Piping Options for Multiple Thermal Storage Tanks

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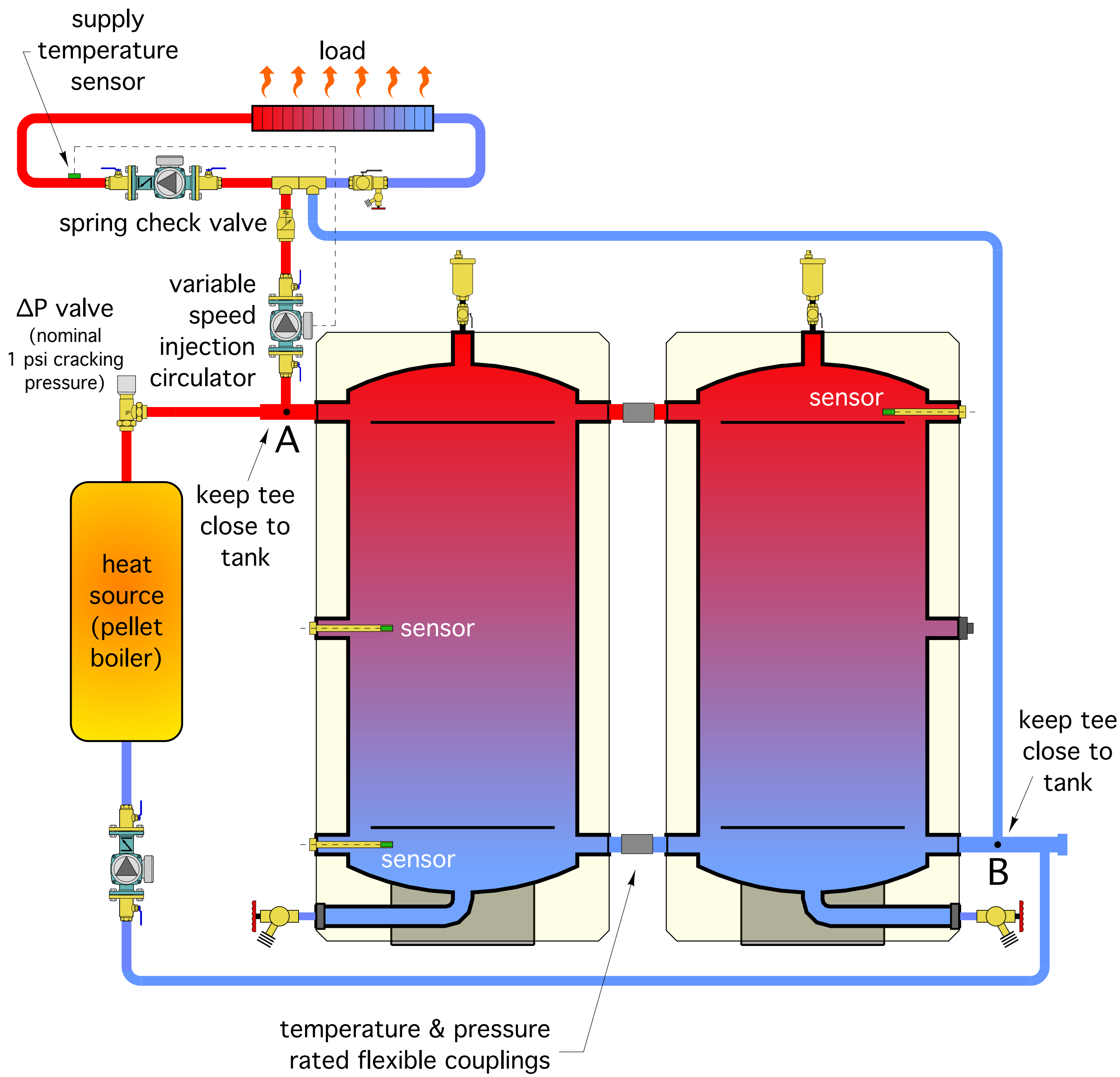

June 17, 2021
1:00 PM

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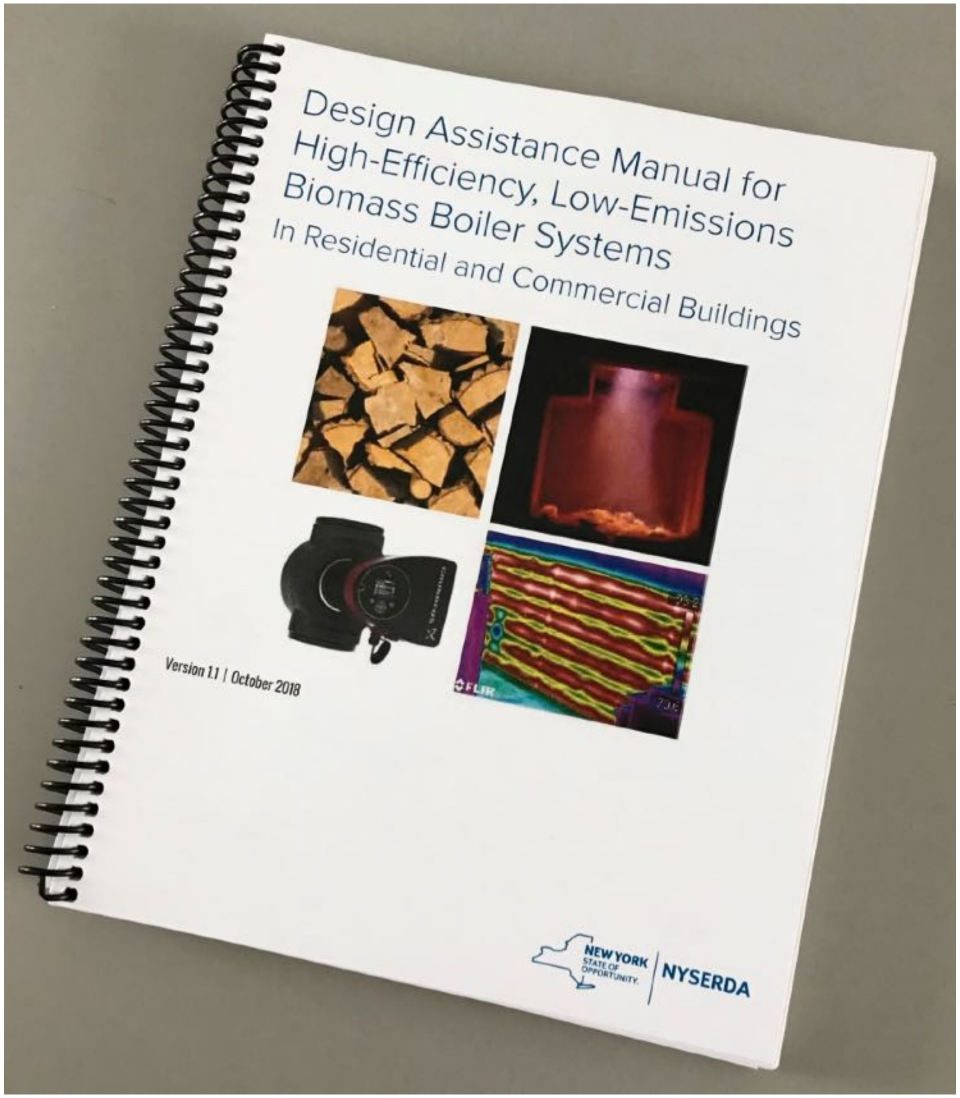
Piping Options for Multiple Thermal Storage Tanks

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.

