Using external heat exchangers in biomass boiler systems with non-pressurized thermal storage.

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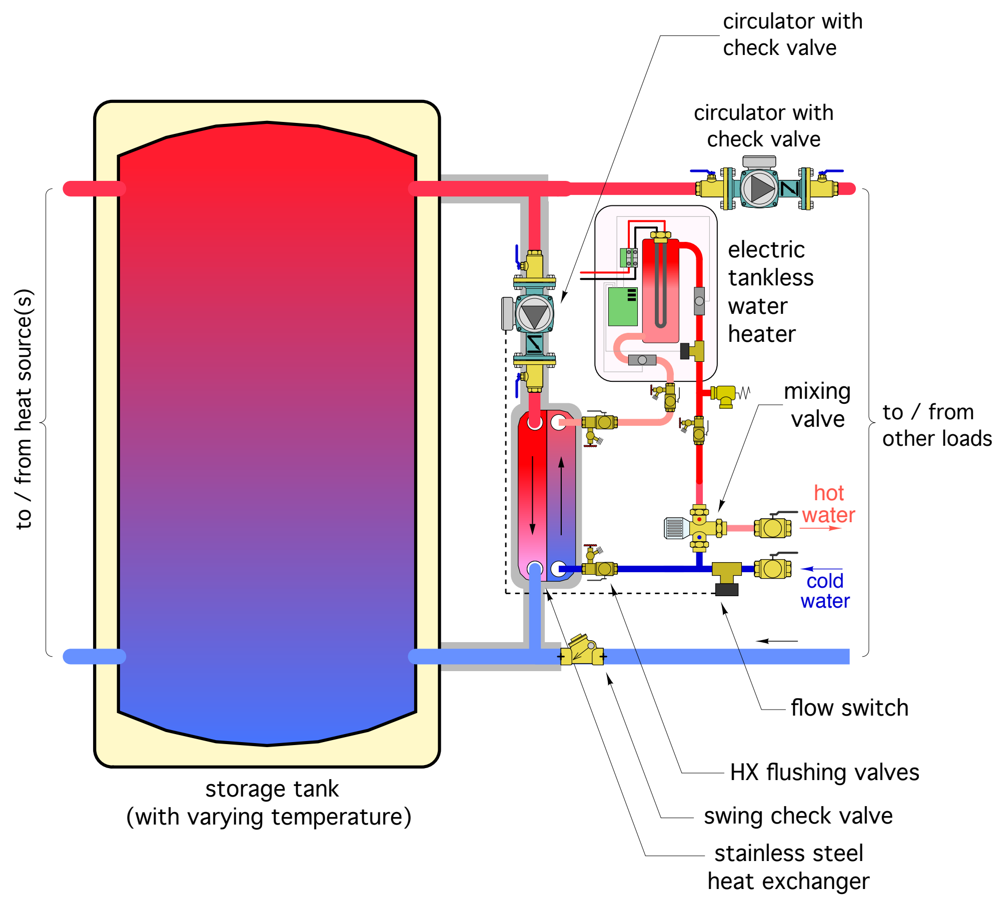
March 18, 2021
1:00 PM



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Using external heat exchangers in biomass boiler systems with non-pressurized thermal storage.

Session description: Many cordwood gasification systems use unpressurized thermal storage tanks. A common approach is to use coiled copper tube heat exchangers suspended within these tanks. An alternative approach uses external brazed plate stainless steel heat exchangers. This webinar exams the advantages of the latter approach. It also shows how a single external heat exchanger can be used for both heat input to the thermal storage and heat extraction.

Learning objectives:

1. Understand differences between immersed coil and brazed plate heat exchangers.

2. Understand how to pipe brazed plate heat exchanger in combination with non-pressurized thermal storage tanks

3. Explain options for heating domestic water in systems using non-pressurized thermal storage and brazed plate heat exchangers.

4. Describe why counterflow is important for heat exchangers.

Design Assistance Manual
for High Efficiency Low Emissions Biomass Boiler Systems

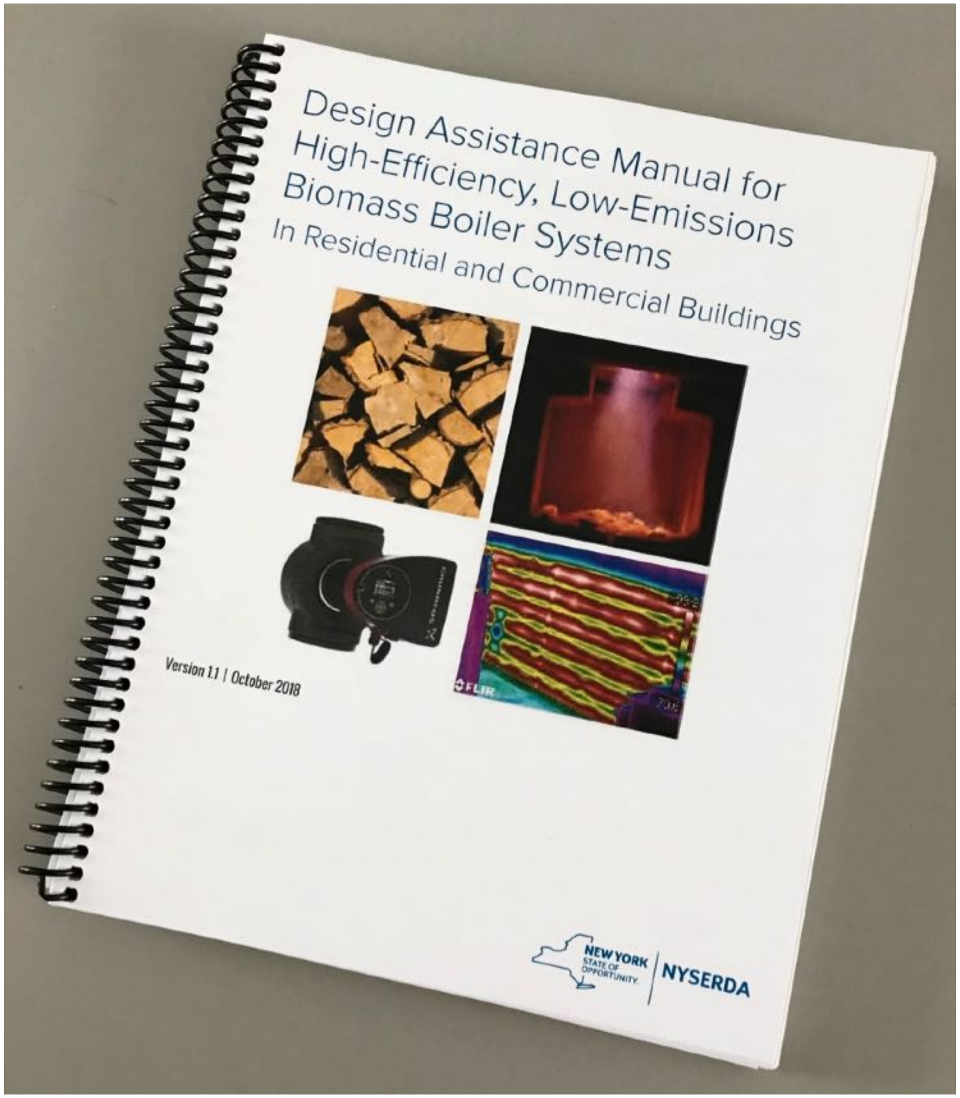


Table of Contents:

It's available as a FREE downloadable PDF at:

https://www.nyserda.ny.gov/-/media/Files/EERP/Renewables/Biomass/Design-Assistance-Biomass-Boiler.pdf

Unpressurized thermal storage tanks

Unpressurized thermal storage tanks

Considerations:

- Water will evaporate - water level must be monitored
- Air space above water accommodates water expansion
- Many open tanks are “knock down” construction and are assembled on site
- Typically lower cost ($/gallon) than pressurized tanks
- Requires one or more heat exchangers to interface with boiler or distribution system
- May require water treatment to control biological slime growth (use Fernox)
- Must use stainless steel or bronze circulators to handle open system water

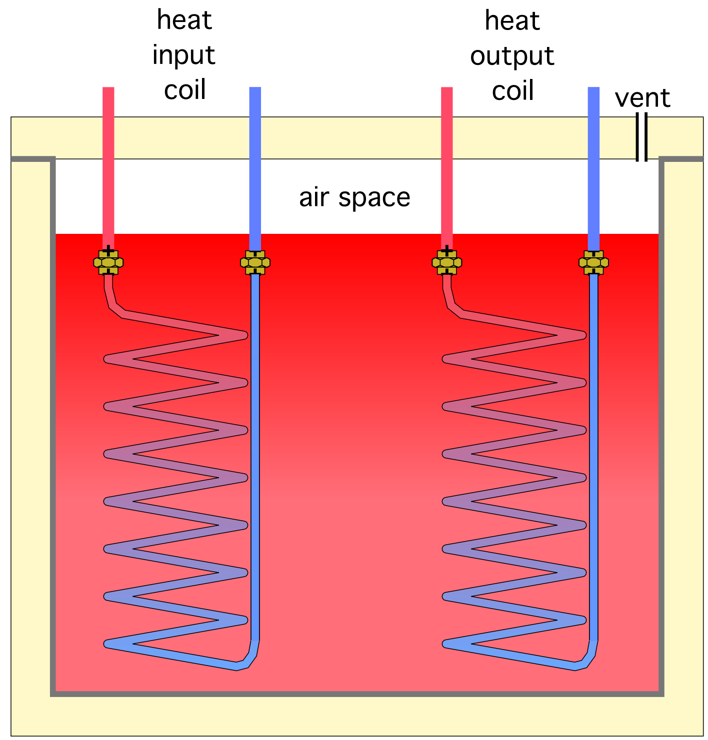
courtesy of American Solartechnics

courtesy of Hydroflex

Open (unpressurized) buffer tanks

images courtesy of Hydroflex

To date, the most common method of adding and removing heat from an unpressurized tank has been to use coil heat exchangers



