Potential for Cross Connection between
Potable and Non Potable Water
in Solar Thermal Systems

by
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Introduction

The Safe Drinking Water Act of 1974 was a milestone in the protection of drinking water from hazardous materials. The act authorized the United States Environmental Protection Agency to set national health-based standards to ensure delivery of high quality drinking water to every tap in a water supply system. One of the key measures is to prevent contamination due to cross-connections. Almost every state and local jurisdiction has potable water safety codes to prevent contamination of drinking water.

Numerous examples are published in various code documents describing the contamination of drinking water from backed up sewers, chemical tanks, boilers, wash sinks, pools, yard run off, and other sources.

All the problems occurred from a cross-connection between the polluted or toxic chemical source and the drinking water supply. A good reference document with diagrams is *Cross-Connection Control Manual, EPA Office of Ground Water and Drinking Water, 1995*.

There are two main forces that transfer non potable (NP) material into a potable water (PW) line. These are referred to as backsiphonage (suction); and backpressure.

Backpressure occurs when the NP line has a pressure higher than the PW line and an open cross-connection. Both lines have greater than atmospheric pressure, making this a double pressure system. Figure 1, from the EPA paper, shows a boiler cross connection hazard. The boiler can have higher pressure than the PW line under some conditions, forcing boiler fluid into the line.

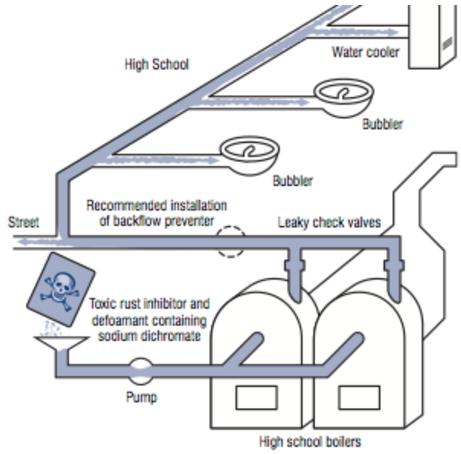


Figure 1. Cross-contamination due to backpressure.

Suction, or backsiphonage, occurs when the PW line draws a vacuum and sucks water out of a sink or open vessel. There is no pressure on the NP fluid side, making this a single pressure suction system. Examples include a garden hose filling a chemical tank as shown in figure 2, also taken from the EPA manual.

Prevention of backpressure and backsiphoning contamination require devices called backflow preventers to be installed between the NP line and the PW line.

Different backflow preventer types are recommended for double pressure and single pressure systems.

Double pressure backpressure systems require double check valves and RPG type back flow preventers.

Single pressure backsiphoning systems require only vaccum breaker devices.

An approved air gap device is acceptable for either type system, illustrated in fig. 3.

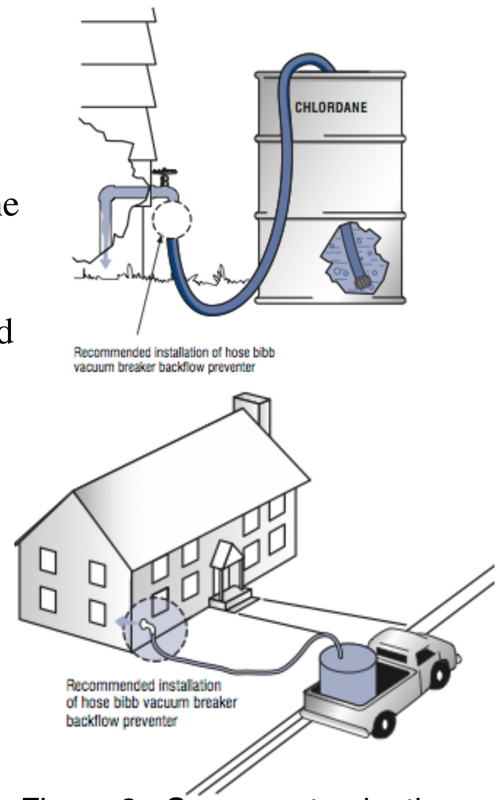
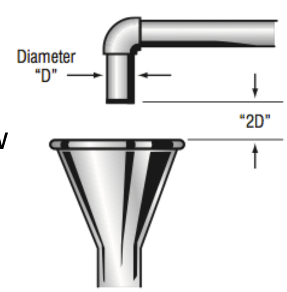


Figure 2. Cross-contamination due to backsiphonage.