Learning Objectives:

- Understand the importance of maintaining temperature stratification within thermal storage tanks.
- Understand the benefits and limitations of multiple thermal storage tanks.
- Understand parallel and "close-coupled" piping options.
- See a complete system designed around multiple thermal storage tanks.

Design Assistance Manual
for High Efficiency Low Emissions Biomass Boiler Systems



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It's available as a FREE downloadable PDF at:

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

Pressure-rated thermal storage tanks

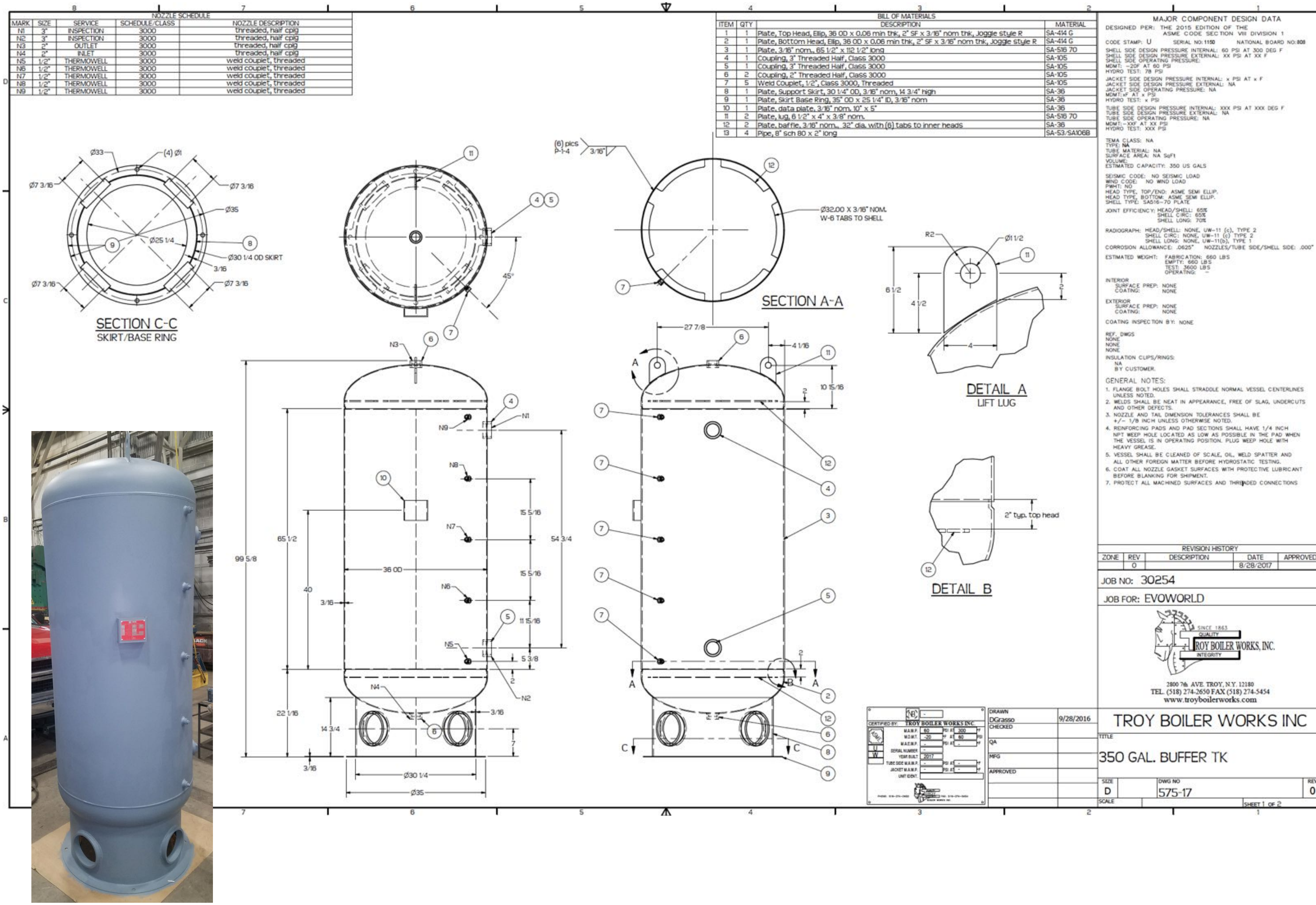
Closed/pressurized thermal storage tanks

