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Coast2Coast Special Report

Eastside Report

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Healthy HEATING

Comforting Your Mind, Body & *Soles*

Water Heaters or Boilers

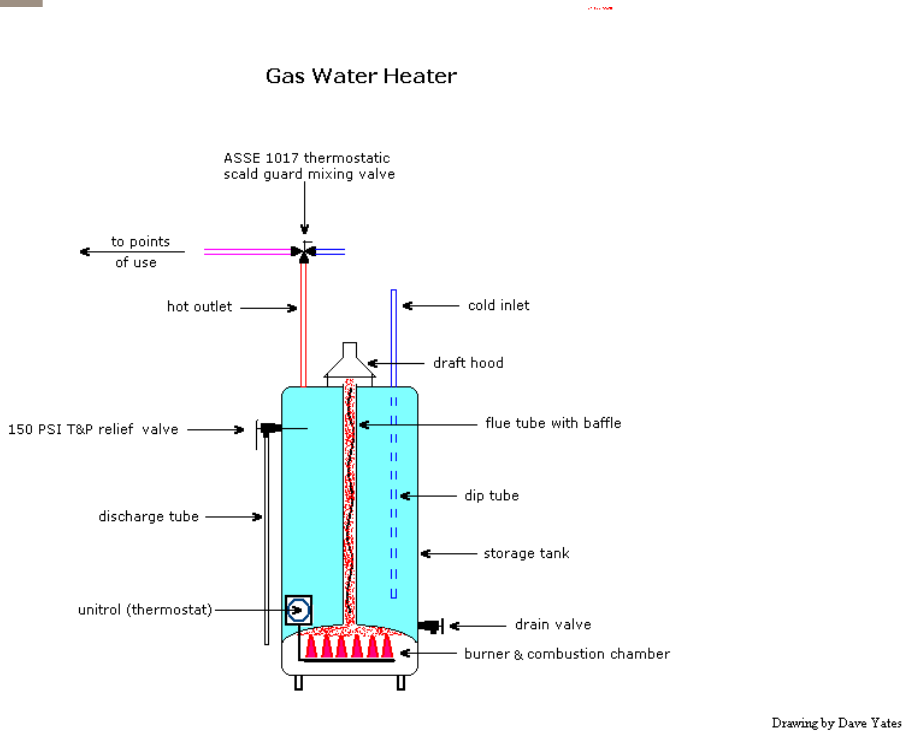
Commonsense or uncommonly senseless?

By Dave Yates

Should a water heater be utilized for both heating and delivery of potable (safe for human use) hot water? In this article, we'll look at various methods using water heaters for hydronics while exploring potential benefits and pitfalls for you to consider.

The concept of using standard water heaters for combination or dual-use potable-hydronic applications is not new, but it has become a very controversial and divisive subject among heating professionals, Master Plumbers and codes officials. The core conflict centers on the potability of the system's water along with bacterial and scalding issues. Homeowners and do-it-yourselfers haven't had very many places to turn where they can obtain factual and unbiased information on which to make reasoned decisions regarding their purchases or installation methods.

In this article, we'll concentrate on standard issue electric, gas and oil fired storage-tank-style water heaters, which are the most widely used in this country. My drawings detail gas fired water heaters, but



the same principals for hydronic installations apply to electric and oil models.

The basic operation of water heaters is not very hard to understand: cold water is heated by infusing energy via one of several fuels. This energy is measured using Btu's (British Thermal Units) and it takes one Btu to raise one pound of water one degree F (Fahrenheit). Each fuel has its own rating for Btu content, which may seem a bit confusing at first, but is necessary to use in calculating demand or capacity if you're going to provide comfort for your family. Btu ratings are as follows: natural gas – 1,000 per cubic foot (check with local utilities as rates vary); propane – 91,500 per gallon; home heating oil – 138,690 per gallon; and electric – 3.414 per watt.

Hot water use in this country has grown in gallons-per-day-per-person quite steadily from those early days when water heaters first began to be used instead of heating water in an open container for a Saturday night bath. Whirlpool tubs and luxurious bathing modules have driven hot water consumption to all time highs. Teenagers tend to remain in the shower until they're fully grown, which is why the water heater that can satisfy their usage demands can't be

built! So, the first question is: Are you currently exceeding the capacity of your existing water heater? If you answered "yes" to that question, adding another load via a hydronic circuit will only make things worse.