Figure 3.
Air gap backflow preventer



Cross-Contamination Protection for Solar Systems

Cross contamination protection in solar hot water systems has been the subject of debate for many years. Code requirements have tended to treat all solar systems alike, without taking onto account the different operating modes.

The most common solar thermal systems today fall into the two cross-contamination categories described above.

Double Pressure Systems

Many solar systems contain a propylene glycol antifreeze solution under pressure inside a heat exchanger as shown in the simplified figure 4. Collector lines may be pressurized from 25 psi to 150 psi, depending on the overtemperature protection method used.

If a rupture occurs in the heat exchanger in the tank, as in fig. 5, the solar fluid may mix completely with the potable water in the tank. Such a rupture is not detectable by visual inspection. If the propylene glycol fluid has been certified as potable or harmless, then a single wall heat exchanger is allowed.

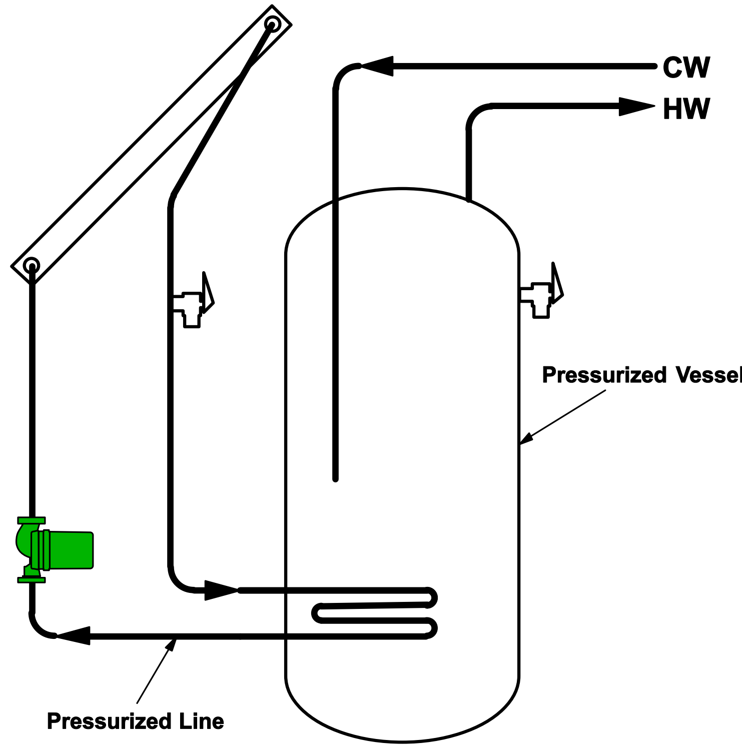


Figure 4. Typical pressurized solar system

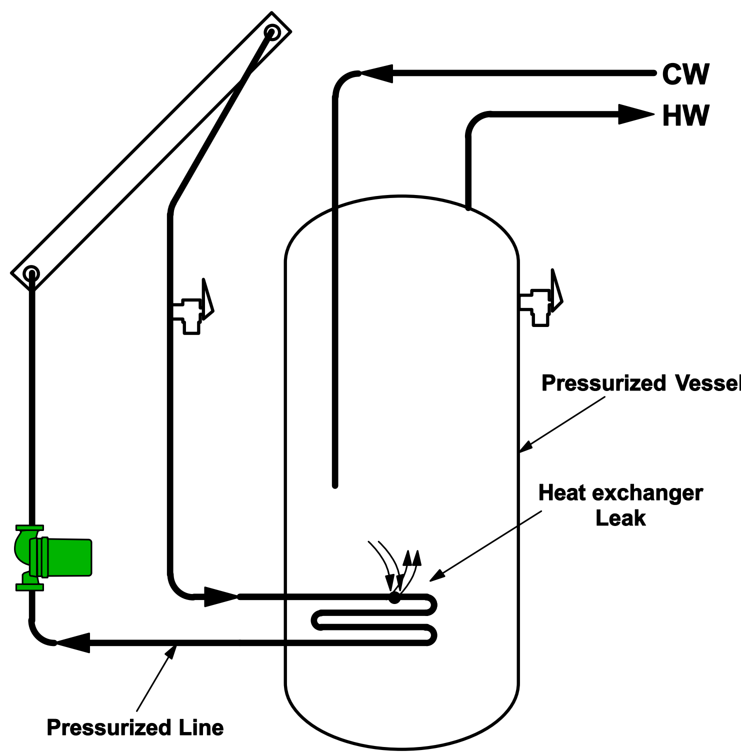


Figure 5. Rupture of exchanger with mixing of fluids.