courtesy of Caleffi North America

courtesy of Hydronic Specialty Supply

courtesy of Troy Boiler Works

Shop drawing of ASME thermal storage tanks



A universal design for buffer tanks

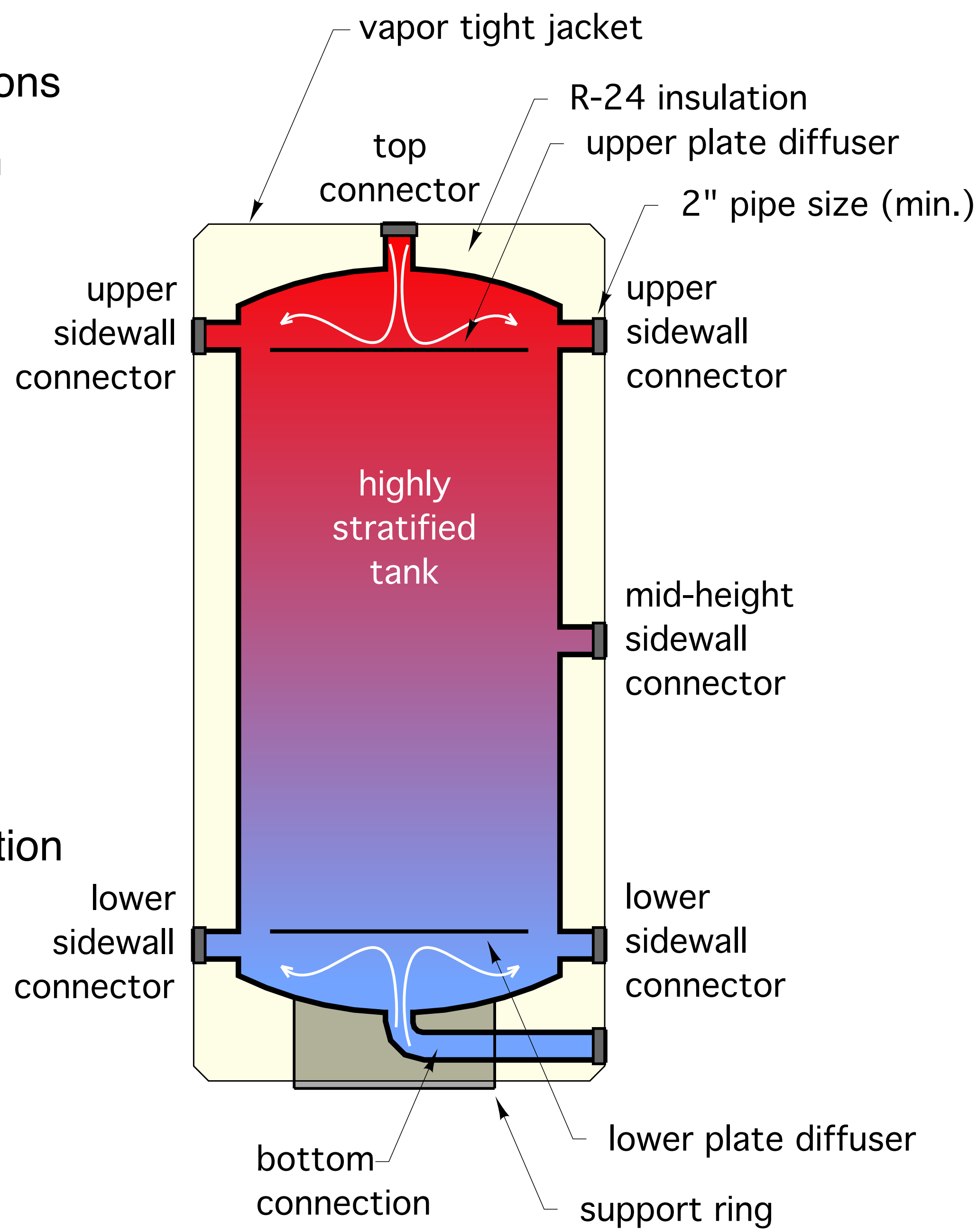
Requirements:

- Able to accommodate several piping configurations
- Very low heat loss (R-24 °F•hr•ft²/Btu) insulation
- Encourage temperatrue stratification
- Adaptable to 200 °F water temperature
- Able to be close coupled
- Able to accommodate multiple sensor wells
- Low pressure drop connections for generously

sized headers

- Able to fit through 36” doorway
- Carbon steel construction
- Monolithic insulation shell for prevent condensation

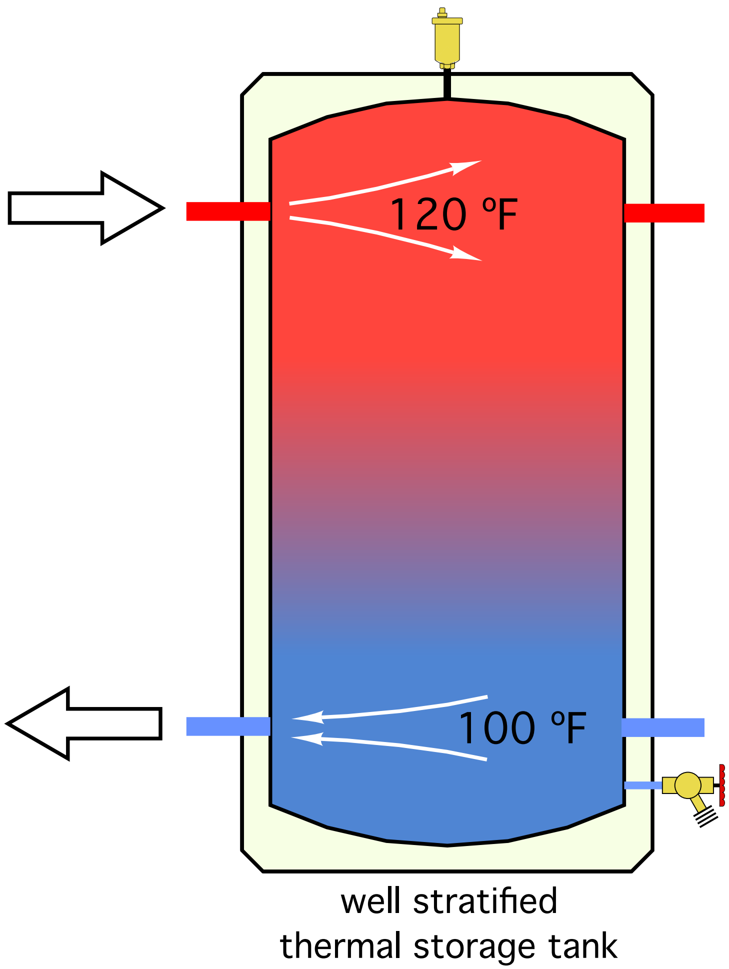
if used in chilled water systems.

