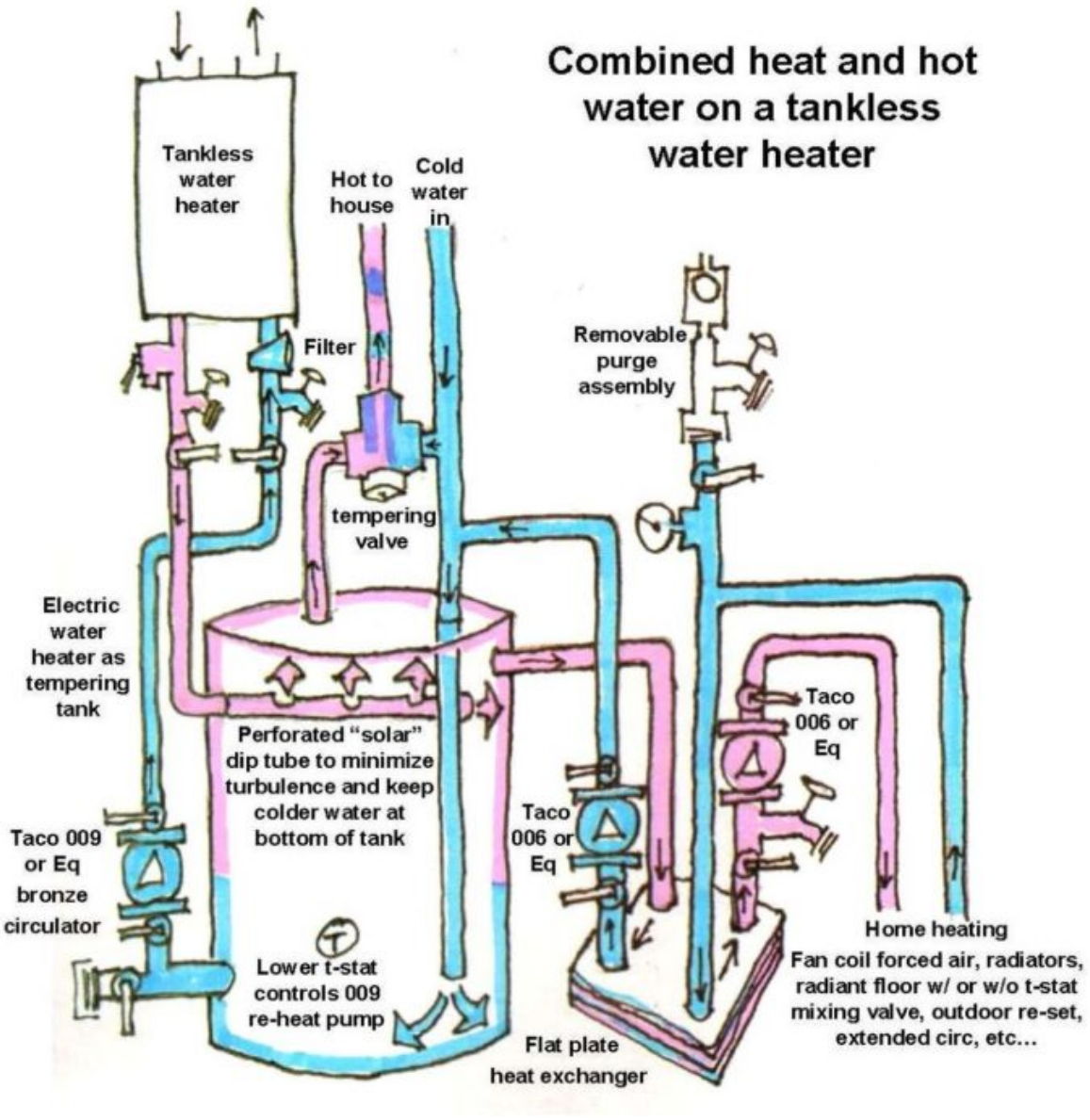
Stuff I Learned at Joe Lstiburek's House, Part 1

Everything I thought I knew about combined hydronic heat and hot water (combo) systems utilizing tankless water heaters is up for debate

 By Michael Chandler | August 10, 2011



Pared-down combined heat and hot water system using a tankless water heater, reflecting lessons learned at Summer Camp 2011.
Image Credit: M. Chandler

The invitation was too cool to be real: My name was somehow on a list of “experts” who were invited to take part in a Building America Water Heater Expert Session on combo systems. The invite noted that the session was to be the day before Joe Lstiburek’s Building Science Summer Camp, and “it is expected that the information obtained will lend itself toward the eventual production of a guide for the best practice application of combination space and domestic water heating systems for new and retrofit residential construction.”