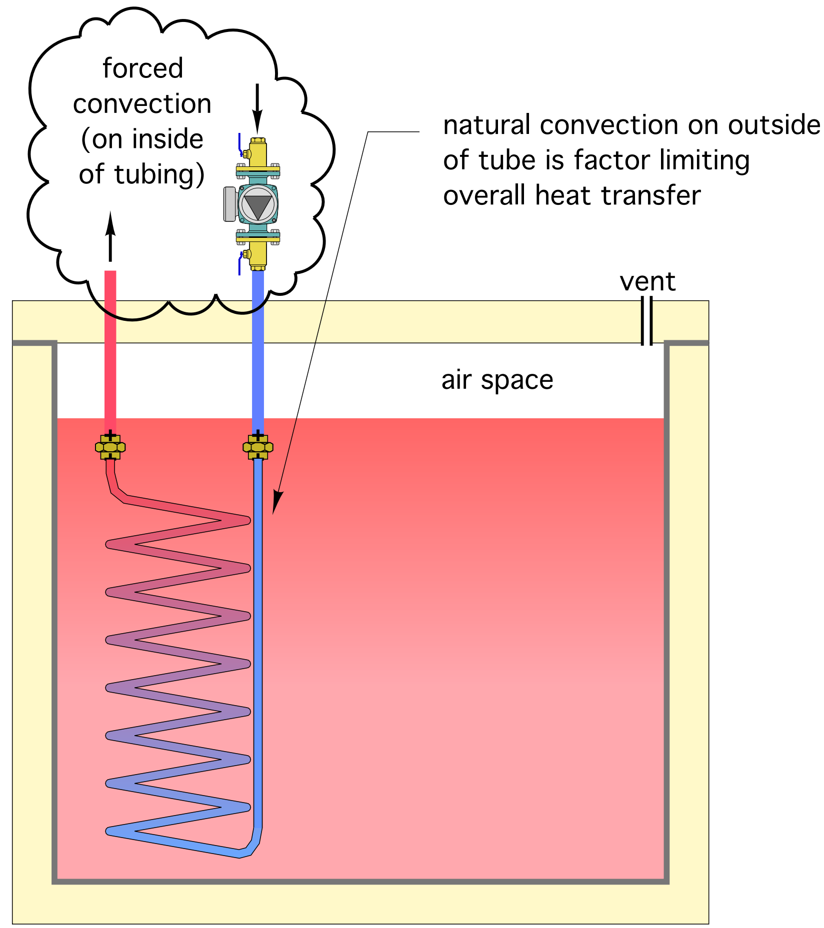
Considerations for coil heat exchangers

• All liquid-to-liquid heat exchangers involve two surfaces where convection heat transfer between a liquid and solid surface occur.

• The rate of convection depends on the "convection coefficient" between the liquid and the surface.

$$q = hA(\Delta T)$$

where:
q= rate of heat transfer (Btu/hr)
h = convection coefficient (Btu/hr/ft²/ºF)
A = surface area over which heat is moving (ft²)
ΔT = temperature difference between fluid "bulk" temperature and surface temperature (ºF)

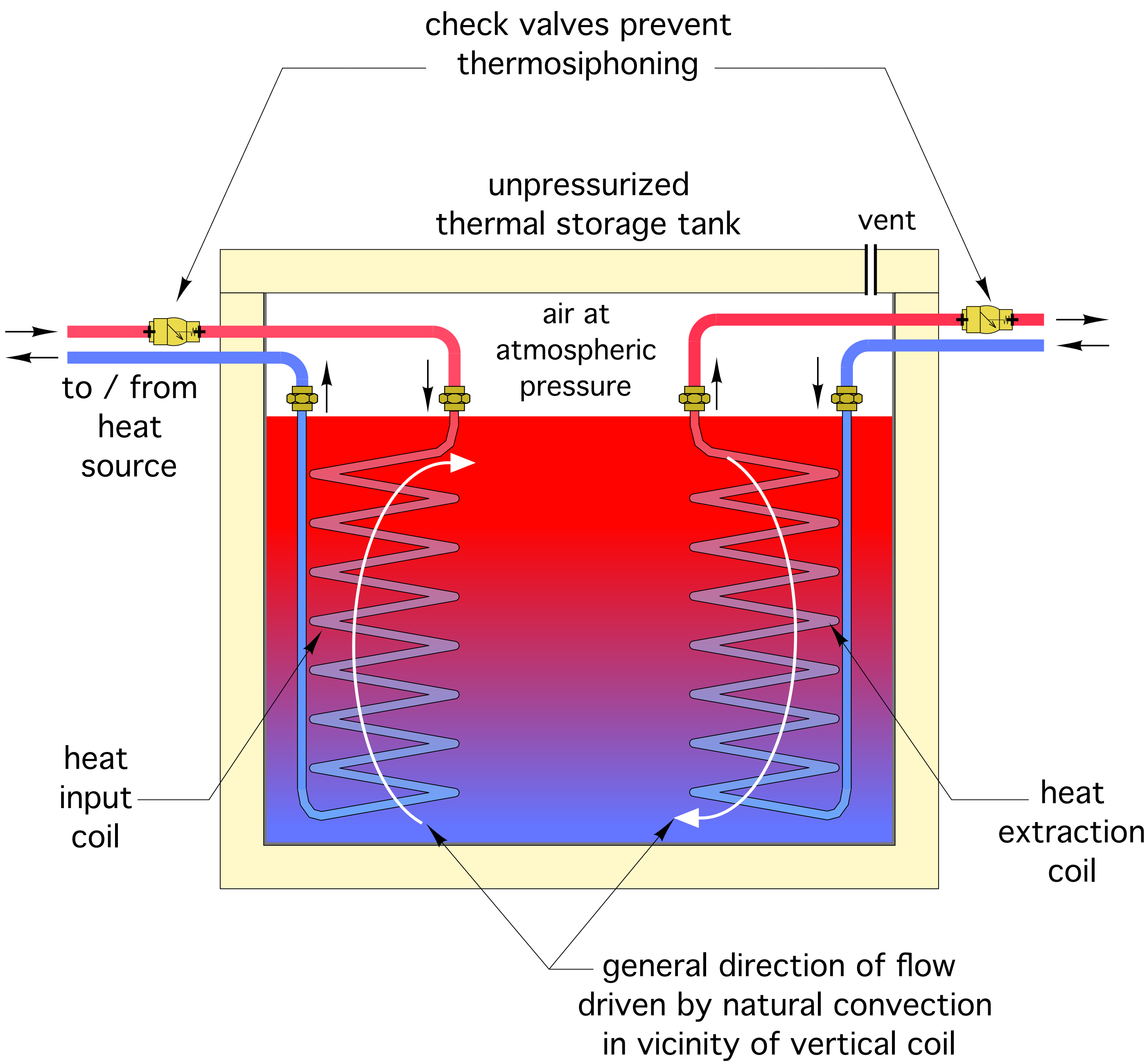


• Convection coefficients can be very complex to calculate. They depend on liquid velocity, fluid properties, geometry.

• **In general, the convection coefficients created by "natural convection" along the outer surface of a coil heat exchanger are much lower (<10%) than those created by "forced convection" along the inner surface of the coil (due primarily to fluid velocity).**

• **For a given rate of heat transfer, the surface area associated with natural convection is much larger than that required by forced convection.**

- Flow direction should **always** produce **counterflow** heat exchange
- Use check valves to prevent thermosiphoning



Limitations of internal coil heat exchangers

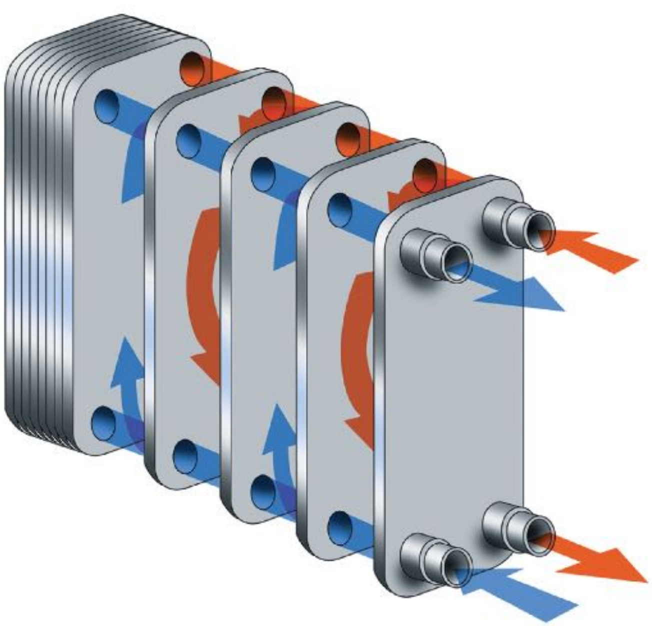
- They are expensive, typical copper coil ≥ $1000
- Limited rate of heat transfer
- Any maintenance requires opening tank - not easy
- Any maintenance may require major piping work inside tank
- Higher head loss requires more pumping power
- **Very limited information for designers to accurately assess thermal performance over a range of temperature and flow conditions**

versus

alternative

Using EXTERNAL heat exchangers

Brazed plate stainless steel heat exchangers



3”x5”