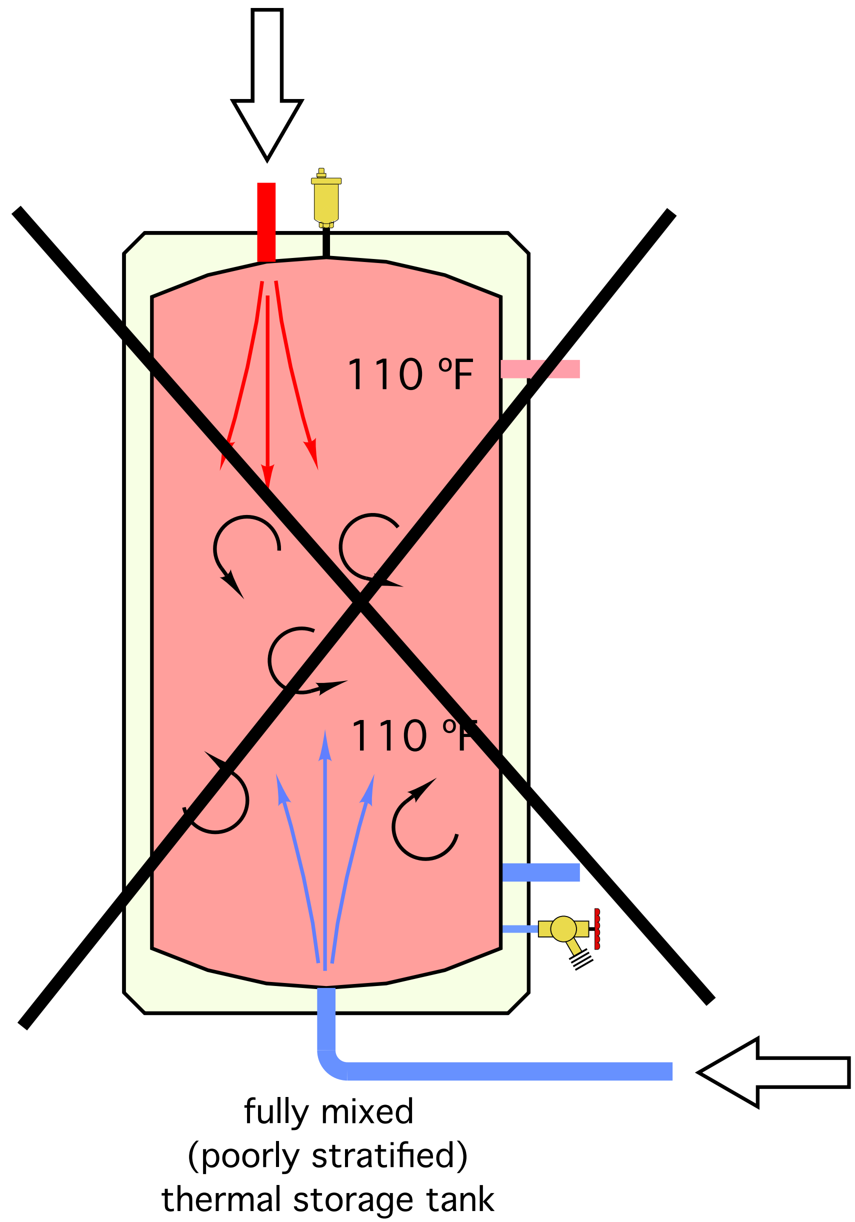


Temperature stratification within thermal storage tanks

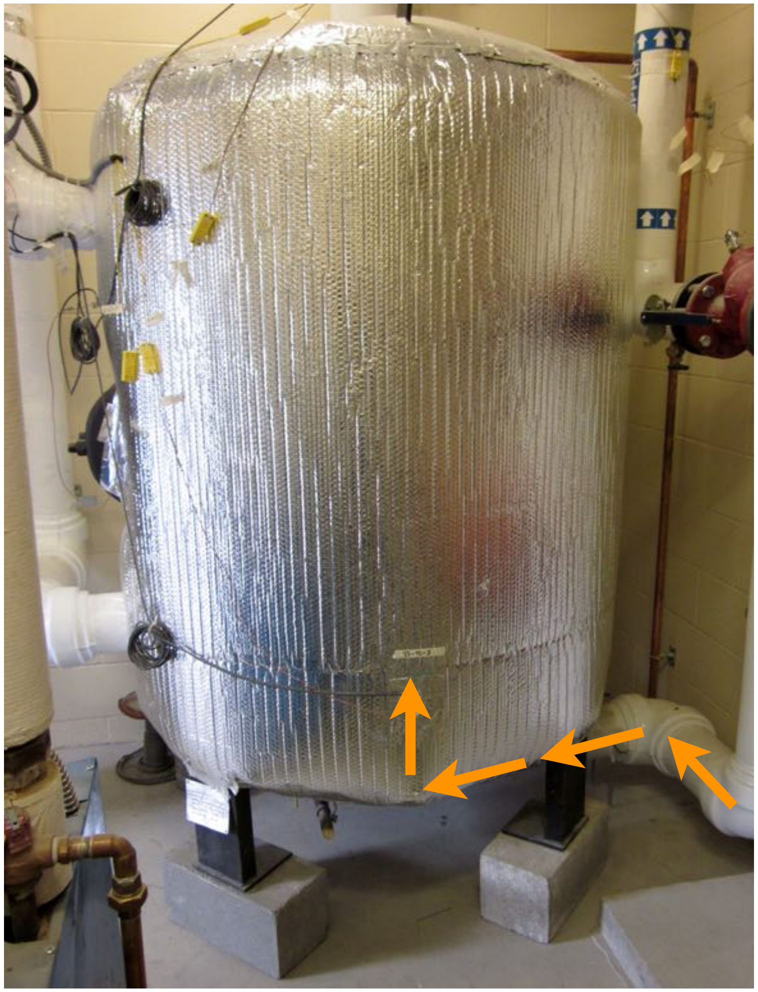
Stratification in thermal storage is DESIREABLE

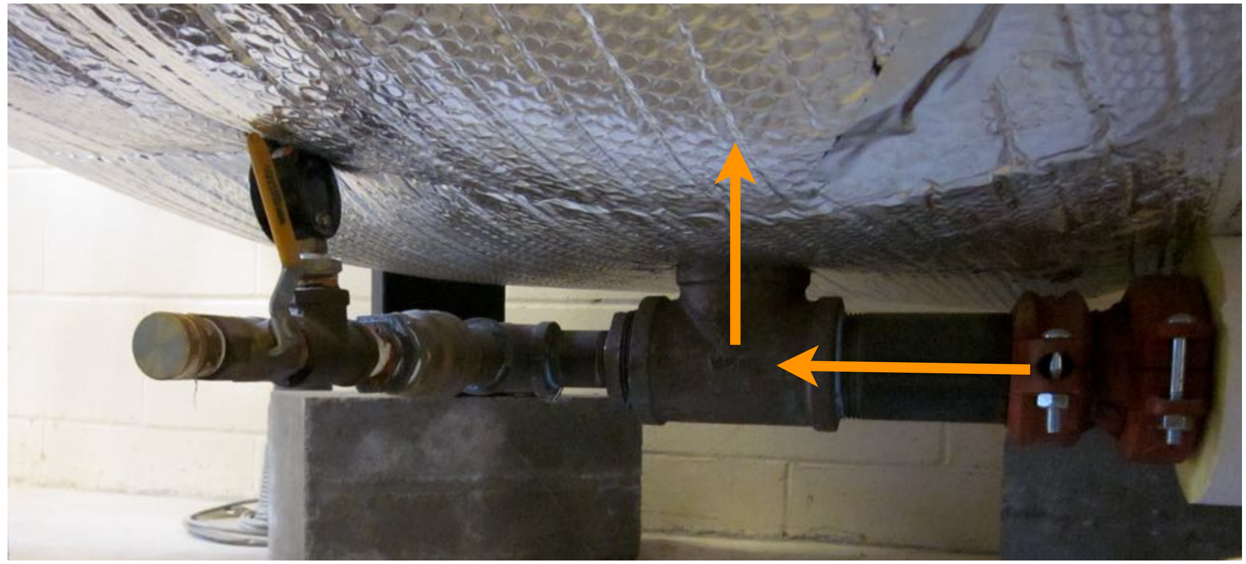
Good temperature stratification preserves the "**quality**" (Exergy)of the heat available from the tank.