40 gallons of water stored at 120 degrees F contains 16,600 Btu's of usable energy (40 x 8.3 Lbs per gallon = 332 Lbs of stored water. 120 F storage temperature – 70 F room temperature = a net of 50 F usable energy. Given that it takes 1 Btu to raise each pound of water 1 degree F, then the Btu capacity looks like this: 50 x 332 = 16,600).

Every water heater has a rating plate, typically attached to the outer jacket, stating its rated energy input. In order to obtain the net output, you need to know the appliance steady-state efficiency, which can be difficult to find. But, as a general rule, most standard gas or oil fired water heaters will operate at or close to 80% efficiency when running. Electric water heaters normally have two elements rated at 5,500 watts each with only one running at a time, which equals a net output of 3.414 x 5,500 or 18,777 Btu's per hour. Residential gas water heaters average 38,000 Btu's input, which gives us a net rating of 30,400 at 80% efficiency. Oil fired residential water heaters typically use a .75 gallon per hour nozzle, which grants an 83,214 Btu net output at 80% efficiency (138,690 x.75 =104,017.5 x 80% = 83,214).

Next comes the single most important piece of the puzzle for any heating system: the heat-loss calculations. Hot moves to cold – always, which means Btu's will move to the greater outdoors at a rate we'll need to determine if your project is to deliver comfort on a design day. The design day represents the worst weather conditions expected during an average winter. (In my area, we use zero degrees for our outdoor air temperature.) An easy to use heat loss calculator can be found on our web site: www.fwbehler.com under the radiant heating section.

Small-load radiant heating systems that don't exceed rated capacity or interfere with domestic needs are an almost perfect match for water heaters due to their utilizing temperatures that generally fall within the same range. Although there are dozens of varying applications for installing radiant systems, most add-on DIY or over-the-net sales deal with staple-up or suspended-tube installations because the focus is on cost. As you might expect, you get what you pay for and there are other methods, such as plated

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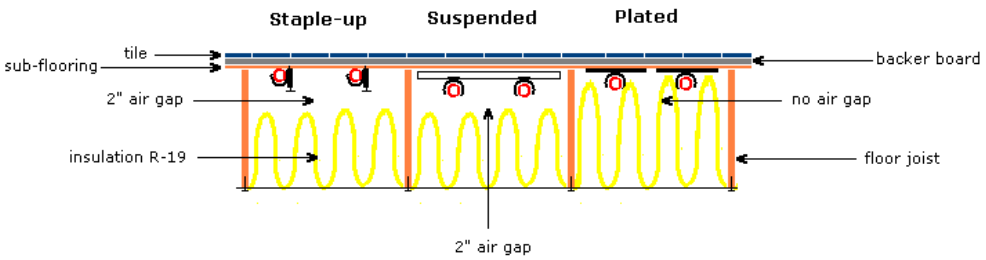
systems, where output and performance can be greatly enhanced. Water temperature and flooring materials determine how many Btu's can be delivered to the living space.



The system components come next and here there are a multitude of choices. One in particular that can make or break a system's performance and ease of installation is the tubing you'll be purchasing. Beware of tubing diameters larger than ½". It's been our experience that tubing diameters larger than ½" are difficult to manage in narrow joist spaces and often kink when attempting to make the 180 degree turns required at the ends of each joist bay. We actually prefer 3/8" tubing for hydronic radiant under-floor installations. The difference between ½" and 3/8" for both flow rates and heat output is minimal, but the ease of workability is greatly enhanced. PEX (cross-linked polyethylene) is our tubing of choice due to its long-term warranties (typically 50 years), durability and rugged construction. PEX is available with ratings for either potable or hydronic use and with or without an oxygen barrier. A wide variety of colors are also available. This is not the place to cut corners where costs are concerned.

The remaining components are fairly standard industry-wide with

personal preference often based upon past experience or sales literature.

The delivery water temperature is an important consideration and although the unitrol (gas models), snap-disc thermostats (electric) or immersion well aquastat (oil fired) have varying degrees of accuracy, they all work over a specified range that allows the stored water temperature to fluctuate by several degrees. The higher the delivery temperature, the greater the difference between room air temperature and the hydronic fluid (known as the Delta-T and represented by this symbol: ΔT).

