elsewhere, use slip-on foam insulation designed for temperatures up to 250°F.

- Thermometers cost \$10 to \$20 and are well worth the investment. They eliminate the guesswork of determining water temperature and let you watch the system operate. Friends will want to see it work, too. Good thermometer locations are shown in the illustrations.

- Copper is usually the easiest pipe material to work with. However, do not use soldered joints near the stove where a heat exchanger filled with air or steam could heat the joints above the solder softening temperature. Table 1 shows the relative melting points of common soldering materials.

- Use only threaded fittings within 18 inches of the stove. If the rest of the plumbing in the system is copper, use threaded brass pipe adjacent to the stove. Copper used with iron will cause the iron to corrode.

- Use gate valves or full port ball valves instead of globe valves in thermosiphon circulation loops to reduce flow resistance.

- Although adding a heat exchanger to your stove could increase the rate of creosote formation in the chimney, the opposite is more likely to occur. If a stove is regulated to maintain desired room temperature, the heat taken by the exchanger will require the operator to run the stove with a hotter fire. This, of course, will actually reduce creosote formation.

- If you fully damper your loaded stove at bedtime, the addition of a heat exchanger will result in more creosote accumulation. Plan to clean the chimney more frequently.

- Solar and wood water heaters work well together, each producing at its best when the other is idle. A separate pump and controller should be used for each, because much of spring and fall weather will require operation of the two systems to overlap.

- Plan to flush sediment out of the heat exchanger every three to four months of operation. If you have hard water, flush it monthly.

Sources of equipment

Many of the items you'll need for building a wood stove water heater are available through plumbing supply shops and hardware stores. Specialty items such as the heat exchanger, pump, and differential controller are available from wood stove stores and solar dealers.

Table 1.—Melting points of common solder and brazing metals

Soft solders			Hard (silver) solders		
Composition (% Tin/%Lead)	Melting begins (°F)	Completely molten (°F)	Composition	Melting begins (°F)	Completely molten (°F)
40/60	362	460	7% Phosphorous/93% Copper	1310	1460
50/50	362	418	6% Phosphorous/5% Silver/ 89% Copper	1190	1485
95/5	362	434	5% Phosphorous/15% Silver/ 80% Copper	1190	1475
95% Tin/5% Antimony	450	464			

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