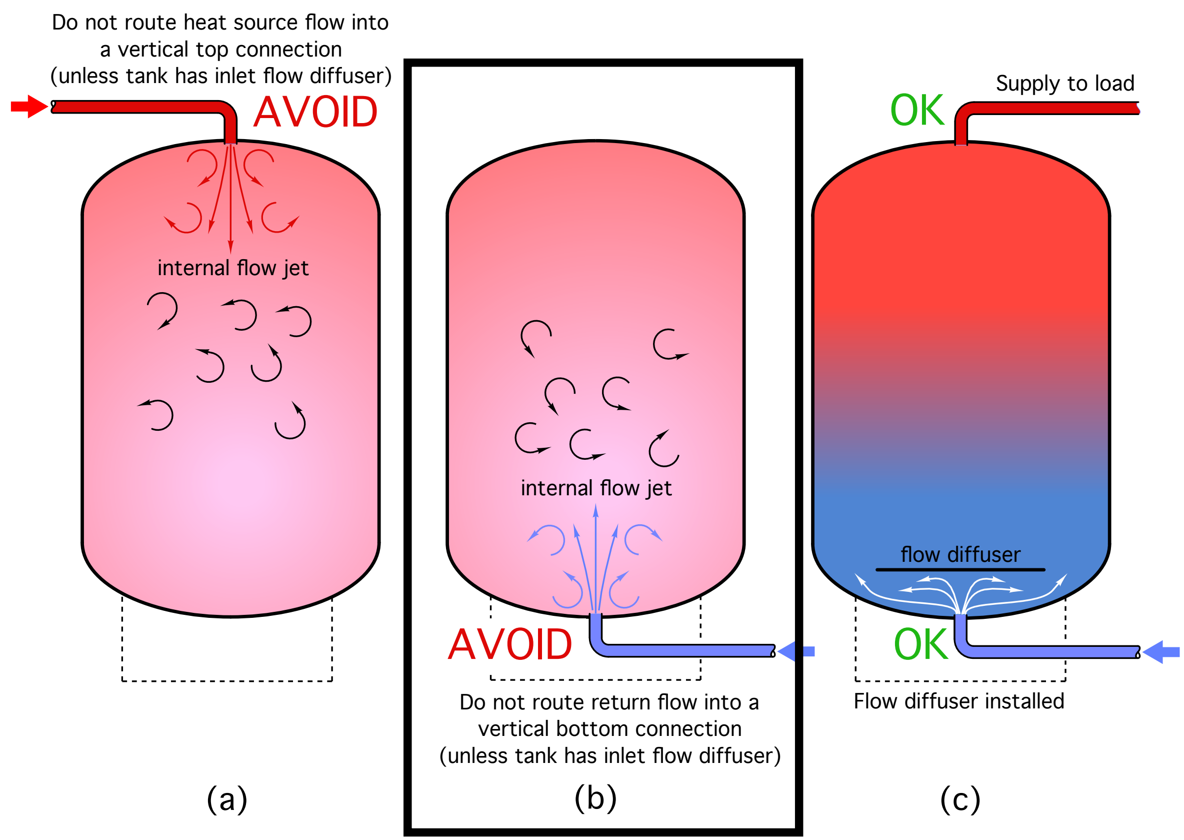




500 gallon ASME tank with poor stratification

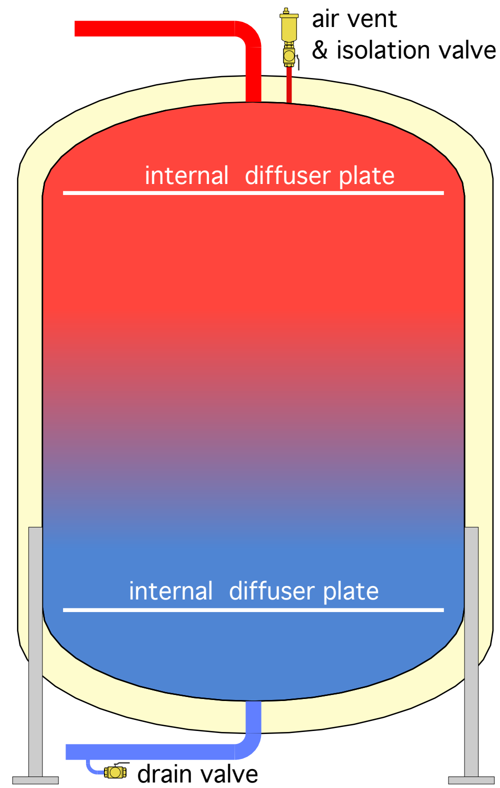


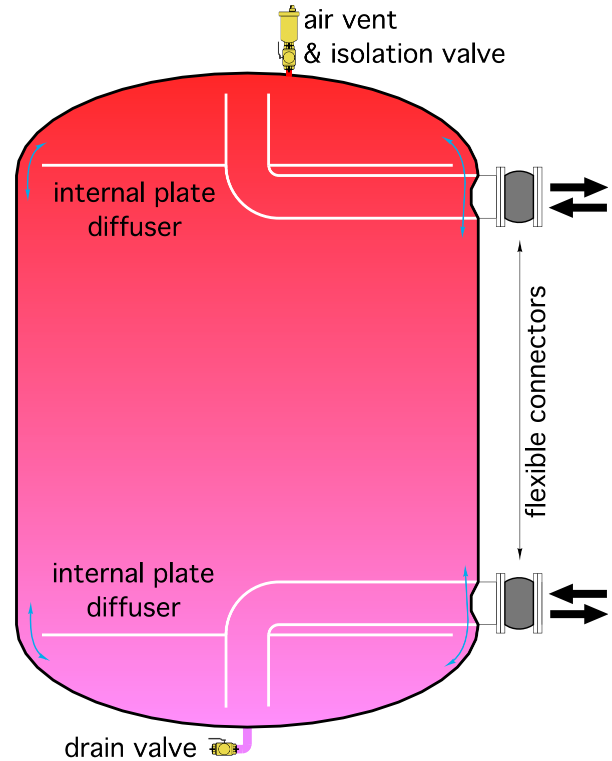




What's wrong?