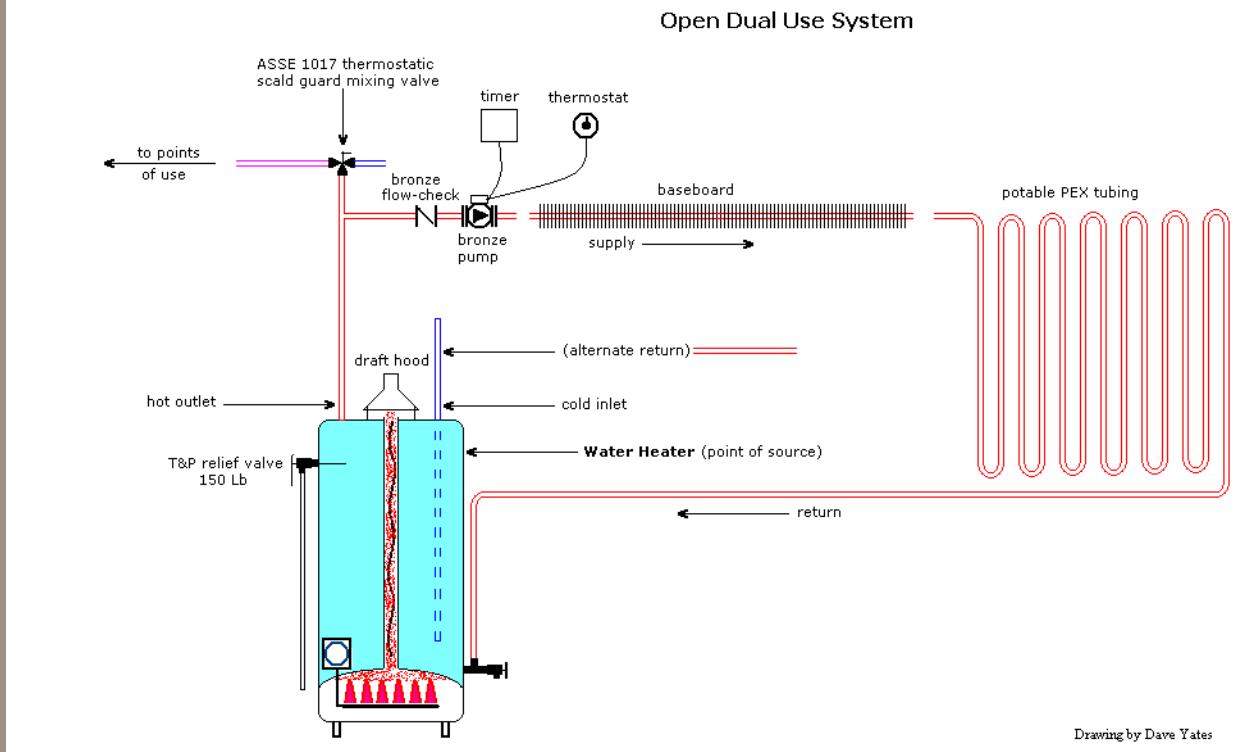
Water heaters are currently delivered from the factory with a 120 F setting. There was a time when that factory setting was 140 F, but scalding cases and federally mandated efficiency ratings led to a drive for lowering them to 120 F. The notion that a 120 F setting results in safe delivery of hot water is a myth. At a 120 F delivery temperature, third degree burns can still be a reality where the elderly and infants are concerned. There is also a phenomenon known as "stacking", which can occur in any storage vessel and the current regulation (ANSI Z21.10.1) governing residential water heaters of 75-gallons or less, allows for stacking temperatures of up to 190 degrees F! Third degree burns occur in the wink of an eye at those temperatures. Think of stacking as if it were layers of hot cakes. If there is a low flow of water, such as a dripping faucet or small demand (a small Btu load from a radiant zone), the burner cycles can add successive layers of heated water, which begin stacking along the upper portion of the tank. A sudden draw from a faucet will send that scalding torrent of water down the line. Each year in the US, there are more than 100,000 cases of scalding treated by doctors and included are several hundred deaths. It's a smart move to install an ASSE (American Society of Safety Engineers) certified 1017 thermostatic mixing valve on the outlet that serves the potable hot water system. (see Watts inset)

Let's look at several basic types of systems that utilize water heaters for their hydronic energy.