However, propylene glycol breaks down into acids and fatty deposits over time, so the certification of new solution does not guarantee long term protection. The article below describes such a situation.

> *CROSS-CONNECTION CONTROL AND BACKFLOW PREVENTION* from the Manhattan, KS, official website <www.ci.manhattan.ks.us/DocumentView.asp?DID=1734>
>
> "At an Arizona State Park in June 1993, employees at the visitors' center began complaining that the water had an odd odor and taste. The condition persisted for the next two months, and several employees reported nausea and intestinal upsets after drinking the water. It wasn't until August that officials began searching for potential causes. Upon inspection, it was found that water in one of the fire sprinkler systems, none of which had backflow preventers, had been leaking back into the water supply system. The systems contained a solution of 30% propylene glycol, an antifreeze, and 70% water."

To minimize the hazard potential of a double pressure system, a double wall heat exchanger is used, as illustrated in fig. 6. The heat exchanger tubing consists of an outer tube and an inner tube with a narrow air space in between that constitutes a leak path. The air space functions the same as the air gap in fig. 3.

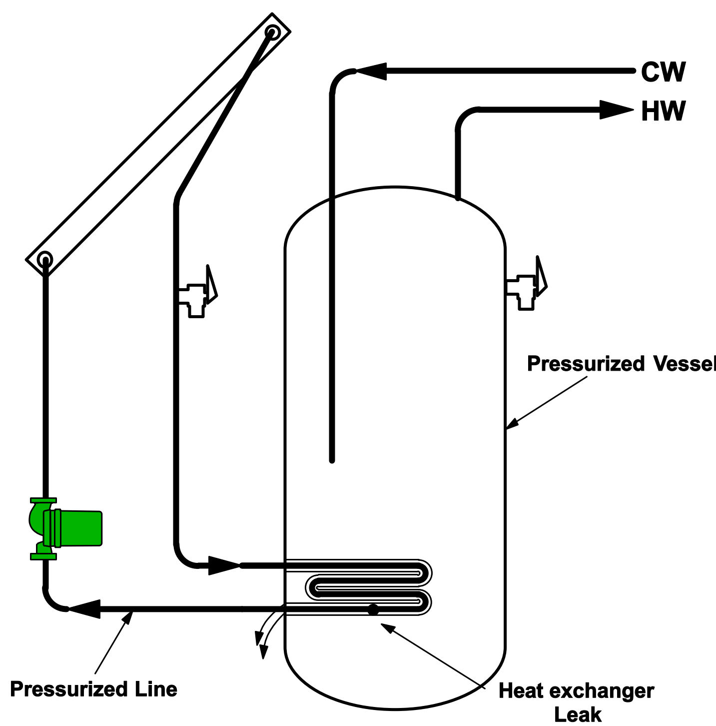


Figure 6. Double wall exchanger with leak path.

If a rupture occurs in either the inside tube or the outside tube, fluid flows down the leak path and shows visibly on the face of the heat exchanger. Double wall heat exchangers are accepted as backflow preventers in double pressure solar systems.

Double wall flat plate exchangers are also used.

However, there are two problems with this approach. First, a small leak may go unnoticed, with evaporation of the warm liquid preventing any visible pooling.

Second, most of the USA has mineral deposits in the water supply that can clog a narrow leak path shut. If this happens, a full rupture across both exchanger walls can occur without detection. This situation then becomes the same as the single wall exchanger. There are no specifications covering the width of the gap in double wall exchangers.

Single Pressure Systems

The second kind of solar system is the single pressure type, used in drainback designs.

Figure 7 is a version of the EPA fig. 2 above, showing a PW line extending into a tank containing toxic fluid. The open end of the pipe allows a maximum amount of toxic fluid to be backsiphoned in to the PW line. A vacuum backflow preventer is the code approved safety measure to prevent backsiphoning into the PW line.