Design diffusers to access the full tank volume

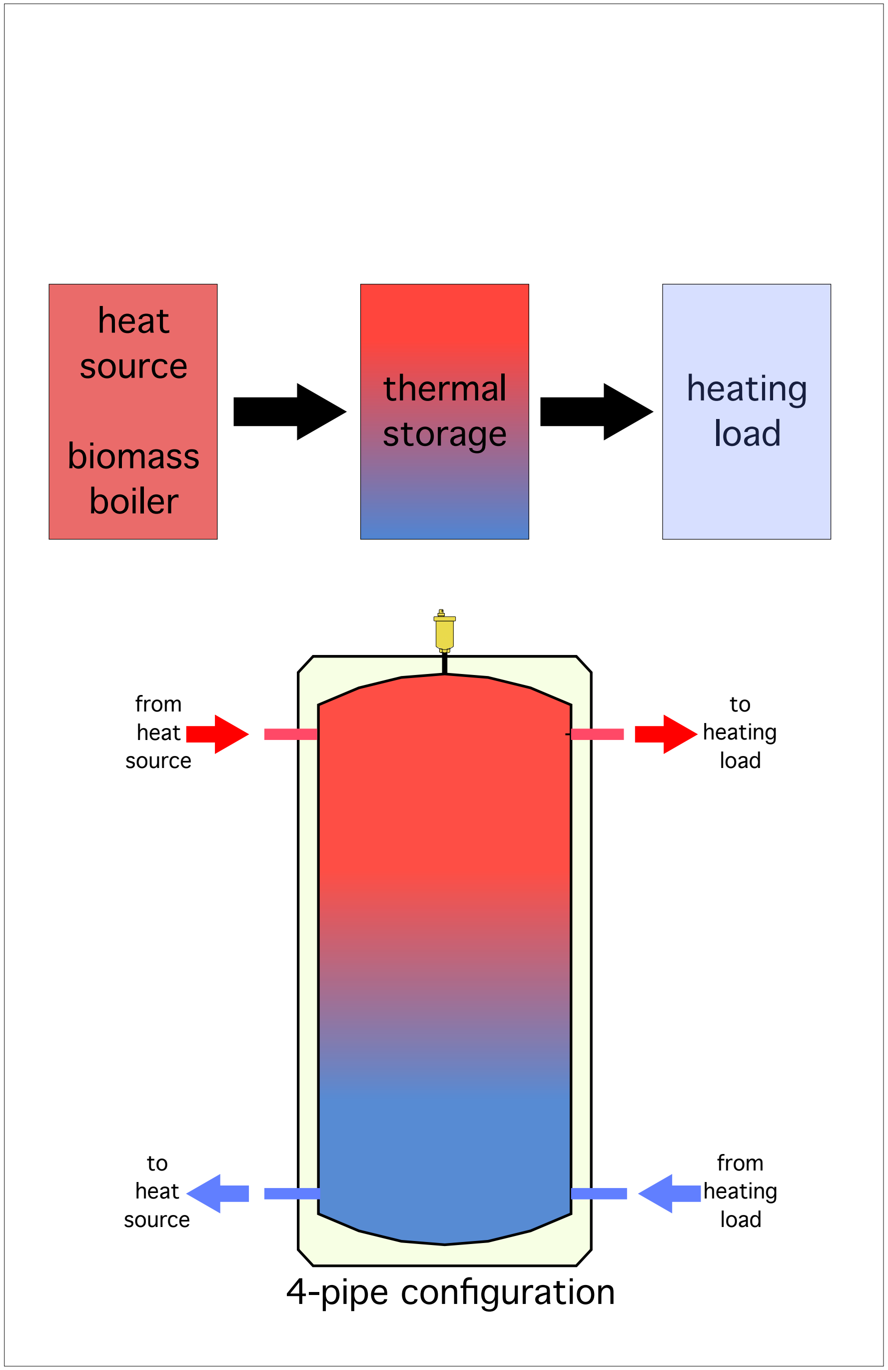


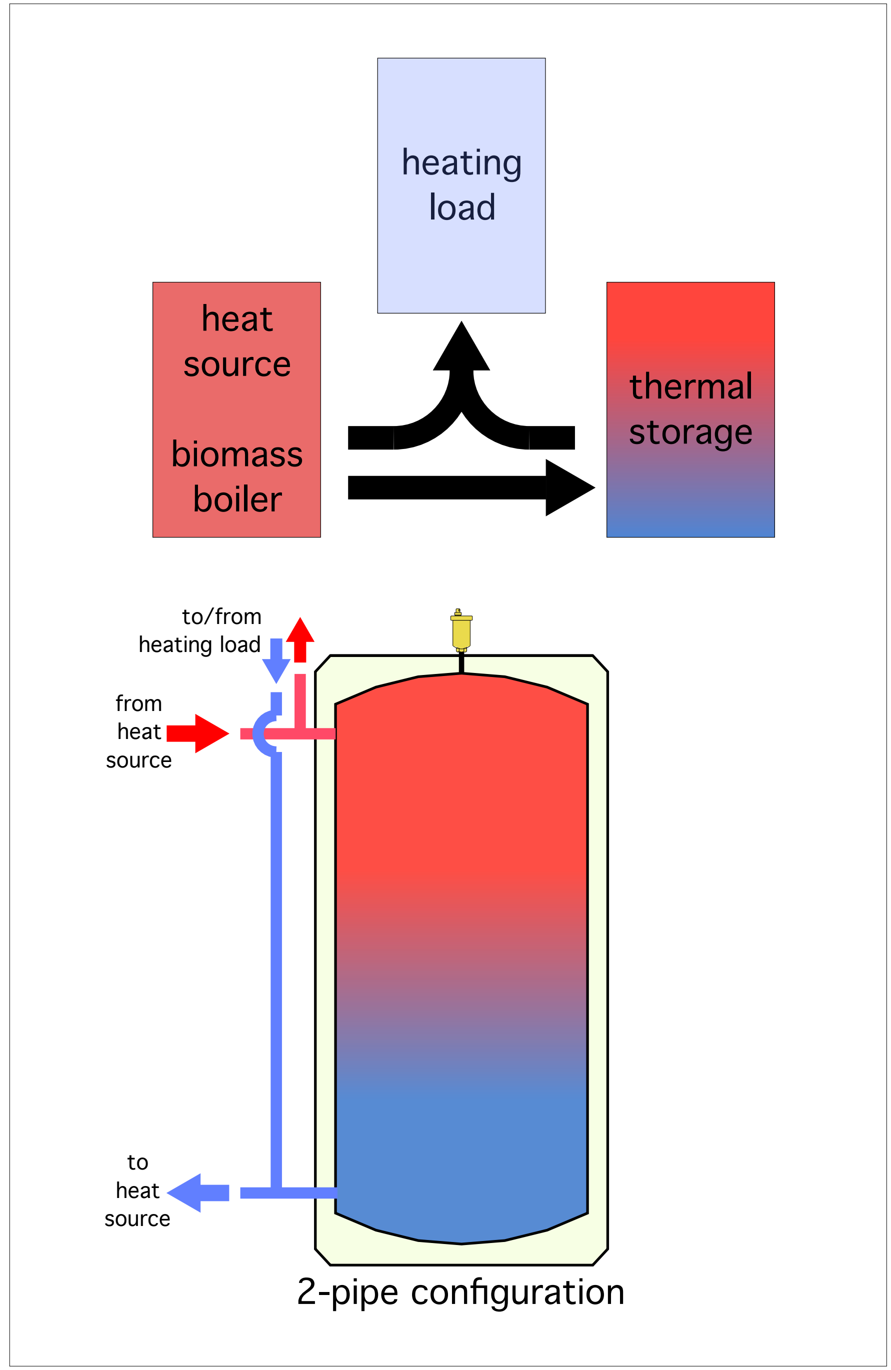


Baffle plate being welded into tank head & base shell at Troy Boiler Works

Piping configurations for thermal storage tanks

“2-pipe” versus “4-pipe buffer tank piping