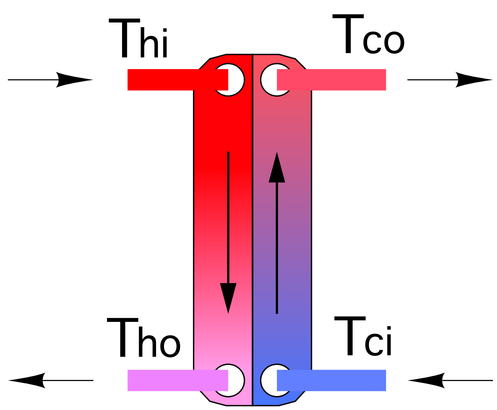
Images courtesy
GEA FlatPlate

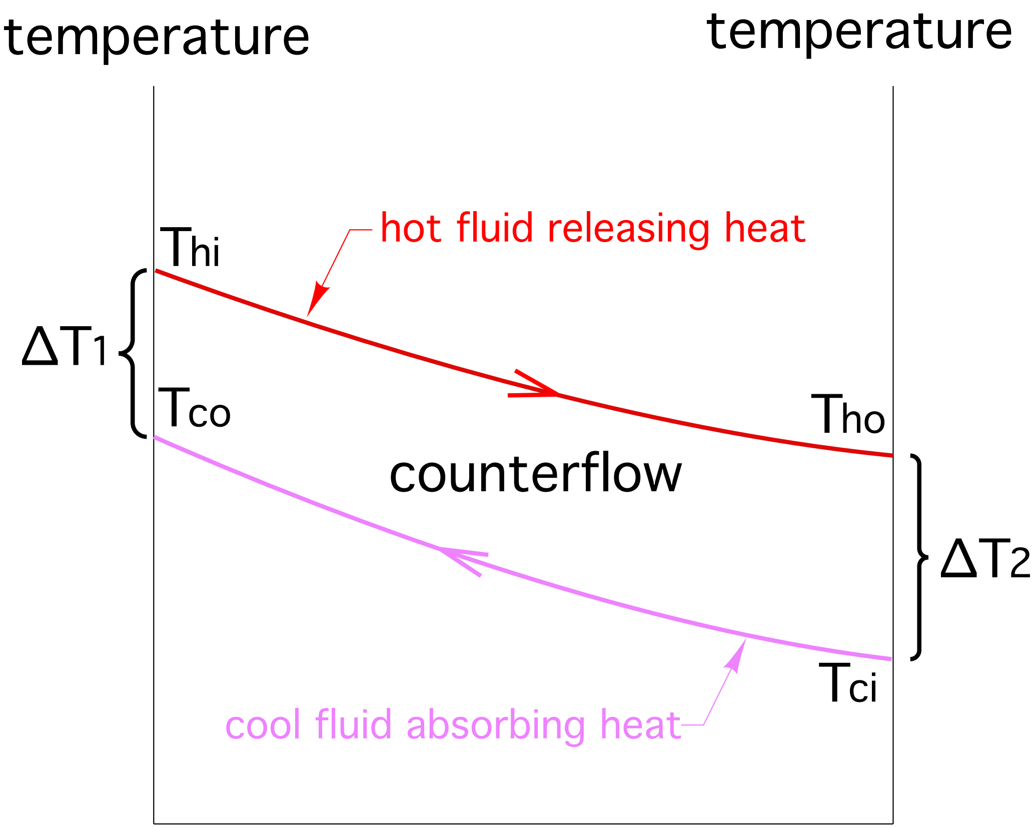
5”x12”

5”x20”

Brazed plate stainless steel heat exchangers

Always connect heat exchangers for counterflow





Counterflow ALWAYS produces the highest "log mean temperature difference" (LMTD) across the heat exchanger.

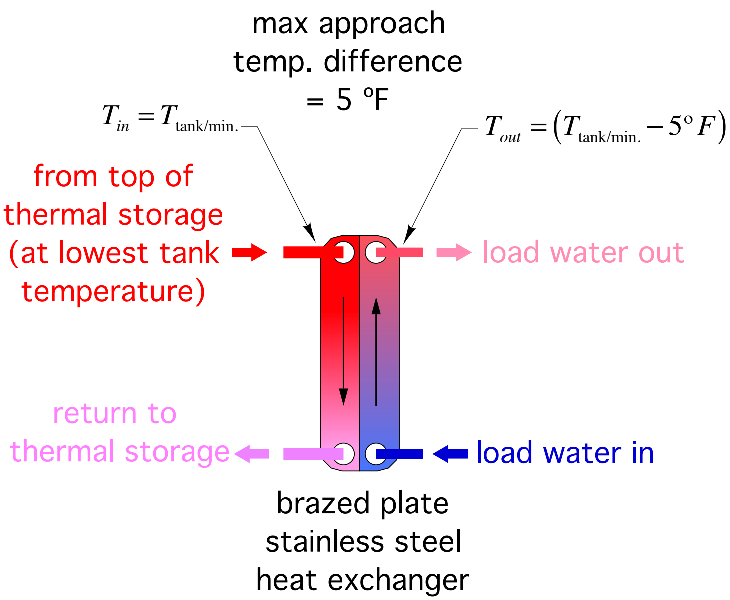
The higher the LMTD, the greater the rate of heat transfer (all other factors the same).

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}$$

Sizing the brazed plate heat exchanger

All heat exchanger create a "temperature penalty" between the material giving up heat, and the material receiving heat.

Suggest a maximum approach temperature difference of 5 °F under max. anticipated load.