I noticed a heavy representation of tankless water heater manufacturers, as well as researchers and giants of the industry Gary Klein and Larry Weingarten. Martin Holladay was invited as designated skeptic and naysayer, a role he served vigorously.

Needless to say, I got there an hour early
To get us started, Hugh Magande from Rinnai ran us through the ignition sequence of the Rinnai condensing and modulating domestic water heater and discussed improvements they have made to shorten it, especially on re-starts after a brief off cycle, to reduce the “cold water sandwich” problem.

Originally the systems required a ten-second cold fan run to clear any residual propane from the combustion chamber and “prove draft” before starting the ignition sequence. Rinnai has reduced this time; the new range is from 10 seconds to as low as 2 seconds to cold start and shorter for re-start after short off periods (short bursts of hot water in close sequence).

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Rinnai has responded to the new ultra-low-flow faucets by dropping the low-flow limit from .7 to .4 gpm for cold start and .2 gpm for re-start, but with less than .3 triggering the shutdown. Once first burn is proved, the two central gas valves ignite and, if water doesn’t come up

to temperature, two more light, then two more. Water is heated to as high as 180°F and then mixed down to the set-point by a computerized mixing valve.

Setting the water temperature too cold can cause low-flame issues, so a 140°F set-point leads to the cleanest burn. Cooler intake water is directly related to better energy efficiency. At 100°F the water heater has an efficiency of 91%; at 110°F that drops to 89%, at 120°F only 88%, and at 130°F intake water it drops it to 86%.

Of course, a few years ago we considered 86% efficiency to be pretty darn good, but these days we're seeking durability and low first cost at 90% efficiency — plus the capacity to provide both domestic hot water and space heating.

What could possibly go wrong with tankless water heaters?
Martin Thomas from NRC (Natural Resources Canada) shared photos of tankless water heaters hooked up to small electric water heaters used as tempering tanks which provide hot water to fan-coil units for forced-air heating systems.

Thomas discussed the problems encountered in these systems: reduced tankless water heater efficiency and perpetually clogged intake filters. Running the tempering loop off the tank bottom at 110°F gives limited opportunity for condensation, but as soon as the water leaving the bottom of the tank exceeds 120°F, you no longer have a condensing water heater. Worse, the warmer water makes the modulating water heater turn down to its lowest setting which, like running a car at 15 miles an hour, further reduces the efficiency of the unit.

People in the audience spoke of measuring the efficiency of on-demand water heaters at about 50% when choked down in this fashion. I have certainly witnessed this problem, as well as soot build-up on heat exchangers when burning propane this way. So if you're running a tankless water heater to maintain heat on a tempering tank for use in a radiant floor, you won't get any benefit from using a modulating unit and very little from using a condensing unit.

Non-modulating units are cheaper
The folks from Bosch were very quick to note that their units are non-modulating (and most of them are non-condensing and sell in big box stores for around $600). Here I was installing the best Rinnai and Quietside units and I would have been better off with the inexpensive Bosch from Home Depot, which would probably have allowed me to size the recirculation pump down to a Taco 006 (instead of the more expensive Taco 009s we've been using).

Dave Hammond from A.O. Smith spoke about using a fast-acting probe-type thermistor rather than the surface-mounted aquastat typically found on the electric tank water heaters to activate and shut down the recharge pump more quickly, improving system efficiency by reducing recharge time.

A casual side comment made me go "Ah ha!" — when someone spoke of wrapping thermistors in electrical tape to "prevent those problems you get when you have metal-to-metal contact with thermistors." I've sure seen the problem, but never realized the solution was so simple.

Rolling the tank stings two ways
The clogged intake filter problem seems to be related to debris coming from the anode rod. The problem is exacerbated by tank turbulence (AKA "rolling the tank" — when incoming water creates a current that sends hot water to the bottom of the tank and pushes cold water and sediment to the top). So using a smaller pump with a shorter run-time could reduce tank turbulence and help solve this problem.

I spoke about returning the water to the tempering tank using a horizontally mounted perforated "solar" dip tube to diffuse the flow and layer the hottest water into the top of the tank, to press the coldest water from the bottom of the tank to the tankless water heater.

The folks from Bosch proposed that plumbers just remove the filter after two months of operation, as their equipment only needs the filter in long enough to keep any teflon tape and pipe dope from jamming the flow. However, the Rinnai and Navien reps at the meeting didn't jump on that bandwagon.

It’s Larry Weingarten’s turn

Larry Weingarten from Water Heater Rescue spoke of using a J-shaped cold-water dip tube to push debris up against the drain port, facilitating tank cleaning during maintenance.