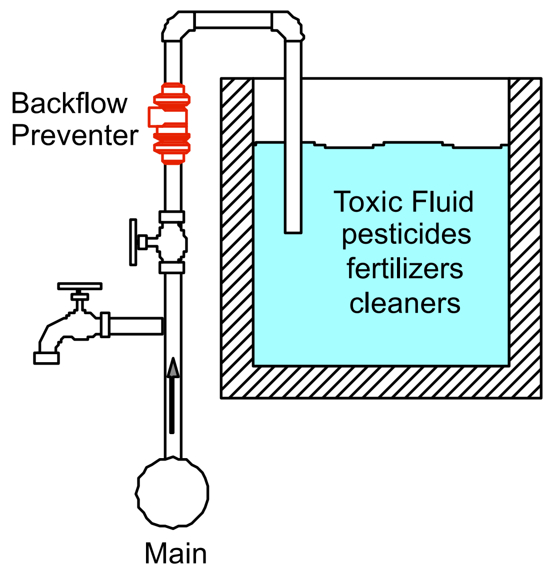


Figure 7. EPA backsiphonage example

The PW circuit of a single pressure solar system is shown in fig. 8. It is similar to fig. 7, except the heat exchanger line goes completely through the tank with no opening to the fluid.

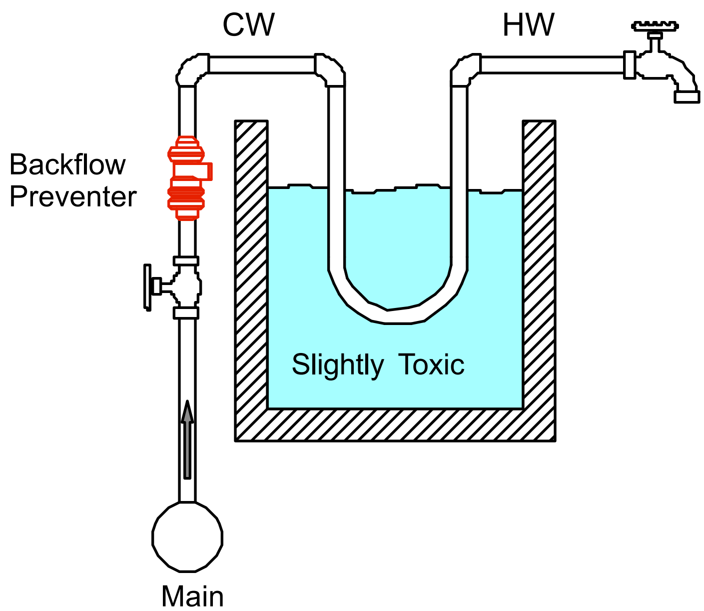


Figure 8. Single Pressure Solar Schematic.

Backsiphoning can occur only if

there is a rupture in the line at the same time that a vacuum occurs. A complete rupture would be equivalent to fig. 7.

In addition, the PW line in the tank of fig. 8 is continually pressurized, so a leak would cause the tank to overflow and readily indicate the problem. Over time, the tank would be completely flushed with fresh water. The bigger the rupture the faster the flushing action.

A complete line break is highly unlikely. A much more probable failure would be a small hole or crack in the heat exchanger pipe. In this event, simultaneous backsiphoning would only be able to draw a very small volume of tank fluid into the line as compared to fig. 7. When the backsiphoning is repaired, the mixed fluid would be blown back into the tank and out the vent. A simultaneous draw of fluid from a tap would be required to transport any mixed fluid down the PW line.

Therefore, the single pressure solar system of fig. 8 is intrinsically much safer than the code example in fig. 7. Backflow preventer protection devices should be the same in both cases. However, the probability of the almost simultaneous actions of leak/crack, backsiphon, repressure, and draw, required to mix NP and PW and deliver it to a tap is negligible.

Conclusions

The two main solar system types fall under the two classical categories of cross connection hazards, namely double pressure and single pressure systems.

Double pressure solar systems come under the backpressure standards, requiring approved double check valve, RPG, or air gap devices. Double wall exchangers fall under the air gap specification.

Single pressure solar drainback systems fall under the backsiphoning standards, which use an approved vacuum breaker. Since these solar systems have a visible leak path, equivalent to an air gap, and are inherently safe from cross contamination, they can be deemed to meet both standards, without additional equipment.