Dual use open cross-connected potable-hydronic:

Let's start with dual use open systems that offer no barrier between the hydronic and potable water because that's the most likely one you'll be pitched as an inexpensive highly efficient system. There's nothing magical about this method or anything that grants an open

system some sort of mystical energy efficiency. It is what it is – a water heater doing double duty. On the other hand, there are a number of valid concerns to be considered before opting to shave a few hundred bucks off your installed costs by eliminating a few safeguards, which will be included in most of the other methods that follow. Bear in mind that all components of open systems must



be rated for potable use. (See inset for drawing of an open system.)

At one time in the not too distant past, the leading cause of death for humans was contaminated water. Typhoid, cholera and dysentery pandemics in the late 1800's & early 1900's caused tens of thousands of deaths each year. On a bad year, you could find one in four of your fellow citizens dying from these illnesses, all of which were directly traceable to contaminated drinking water. In the early 1900's, safe plumbing practices evolved that developed into standards we refer to as plumbing codes, which together with the advent of chlorination led to saving more lives than all of the medical community advancements combined throughout history. When the move to lower water heater temperatures to 120 F began, no one envisioned or much less understood, the bacterial implications storage temperatures below 133 F held. Today we know that lower temperatures have created an environment suitable for bacteria like Legionella to survive and thrive.

In 1976, while attending an American Legion Convention at the Bellevue Stratford Hotel, 211 people became ill and 34 of them died from what was thought to be a previously unknown type of bacterial pneumonia. After this outbreak and identification of the bacterial strain, the Centers for Disease Control and Prevention examined some previously collected tissue samples, which revealed earlier cases of Legionnaire's disease.

One was circa 1947 from a soldier who had developed and died of pneumonia while at Fort Bragg, N.C. Further study revealed an outbreak occurred in 1957 at a meat-packing plant.

Another form of infection caused by legionella bacteria is Pontiac Fever. Its name is derived from the first recorded outbreak in Pontiac, Mich., which affected 144 people at the Oakland County Health Department. Flu-like symptoms occur that last for several days set in, but a full recovery can be expected.

So who is at risk? Generally speaking, elderly people with immune systems that are compromised by medication or illness; smokers; heavy drinkers; and aids, heart and kidney patients. Blood samples have shown that a large percentage of the population has been exposed to legionella bacterium. As many as 10,000 deaths from Legionnaire's disease occur each year (depends on whose statistics you believe), and some think those are low numbers. The vast majority of cases go unreported because they are simply listed as CAP (community acquired pneumonia). Penicillin, a drug often prescribed to pneumonia patients, is ineffective. Erythromycin is the proper medication, but not nearly as effective if you're over 50. "Amplifiers," a term often used with this issue, are devices capable of providing an environment suitable for the growth of legionella bacteria. Some examples include air conditioning cooling towers, potable water systems, humidifiers, whirlpool tubs, spas and domestic water heaters. Now we can add open systems, which by their very nature must be included as an amplifier. Any device capable of creating a mist that can be inhaled (vegetable misters, shower heads, aerators) in an environment where people are present can deliver a potentially fatal dose if the bacteria are present in sufficient numbers to overwhelm the immune system. Human lungs are a virtually perfect environment for legionella bacteria.

Legionella bacteria need four very basic conditions to survive and grow and they are commonly found in our potable water systems:

1)Water temperatures between 55 F and 133 F, with 68 F to 122 F being considered very favorable while 98.6 F the ideal temperature for rampant reproduction

2)A pH between 5.0 and 8.5

3)Biofilm (sediment)

4)Stagnation.

Biofilms are the slime and layer of junk we find in virtually all water piping. Sediment, another source of food and shelter for bacteria, occurs in tanks. Although free-roaming legionella bacteria begin to die above 122 F, they don't really get kicked in the pants until the temperature rises above 133 F and remains elevated for sufficient contact time – said to be 20 minutes minimum at those temperatures. Tests have proven the bugs can survive long periods of much hotter water by hiding within the outer fringes of biofilms.

The pH of nearly all potable hot water systems falls right in the most desirable range for growth.

Stagnation is all that we're really missing.

The hydronics industry is enjoying a radiant revolution. As more and more people discover the benefits, comfort and reliability of these products, the pressure has increased to find more economical installation methods. The temptation to cut corners and compromise consumer safety, knowingly or unknowingly, has given rise to cross-connecting potable water with hydronic loops while using a domestic water heater as the energy source.

What happens when the cross-connected hydronic system is at rest – even for brief periods of time?