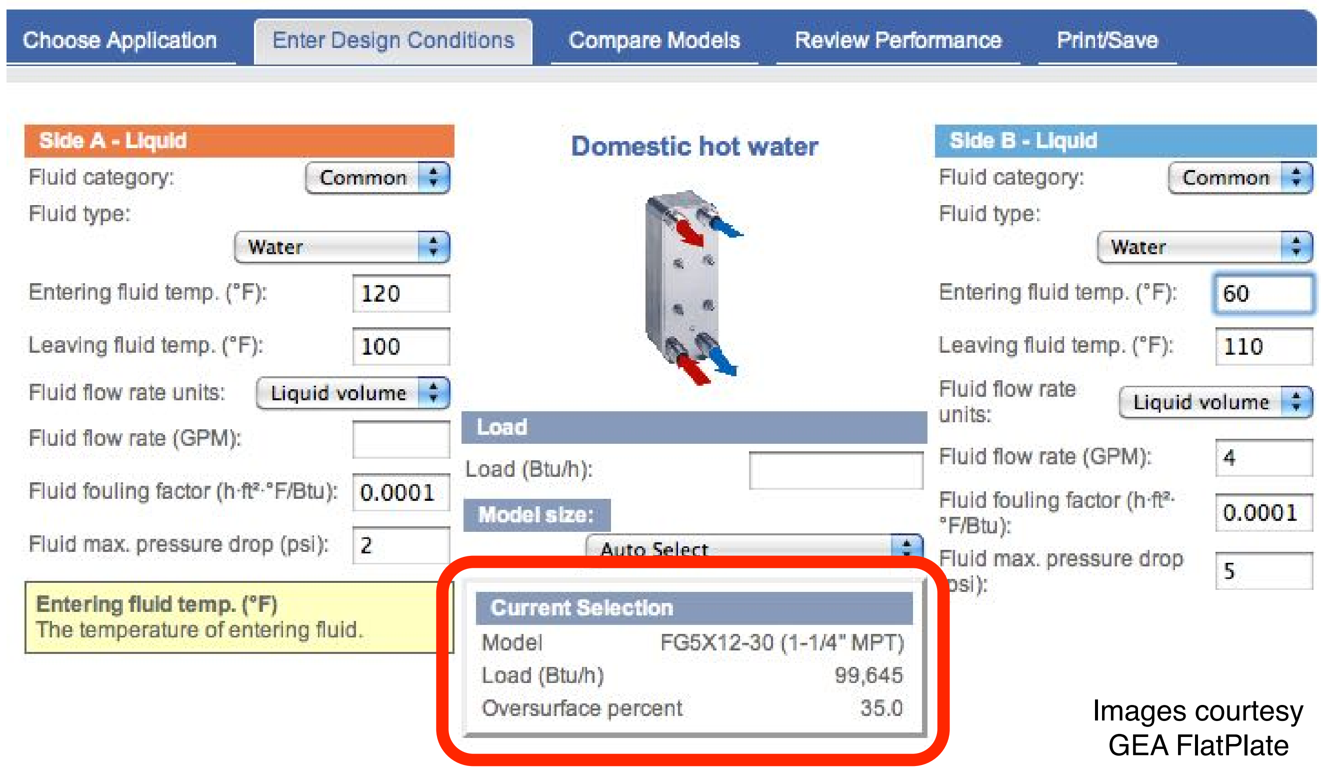


FG5x12-30

5" wide x12" long -30 plates

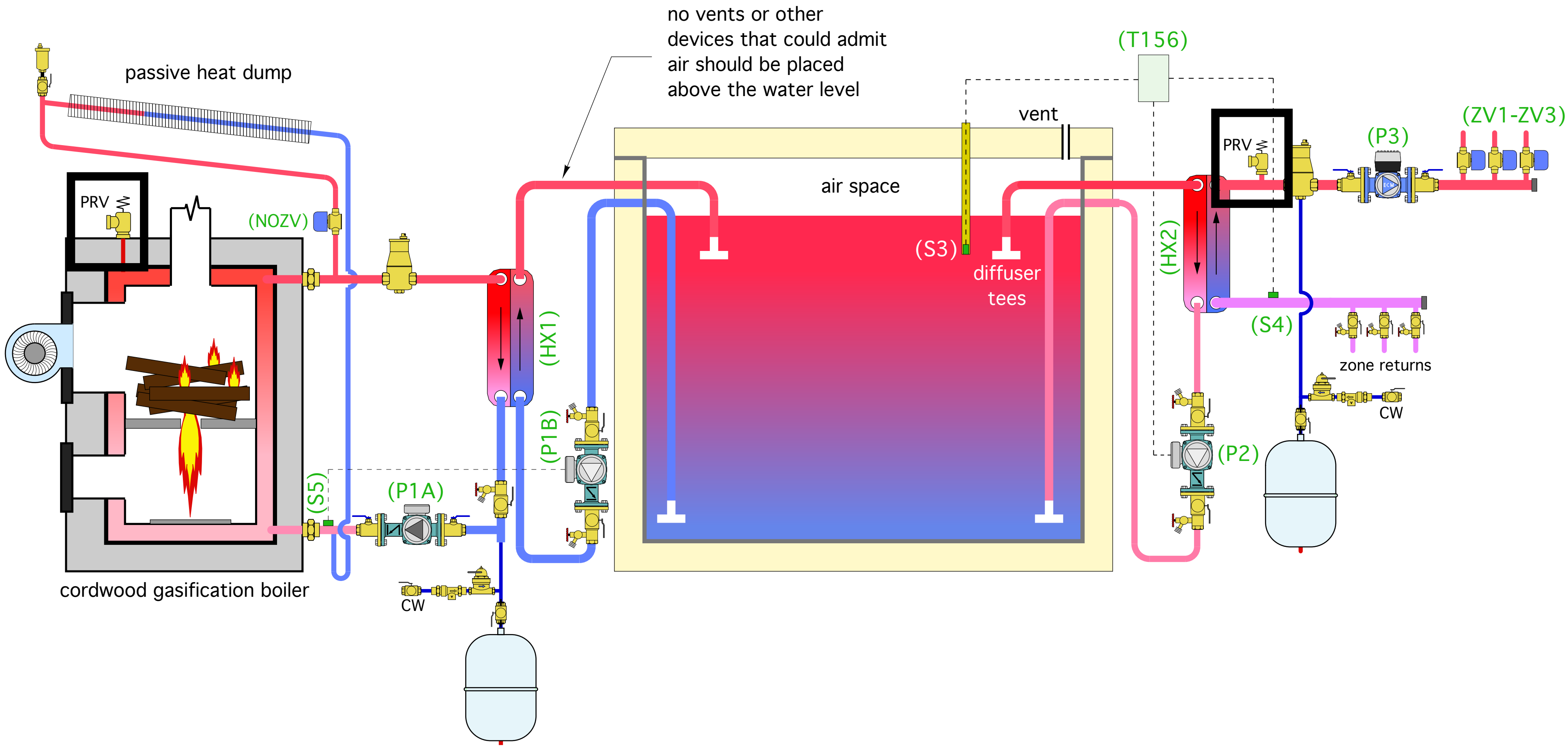
http://flatplateselect.com

GEA FlatPlateSELECT™ – ONLINE



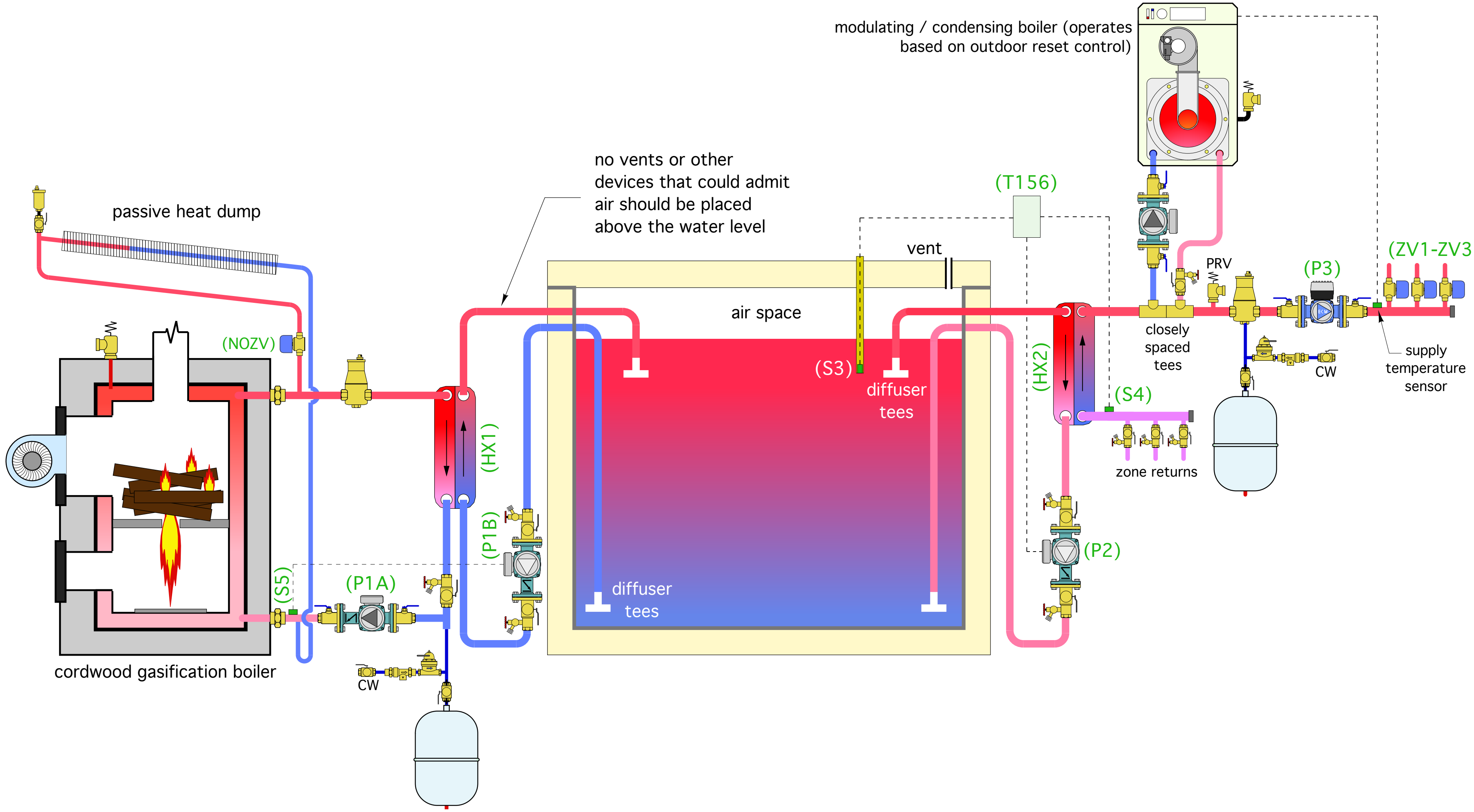
Images courtesy GEA FlatPlate

Using brazed plate heat exchangers rather than internal coils



- All circulators handling tank water must be stainless steel or bronze
- All piping and sensor well penetrations of tank must be above highest water level
- Wood gasification boiler upper temperature limit must not exceed tank line temperature limit
- Circulators handler tank water should be mounted low to provide higher NPSH
- Size heat exchangers for a maximum approach temperature difference of 5 °F
- Circulator (P1B) is variable speed for anti-condensation control of wood gasification boiler. It is off below 130 °F at sensor (S5)