Combined heat and hot water systems increase tank cycling and accelerate aging, so tank durability is an important part of this discussion. Weingarten stimulated a glorious conversation with graphic photos of tank failures and premature anode-rod decay. He proposed the idea of buying souped-up electrically powered anode rods and avoiding soft aluminum anode rods, and he explained how to tell the difference between magnesium and aluminum anode rods by looking for a bump on the nut (bump good, flatness bad).

Larry also sold me on using plastic-lined steel nipples to minimize corrosion in the transition between glass-lined steel tanks and brass or copper fittings. He also made a convincing argument to replace the plastic drain port at the bottom of the tank with a proper 3/4-inch ball valve and to take the time every year to flush the corrosive sediment.

The low flow rates of modern WaterSense-listed fixtures has created problems with tankless water heaters that tempering tanks can help address. Larry led a discussion on faucet aerator designs, citing Brycor and Neoperl. You can open up your design choices in faucet selection and just swap out the aerators — the low-flow ones are even helpfully made from green plastic, so the green building rater can verify the swap. We also discussed the pressure drop of different tankless water heaters, noting that the same flow from a Taco 009 pump on a Rinnai would require a Taco 013 in a Navien.

A vote for simplification

Martin Holladay pointed out (vigorously) that we were all going around our elbows to get to our thumbs, by designing and fine-tuning these complex systems when we should just give up and admit that we need one appliance to heat domestic hot water and another to heat the home. (My lead plumber, Matt McDonald, points this out to me on a regular basis, much to my annoyance.) He also noted that most of the suggested modifications to tankless water heaters used for space

heating — adding a storage tank, a huge intake filter, and a circulating pump, for example — complicated the systems in the effort to restore the advantages of a cheaper tank-style heater.

Martin loves wood stoves, solar water heaters, and wall-hung minisplit heat pumps, but he has a point. From my perspective, I just can't imagine building a passive solar house without a well insulated slab floor, and I can't imagine skipping the opportunity to put radiant piping in a slab and heating it with a water heater, especially with a solar tie-in.

Someone in the audience pointed out that A.O. Smith makes the Vertex condensing tank-type water heater that doesn't cost much more than a good condensing tankless water heater, and solves many of the problems of marrying a tankless to a tempering tank. The Vertex still hits condensing efficiencies when supplying heat and hot water (or in a radiant floor application). Up to now, condensing tank-type water heaters like Triangle Tube, Polaris, and Phoenix have been much more expensive than condensing tankless water heaters, but it appears that the Vertex at least is competitive with all but the Bosch, which appears to be what we should have been using all along.

Problematical standards, again

The discussion then degraded to raging against the test standards by which these devices are rated. Most excoriated was the ASHRAE 124-2007, "Combined Heat and Hot Water Annual Efficiency Test Standard," which prescribes supply and return temperatures which may not be the temperatures your equipment is designed for, and further requires that all "smart controls" be disabled prior to testing the equipment. The test gives no way to assess the real-world performance of a system with advanced electronic optimization.

Slightly less vitriol was directed at the Canadian CSA P.9-2011 standard, and mention was made of a new ASHRAE 206 standard for heat-pump water heaters.

I inserted my foot in my mouth by kvetching about how our local HVAC contractors have taken radiant heating away from the plumbers here in North Carolina through activism with their licensing board. My

comment fired up the HVAC contractors in the back of the room, who took exception to my complaint. I countered that profiteering by the HVAC industry is slowing the acceptance of minisplit wall-hung heat pumps, because folks who sell ducted heat seek higher markups from systems that are ductless.

We agreed to revisit it at the club house, and eventually all ended well. Last year I ticked off the spray foam industry by bringing up the halogenated flame retardant issue; this year I ticked off the HVAC guys. Joe says I'm not off the list so far, so I'll see who I aggravate next year.

The elephant in the room

We are all expecting the manufacturers who are putting out these tank-top heat pump water heaters to come out with minisplit versions, where the compressor is located outdoors and doesn't heat your water by cooling the air that has just been heated by your furnace, but instead harvests heat from outside the house. I assume that they are still working out the issues of stripping the heat off the coil efficiently, and I hope that they will get these products on the market soon.

At this point the Daikin Altherma, Multi Aqua, Space Pak, Unichiller RC, and Aqua Products reverse-cycle chillers are too multi-purpose and expensive to economically serve the simple need to heat a tank of water with a recharge rate of 60 to 140 kBTUh (the typical range for combined heat and hot water systems). Most of these are designed to provide both modulating heat and cooling to fan-coils in forced-air applications.

We need to see a convergence of these technologies, and I think a lot of that innovation will come from the folks at the annual Westford Summer Camp.