Stagnation, which aids in bacterial reproduction as their nurseries burst open with free-roaming offspring. Various code bodies and professional organizations want to see timers installed to exercise the system pump to prevent long-term stagnation, but like any mechanical device, they are subject to failure. By the time that mechanical failure becomes known (when the heating season

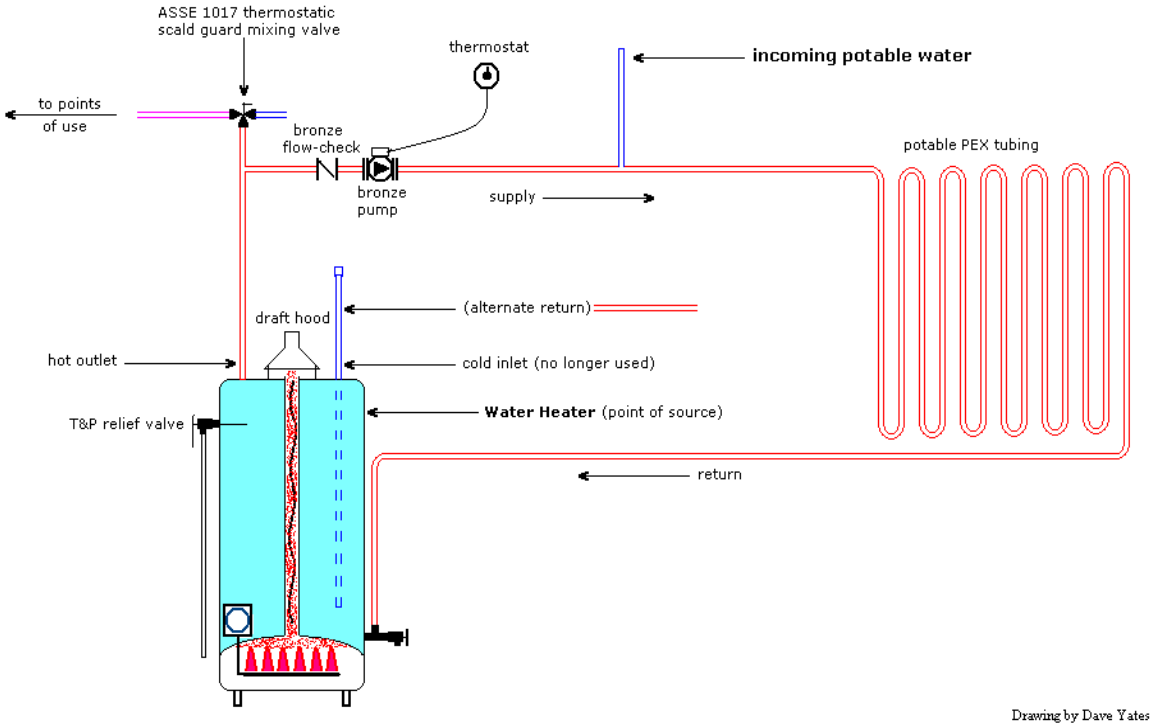
arrives), several months of stagnation may have occurred.
If you think chlorine is keeping your water safe from legionella bacteria, think again. Chlorine levels in typical potable water systems are 10,000 times lower than the levels needed to suppress these bacteria cultures. High chlorine concentration flushes of infected systems do not eradicate the bacteria and they typically return within just a few short weeks. Elevated levels of chlorine in potable water also create carcinogens. Chlorine dissipates in hot water, which contributes to pitting in copper tubing.

All in all, there are too many reasons why dual use open cross-connected systems should not be utilized. The potential dangers are simply too great, in my opinion, to warrant their consideration. I'd give these systems a two thumbs down!

* Check with local code authorities to determine if this type of system may be legally installed in your area.

Dual use open cross-connected potable-hydronic – with an added twist:

As you can see in this drawing, a new twist has been added. We're



now being instructed to run the incoming water through the hydronic system for all intended hot water usage. The theoretical

benefits are said to be: no stagnation; reduced energy consumption; and some free air conditioning. Let's check out these too-good-to-be-true claims.

Stagnation – whenever this system is at rest. Now when you go away on vacation, the neighbors can "exercise" your stagnant system by wasting hot water while feeding the pets!