Add and auxiliary boiler to previous system



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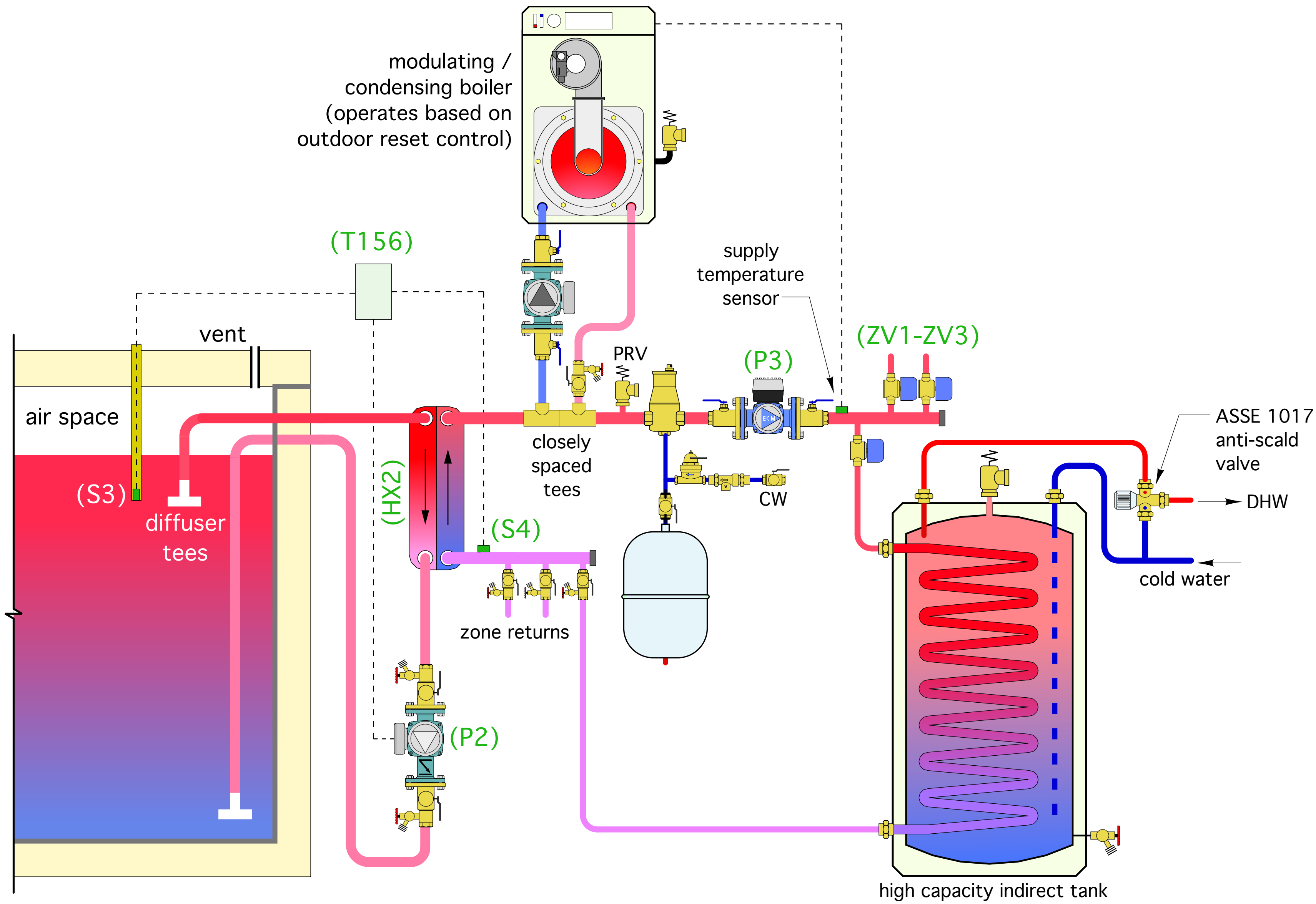
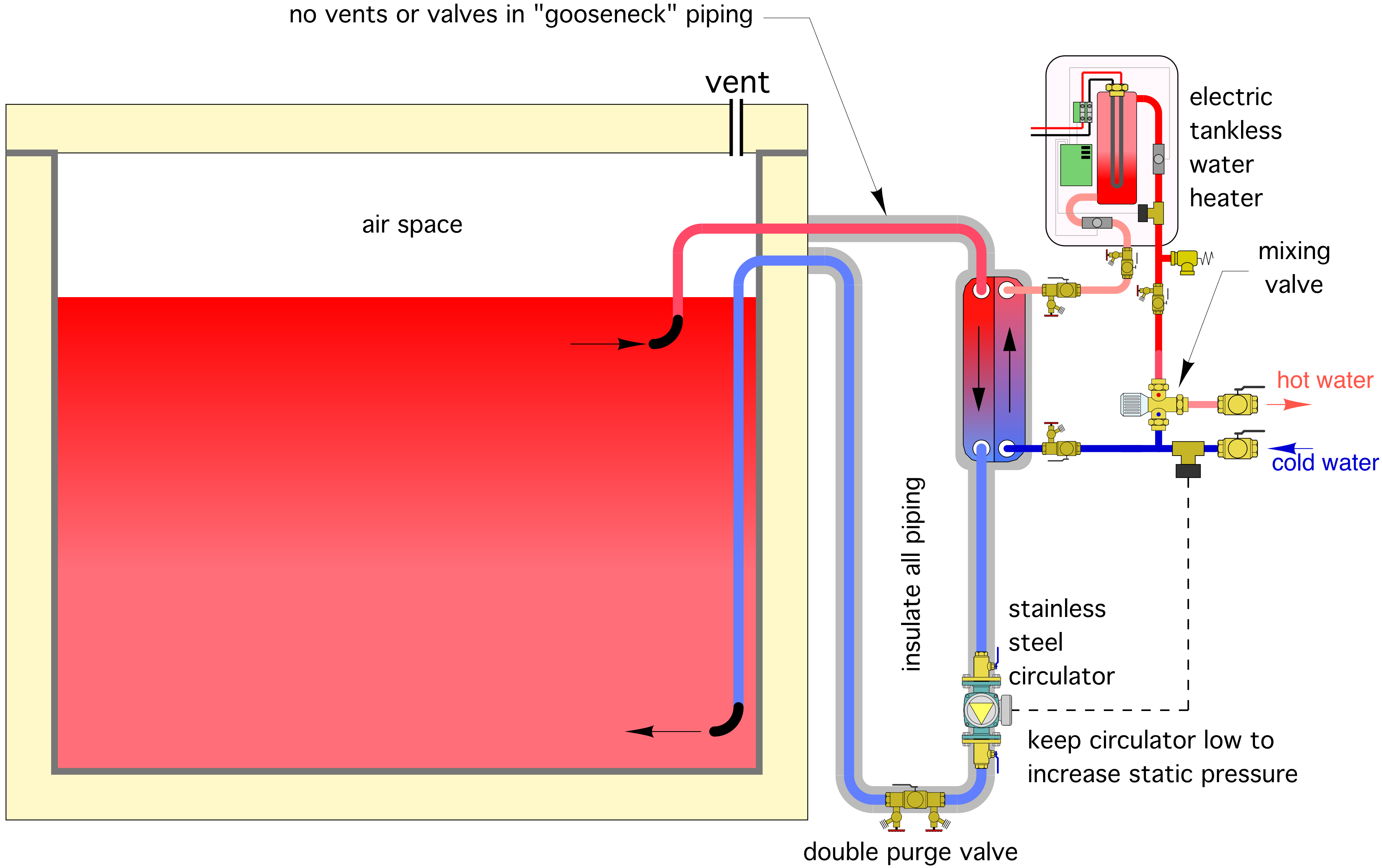
Add provision for domestic water heating to previous system



- Use indirect with large coil to enable max preheating & lowest aux boiler temperature
- Aux boiler can “top off” temperature in indirect tank
- ASSE 1017 setting no higher than 120 ºF