Tanks designed for good stratification

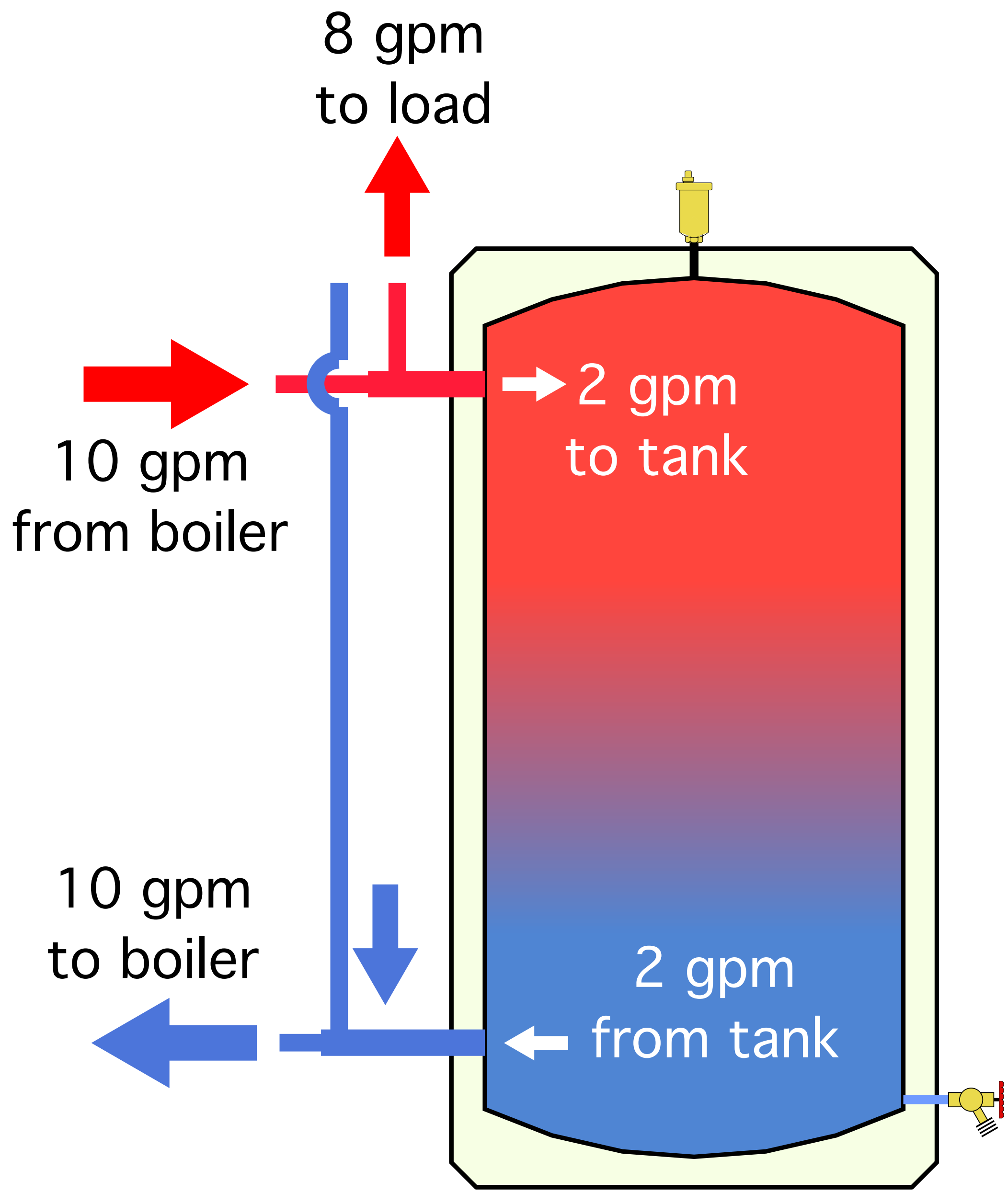
- **All ingoing or exiting flow should be horizontal.**

- Flow into tank = flow from boiler minus flow to load

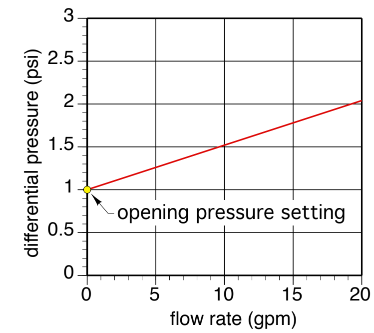
- Lower flow velocities into & out of tank enhance temperature stratification.