Reduction in energy consumption. There is a slight benefit here due to a minimal increase in the supply water's temperature if it enters the home at a lower temperature than the air surrounding the tubing. Well water delivery temperatures average 55 degrees F, but municipal water systems often see elevated delivery temperatures, as high as 85 degrees F, in summer months. In the latter case, that incoming water is slightly cooled, adding energy costs for both the home's cooling needs and for heating the water once it reaches the tank. Bear in mind that the incoming water races along with normal start-to-finish travel time of less than 30 seconds till it arrives in the tank – hardly enough time to provide any substantial change in its temperature. Once stagnant again, the new water will either warm or cool until matching the surrounding air temperature.

Free cooling. Bear in mind that the tubing resides in a well insulated box and your system's performance is based upon driving energy up through the sub-flooring and whatever surface treatment you've installed: carpet; linoleum; ceramic tile; or hardwood. The delta T is not very significant, even if this is a well water system, and you'd need to waste large volumes of water in order to achieve any appreciable reduction in living-space air temperatures. If you've ever witnessed a cool drink "sweat" in summer weather, wet cold-water piping in your basement or a toilet tank dripping due to condensation of humidity, you can begin to understand what will likely occur in that darkened void space where your floor-circuit tubing resides. The last thing you'll need is a potential mold breeding scenario where you're providing everything needed: food; moisture; and perfect temperatures.

There's another important issue to raise here that deals with pressure drops in long runs of tubing. It's crucial for you to know what the pressure drop, or resistance to flow, is for the tubing you're using. The math really isn't very difficult. Common sense tells you a system installed in this manner might be troublesome. For instance, in a ½" PEX tubing application (the largest size good-quality plastic tubing I'd recommend you consider using for ease of

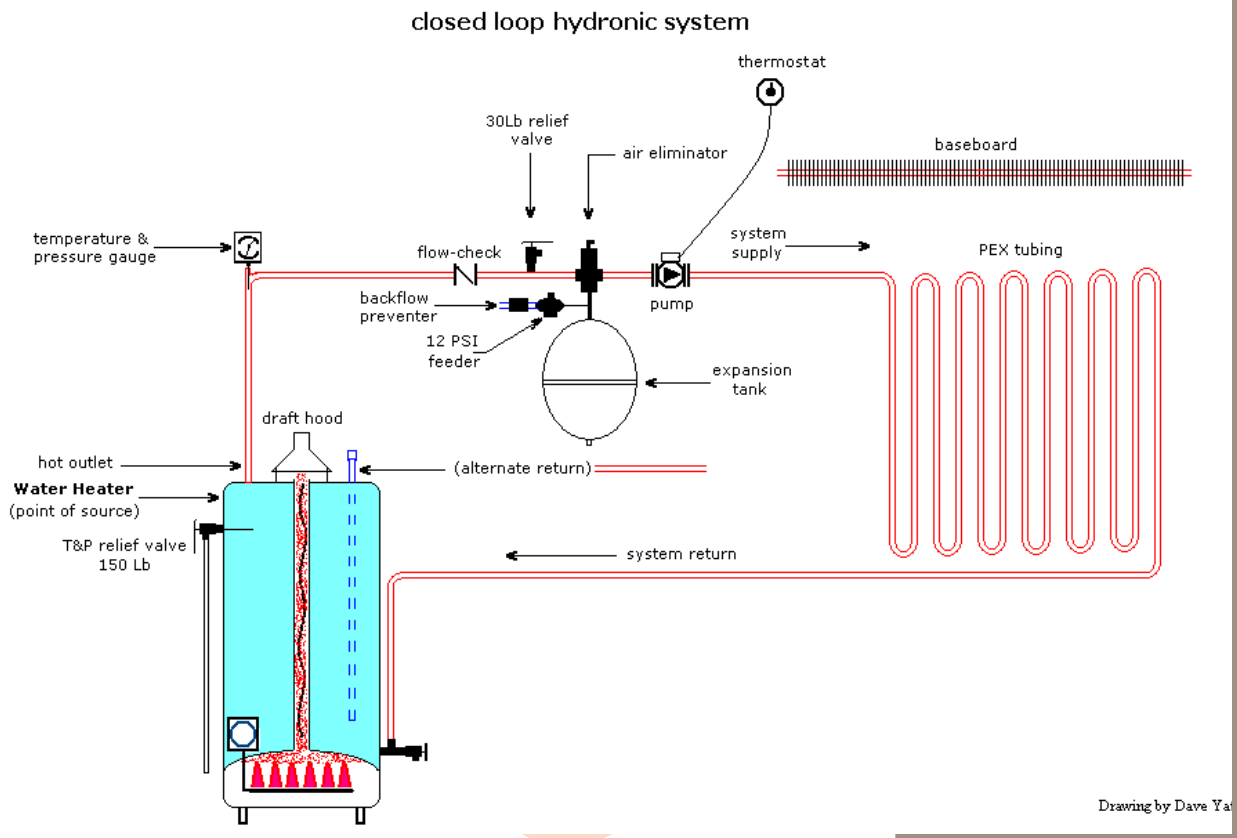
installation), the pressure drop at 4 GPM (gallons per minute flow rate) equals.208 in PSI/FT. A 4 GPM flow rate equals 8 ft. per second, which some codes list as the allowable limit. But most PEX manufacturers show a maximum flow rate of 7 GPM for ½" PEX tubing. On horizontal runs, you need to multiply the length times the pressure drop to find the net loss. If the system has tubing that extends vertically, you'll need to add another 1-PSI loss for every 2.31 feet of rise in elevation.