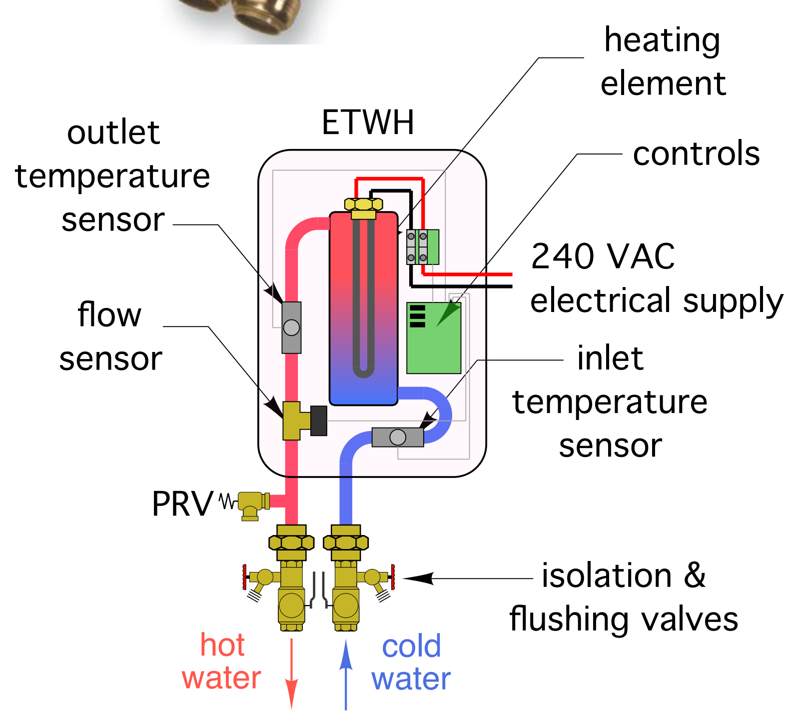
Instantaneous DHW subassembly piping

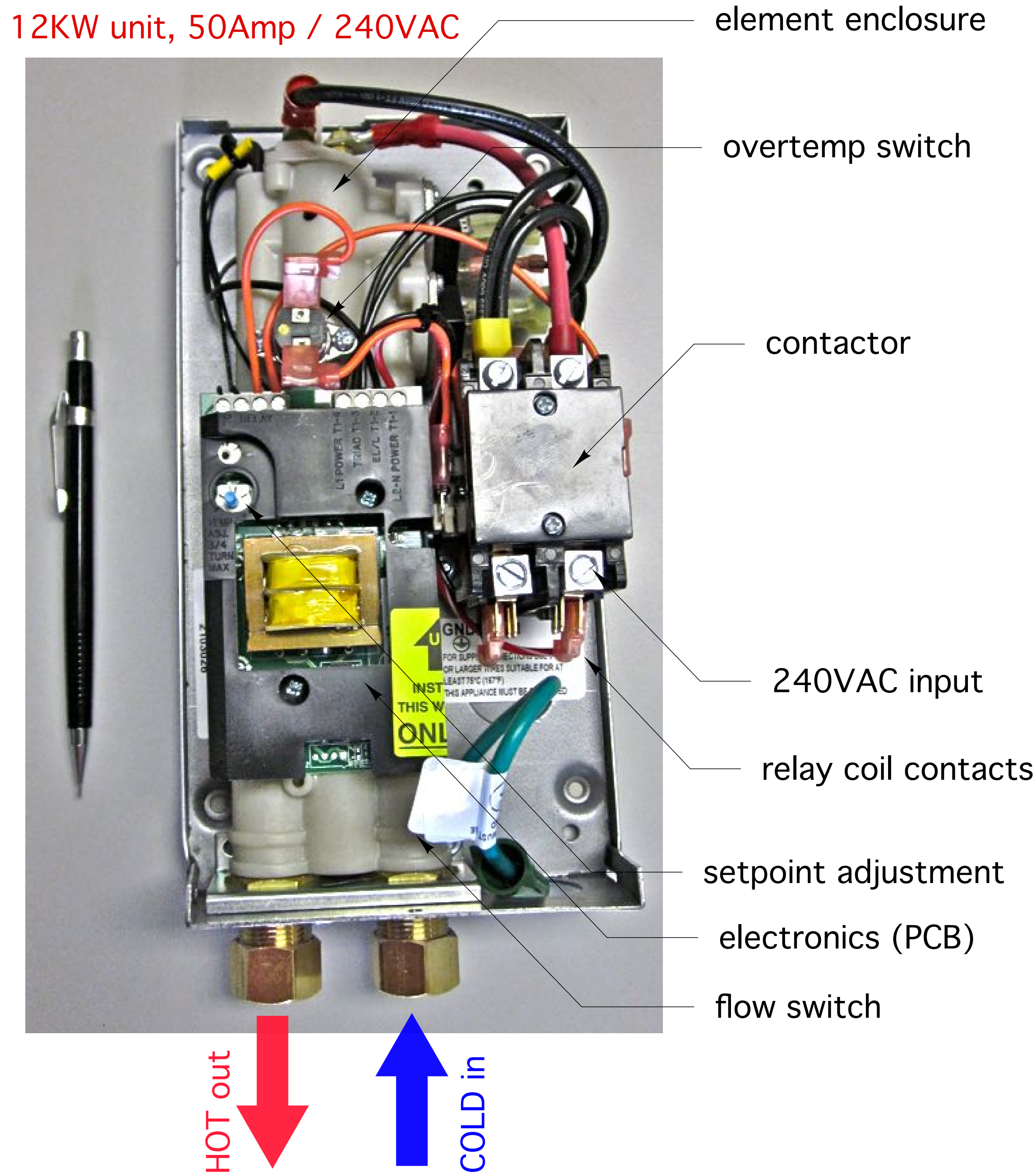
Using it with unpressurized thermal storage



Thermostatically controlled electric tankless water heaters

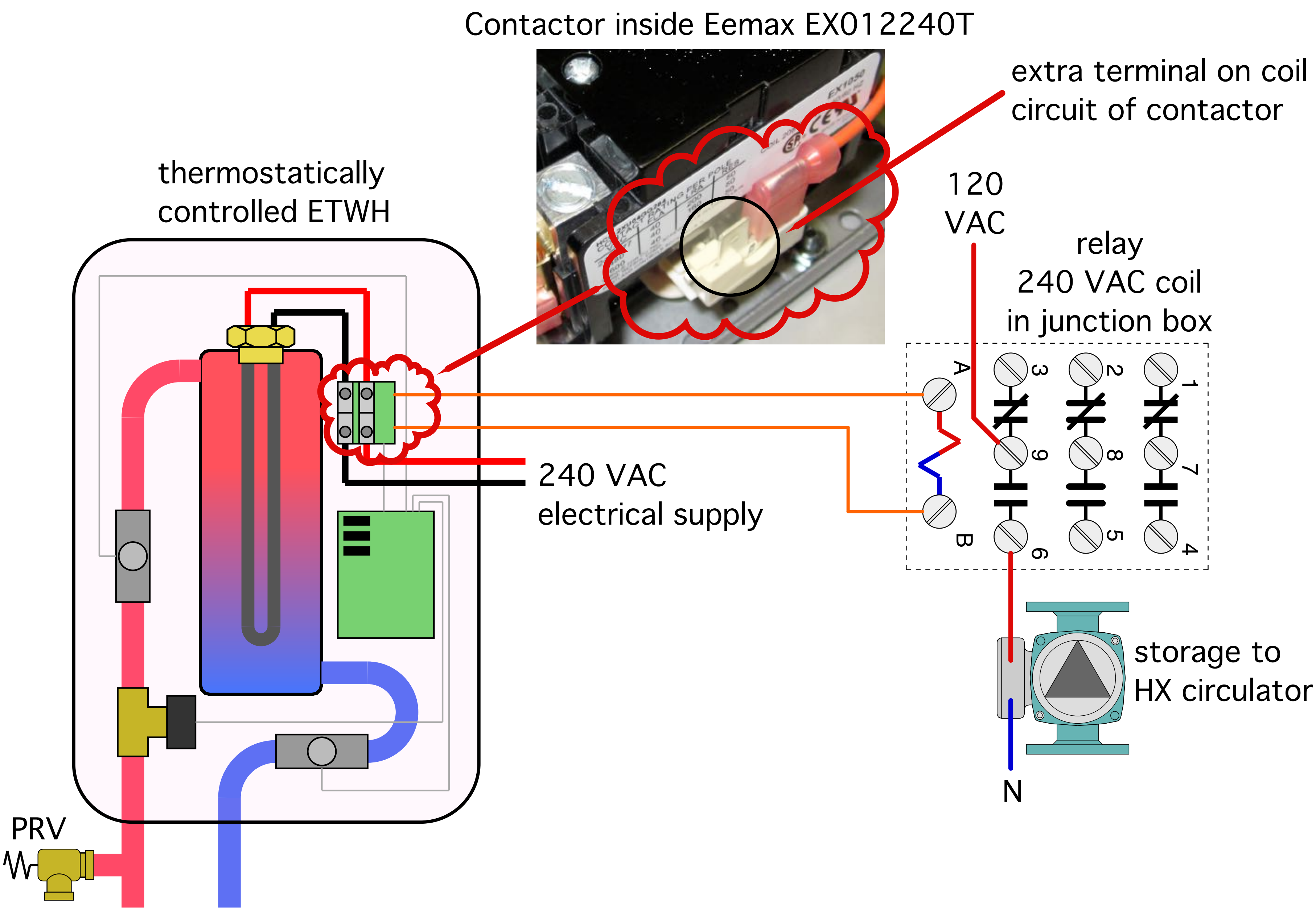
Image
courtesy
Eemax



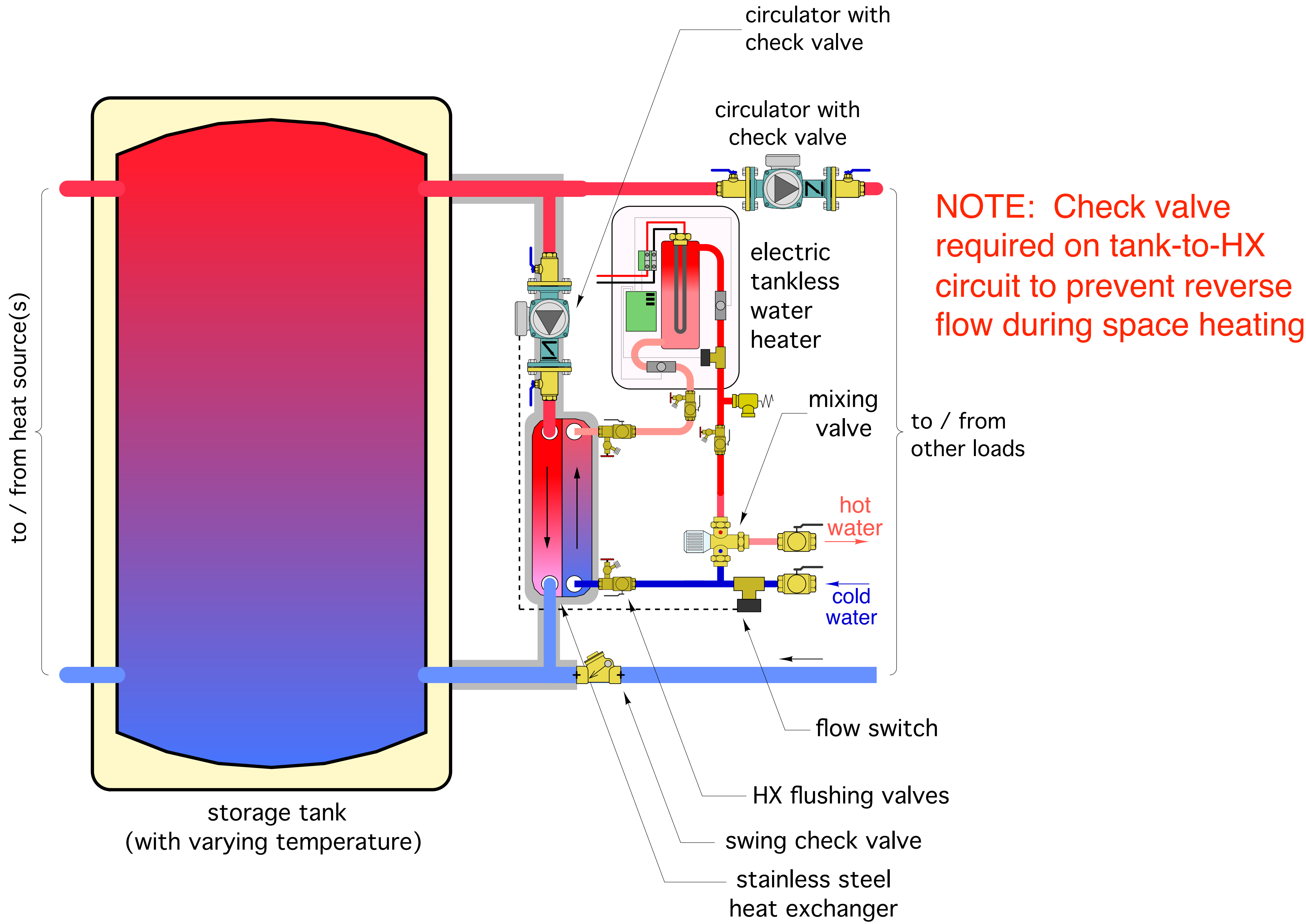


Using extra terminal on ETWH contactor to operate circulator

This eliminates the need for the flow switch.



Instantaneous DHW subassembly piping



Add provision for domestic water heating to previous system

- Only one heat exchanger b/w tank water and domestic water

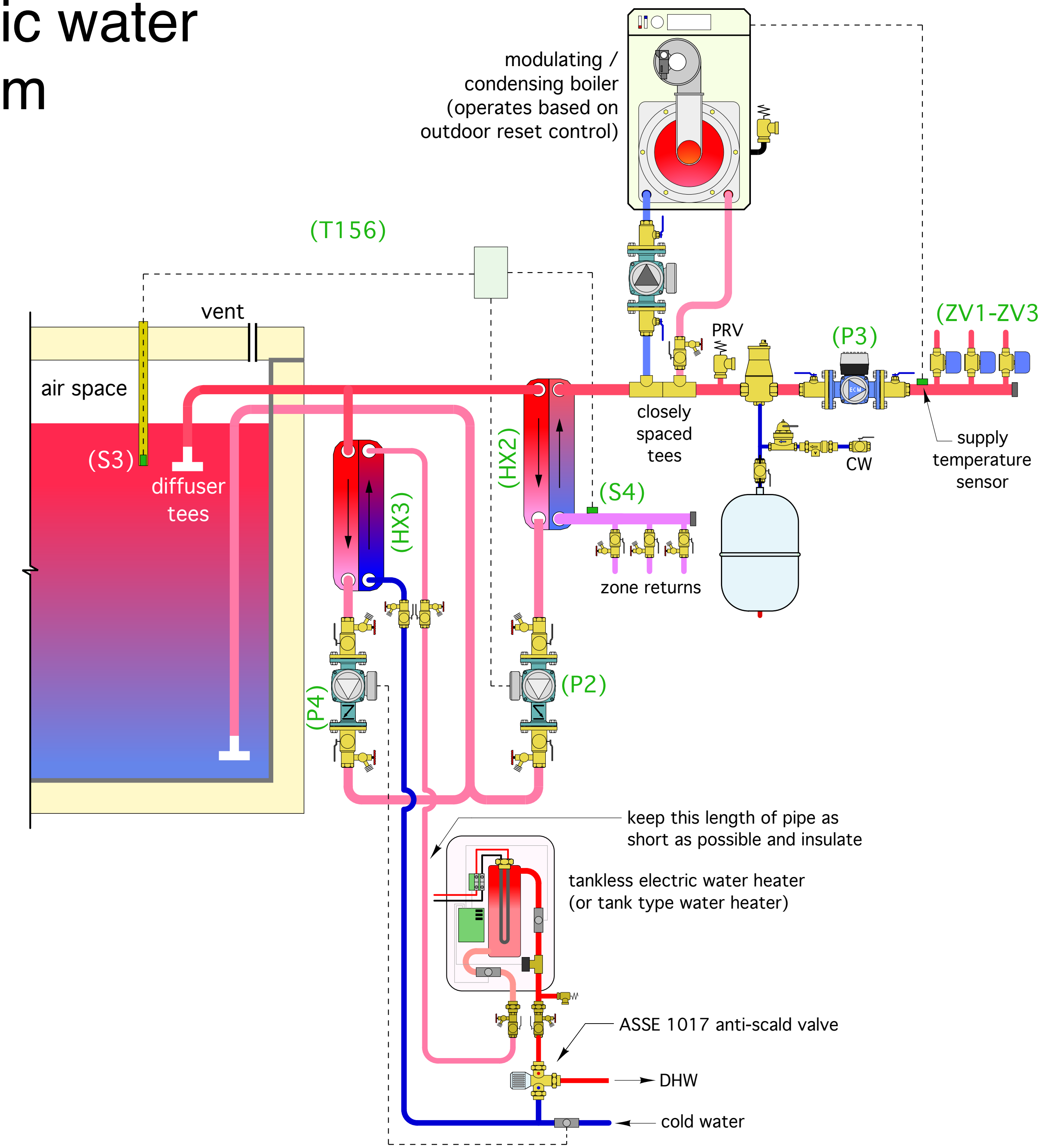
- Showing electric tankless aux heater - could also be a tank-type water heater

- Circulator (P4) must be stainless steel

- Combination isolation / flush valves on heat exchanger (HX3)

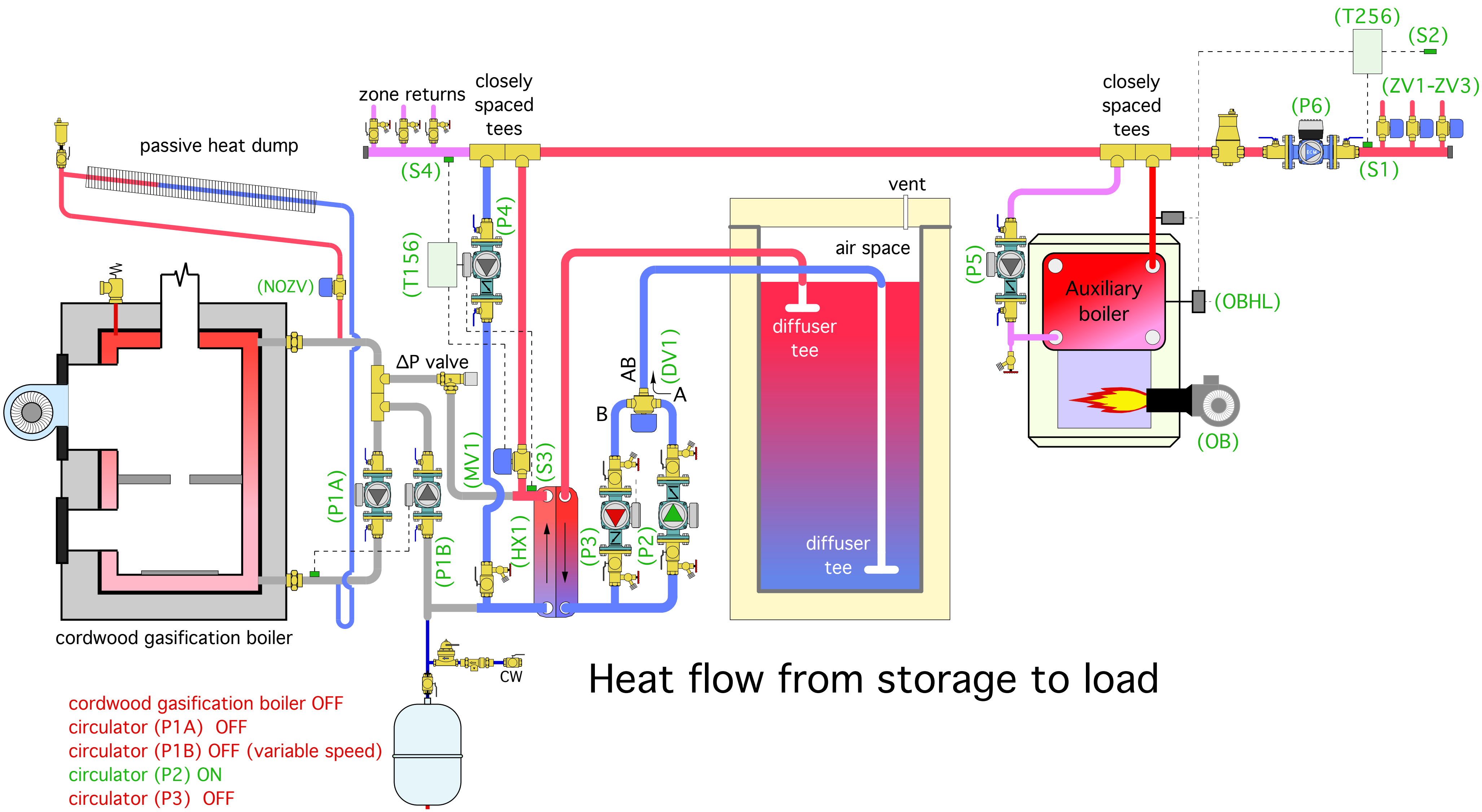
- Flow switch actives (P4) through a relay when DHW demand ≥ 0.7 gpm, of when demand ≤ 0.4 gpm