So you've initiated a pressure loss and your thoughts might be – so what? Don't forget that you're serving multiple fixtures and that the cold-water line doesn't suffer the same pressure losses. As a result, if a toilet is flushed (or other sudden use - like a clothes washer) while someone is in the shower, a potential for scalding will be created. Good plumbing systems are designed to avoid this type of scenario.

* Check with local code authorities to determine if this type of system may be legally installed in your area.

Let's move on to systems that don't include these risks.

Dedicated Hydronic Use:



For the first time, we're seeing several new items: a backflow preventer, which stops hydronic water from entering the potable water system; a pressure reducing valve set to deliver 12-PSI; an expansion tank due to water expanding as it is heated (this is a sealed system); an additional relief valve set for 30 PSI; and a combination temperature and pressure gauge. Now that we're isolated from the potable water system, none of these components are required to be rated for potable use. You've got some additional choices to make too. If you want to scrimp on the PEX tubing costs, you can purchase tubing without an oxygen barrier, but then all other components must be non-ferrous or they'll rust away in fairly short order. The cost savings of using an iron bodied pump, flow check, air eliminator and nipples to join them together will more than offset the additional costs for using PEX tubing that includes an oxygen barrier.

The water heater must be labeled "NOT FOR POTABLE USE" to comply with some jurisdictional codes, which is based on the concern that some unsuspecting consumer might re-use it for domestic hot water production. Not very likely, but it can't hurt to add the labeling just in case.

Why two relief valves? That's a good question and the answer is that you're still dealing with a storage tank where water under pressure can become super-heated above 212 degrees F. Super-heated water is extremely dangerous as its energy will be immediately released in the form of steam if it reaches its saturation temperature or pressure is suddenly dropped. When making the transition from water to steam, it expands 1,700 times in volume! The relief valve's probe (see inset of Watts T&P valve) ensures a discharge if the internal temperature reaches 210 degrees F, thereby avoiding any possibility of super-heating the water. Prior to the invention of the temperature & pressure relief valve by Watts Regulator Company in the late 1920's, water heaters used to explode on a regular basis. The energy released is equivalent to several sticks of dynamite! The 30 Lb. relief valve is required due to this being an isolated hydronic loop.

* Check with local code authorities to determine if this type of system may be legally installed in your area. Additionally, not all water heaters are rated for stand-alone hydronic use by the manufacturers and you'll need to be in compliance for any warranty or liability issues.

Dual Use Closed Loop Potable/Hydronic:

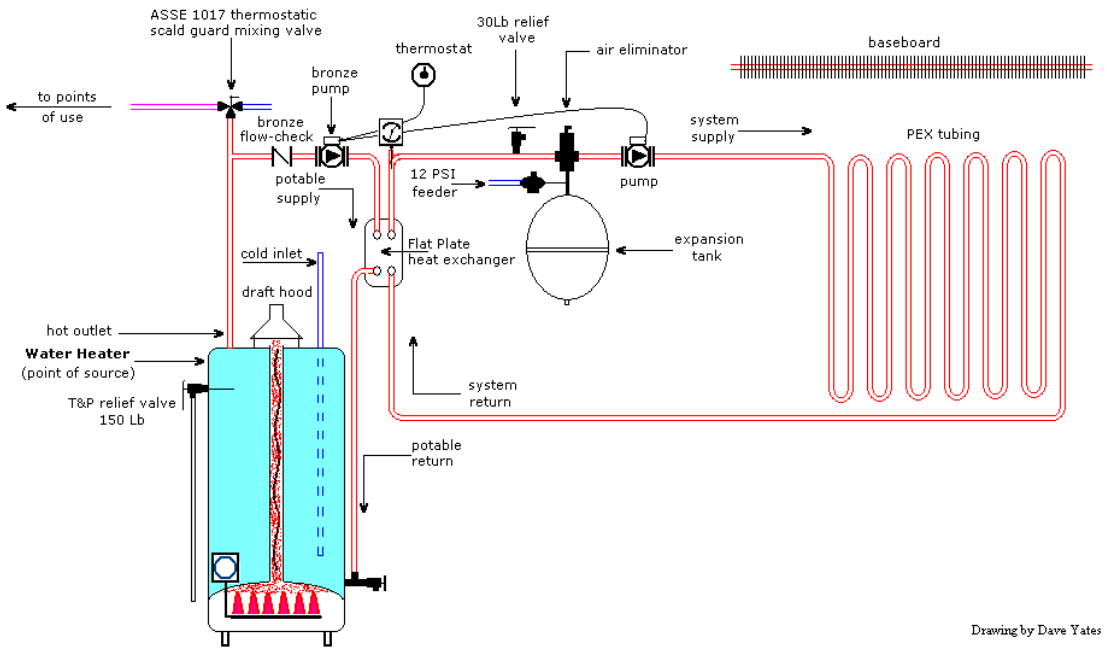
By far and away, this is the best practice I can recommend if you're

planning on using your water heater to perform dual use for potable water and hydronic heating. This is a perfect marriage between the open and dedicated systems already detailed above. You'll see that there's been a single addition: a Flat Plate stainless steel heat exchanger. The counter-flow pumping through the Flat Plate heat exchanger permits us to utilize a very small and inexpensive model with virtually no loss of efficiency. These come in a wide variety of sizes and your model should be matched to the heat loss for the total area being heated.

If a tiny hole is drilled through the swing-check gate on the bronze flow-check, a nice trickle of gravity circulation will be set up, which eliminates any stagnation without relying on any electro-mechanical devices to maintain potability. The ASSE scald-guard thermostatic mixing valve permits you to raise the manufacturer's storage tank temperature setting to 133 F for maximizing sterilization of the potable water.

* Check with local code authorities to determine if this type of

Dual use - closed loop potable/hydronic system



system may be legally installed in your area.

There are a number of web sites in particular that I know you'll find useful and they're both chock-a-block full of professional, knowledgeable and friendly contractors who specialize in hydronics. Both are also DIY friendly sites where polite decorum

Our Position Statement:

We are not aware of any manufacturer or any jurisdiction in North America which permits water heaters furnished with relief valves rated above 30 psi to operate as stand alone space heating devices. We will be happy to acknowledge any written proof offering a different position.

We are not aware of any water heater manufacturer which furnishes its product with relief valves rated above 30 psi to recommend its product be used as a stand alone space heating appliance. We will be happy to acknowledge any written proof offering a different position.

We are aware of the availability of water heaters manufactured rated for dual purpose which may or may not be permitted in one's municipality. It is important to mention the availability of dual purpose products does not necessarily mean it's acceptable across the country.

We are aware that any field alteration of a factory certified product to circumnavigate local codes or knowingly using a water heater for something other than what it was otherwise intended exposes one to a liability issues which in the event of illness, injury or death could give cause for criminal charges.

Some parts of North America also hold current property owners liable to new owners for components, systems, and assemblies which do not meet local codes and standards.

Our advice at www.healthyheating.com is to contact the insurance company that underwrites ones home owner policy to see what they are prepared to cover particularly if ones decision contravenes local codes, standards and manufacturers recommendations. Then ask,

"is it really worth the risk?"

and discourse prevails on their public bulletin boards. They are: www.heatinghelp.com and www.rpa-info.com and www.healthyheating.com. Each has a referral search engine to put you in touch with local professionals should you want expert assistance.

Other web sites of interest are:

www.cdc.gov

www.legionella.org/100960699-1.pdf

http://www.estechlab.com/Legionella-Friend%20or%20Foe.htm

http://www.contractormag.com/articles/column.cfm?columnid=98
http://www.contractormag.com/articles/column.cfm?columnid=22
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For additional information, simply place key phrases such as "Legionella + potable hot water" or "scalding + potable hot water" into your favorite internet search engine.

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