- ASSE 1017 setting no higher than 120 °F



System using single external heat exchanger

single external heat exchanger system

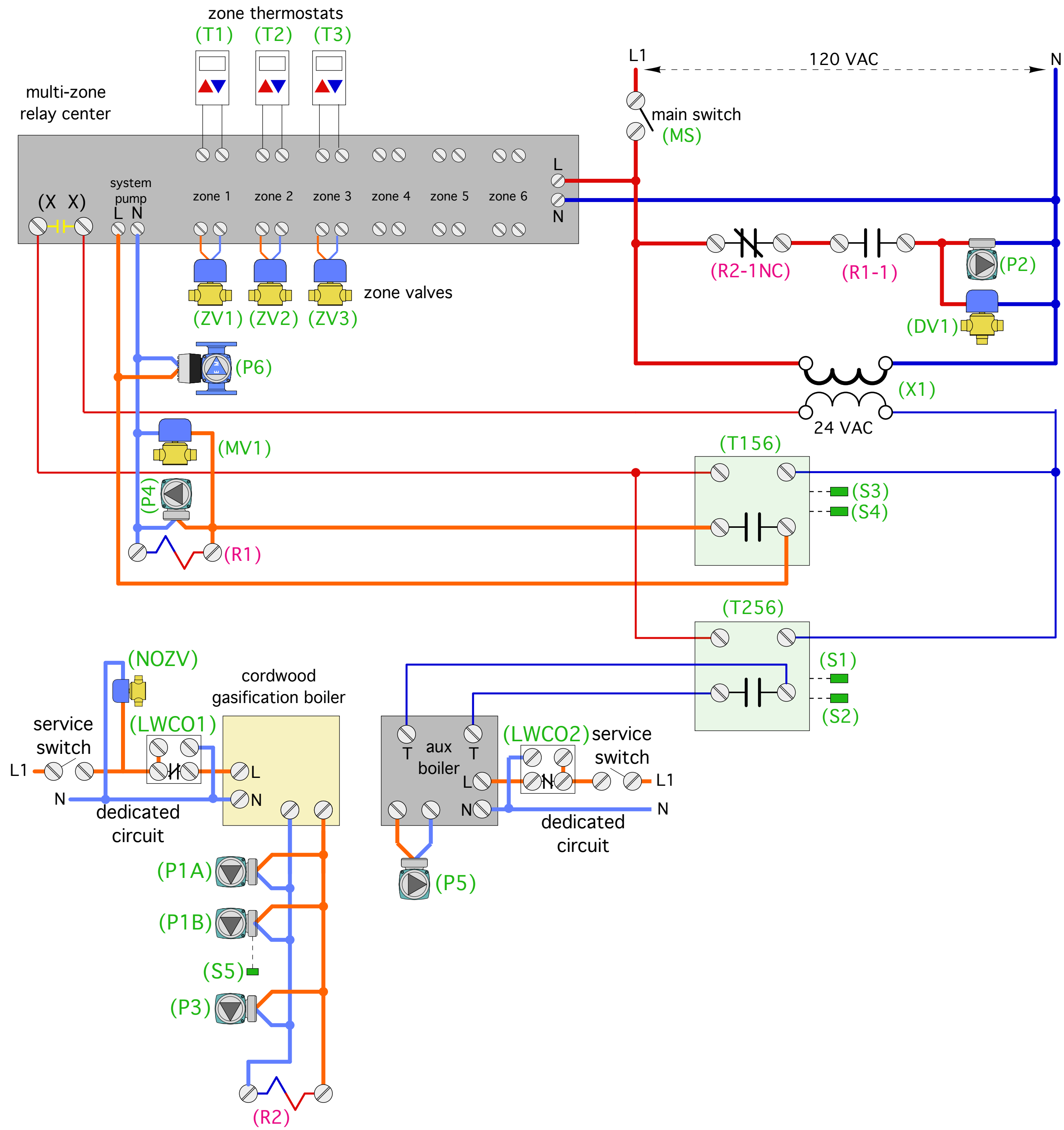


Heat flow from storage to load

cordwood gasification boiler OFF
circulator (P1A) OFF
circulator (P1B) OFF (variable speed)
circulator (P2) ON
circulator (P3) OFF
diverter valve (DV1) ON (flow from A to AB port)
load (calling for heat)
circulator (P4) ON or OFF depending on ΔT b/w (S3) & (S4)
motorized valve (MV1)on if (P4) on, otherwise off
Aux boiler & circulator (P5) ON or OFF depending on supply temperature at (S1)
circulator (P6) ON (variable speed)

Single external heat exchanger system

See section 8 in Design Assistance Manual for complete description of operation.



RHNY Incentives

<table>
<tr><th>Program</th><th>System Type</th><th colspan="2">Installation Incentive</th><th colspan="3">Additional Incentive</th></tr>
<tr><td rowspan="3">Small Biomass Boiler</td><td>Advanced Cordwood Boiler with Thermal Storage</td><td colspan="2">25% installed cost ($7,000 maximum)</td><td>-</td><td rowspan="5">Recycling

$5,000/unit for old indoor/ outdoor wood boiler
or
$2,500/unit for old wood furnace</td><td>-</td></tr>
<tr><td rowspan="2">Small Pellet Boiler with Thermal Storage</td><td>≤120 kBtu/h (35 kW)</td><td>45% installed cost ($16,000 maximum)</td><td rowspan="4">Thermal Storage Adder

$5/gal for each gal above the minimum thermal storage requirement</td><td>-</td></tr>
<tr><td>≤300 kBtu/h (88 kW)</td><td>45% installed cost ($36,000 maximum)</td><td>-</td></tr>
<tr><td rowspan="2">Large Biomass Boiler</td><td>Large Pellet Boiler with Thermal Storage</td><td rowspan="2">>300 kBtu/h (88 kW)</td><td>65% installed cost ($325,000 maximum)</td><td rowspan="2">Emission Control System

$40,000</td></tr>
<tr><td>Tandem Pellet Boiler with Thermal Storage</td><td>75% installed cost ($450,000 maximum)</td></tr>
<tr><td>Residential Pellet Stove</td><td>Pellet Stove</td><td colspan="2">$1,500
($2,000 for income qualified residents)</td><td>-</td><td>Recycling

$500
(income qualified residents only)</td><td>-</td></tr>
</table>

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LMI Incentives - Boilers

Program	System Type		Market Rate Installation Incentive	LMI Installation Incentive
Small Biomass Boiler	Advanced Cordwood Boiler with Thermal Storage		25% installed cost ($7,000 maximum)	65% installed cost ($18,000 maximum)
	Small Pellet Boiler with Thermal Storage	≤120 kBtu/h (35 kW)	45% installed cost ($16,000 maximum)	65% installed cost ($23,000 maximum)

For more information:

- "Google" Renewable Heat NY
- contact Sue Dougherty at NYSERDA sue.dougherty@nyserda.ny.gov

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Thanks for attending this series of webinars.

April 15 2021 1-2PM
Title: Creating A "Summer/Winter" Pellet Boiler System
Description: Many residential hydronics system include a provision for heating domestic water. When the pellet boiler is active it might be used for domestic water heating. However, it may not be practical to use the pellet boiler for DHW in summer. This webinar explains the options and shows how to create a system that can easily switch between a winter and summer mode.

May 13 2021 1-2 PM
Title: Piping Options For Multiple Thermal Storage Tanks
Description: Some biomass boiler systems are installed in situations where it's impractical to use a single large thermal storage tank. There are several multiple tank options that may be suitable. This webinar shows and describes several ways to configure a multiple tank array and explains tradeoffs in thermal performance. Example systems will be presented.

June 2021
Title: Case study: A pellet boiler system for a highway garage
Description: Large slab-on-grade buildings are ideal candidates for combining a pellet boiler system with floor heating. This webinar will show the details for a system designed to heat a 13,000 square foot highway garage, including system piping, combustion air supply, thermal storage, controls, and a staged modulating/condensing auxiliary boiler system. The concepts shown are scaleable and repeatable for similar structures.

Additional webinars will be announced for fall 2021 (September, October, November)

All of these webinars will be posted on NYSERDA's Renewable Heat NY website - under "training opportunities" link.

QUESTIONS ?