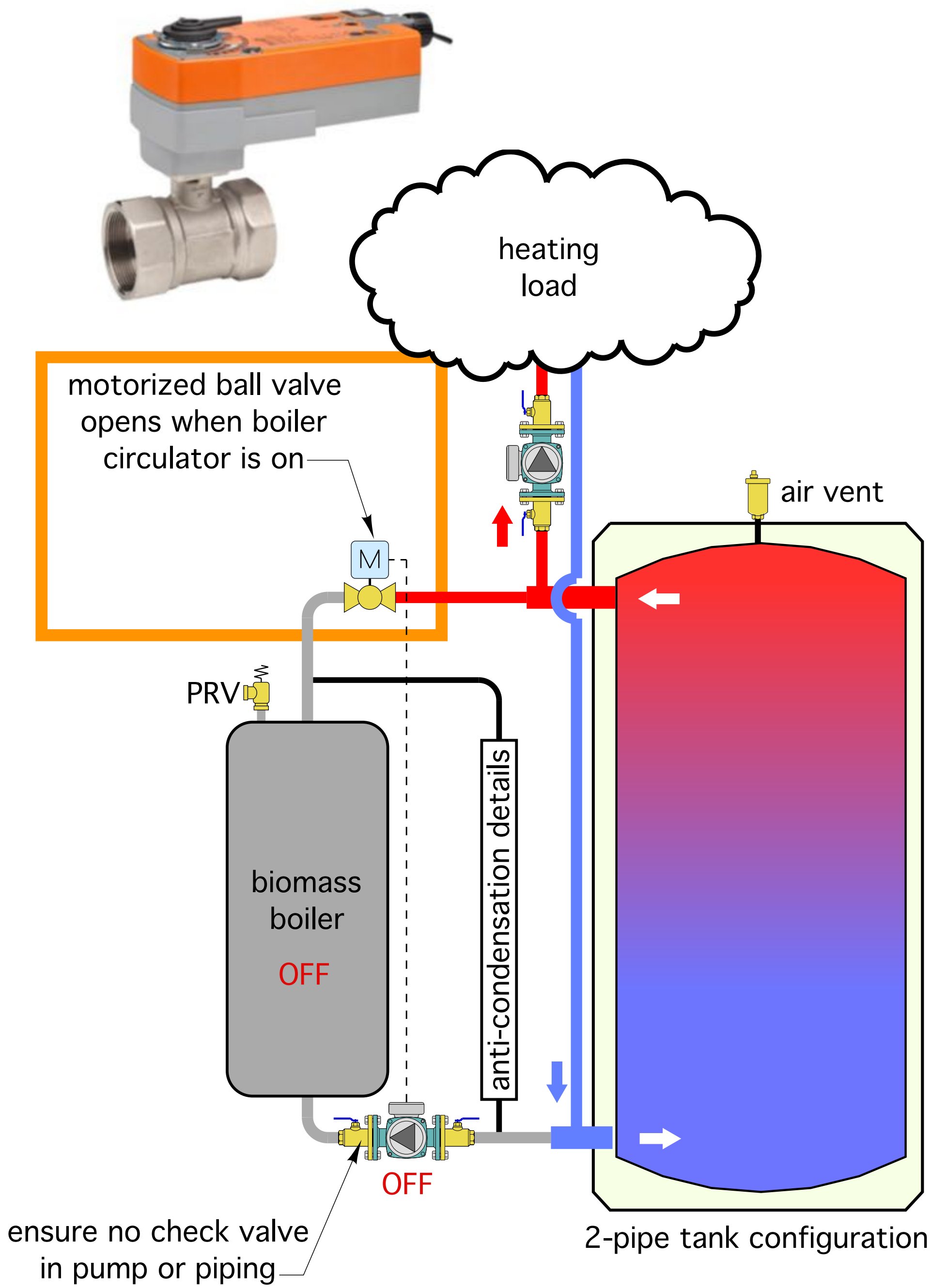
- Allows rapid heat delivery to load during recovery from setback or startup.

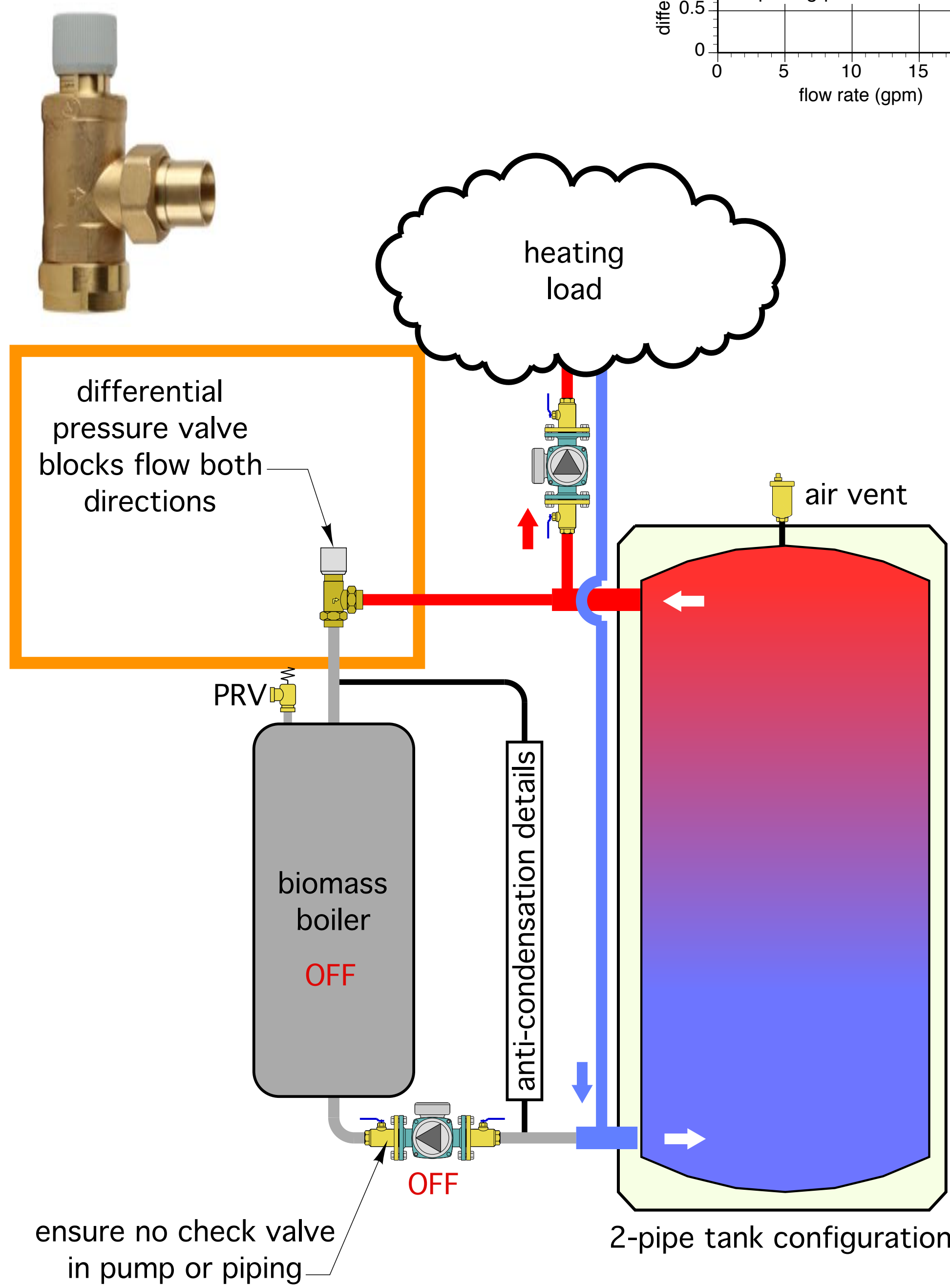
- Keep load connections close to tank, & use generous pipe sizing to tank connections, which provides hydraulic separation.



Preventing flow through unfired boiler



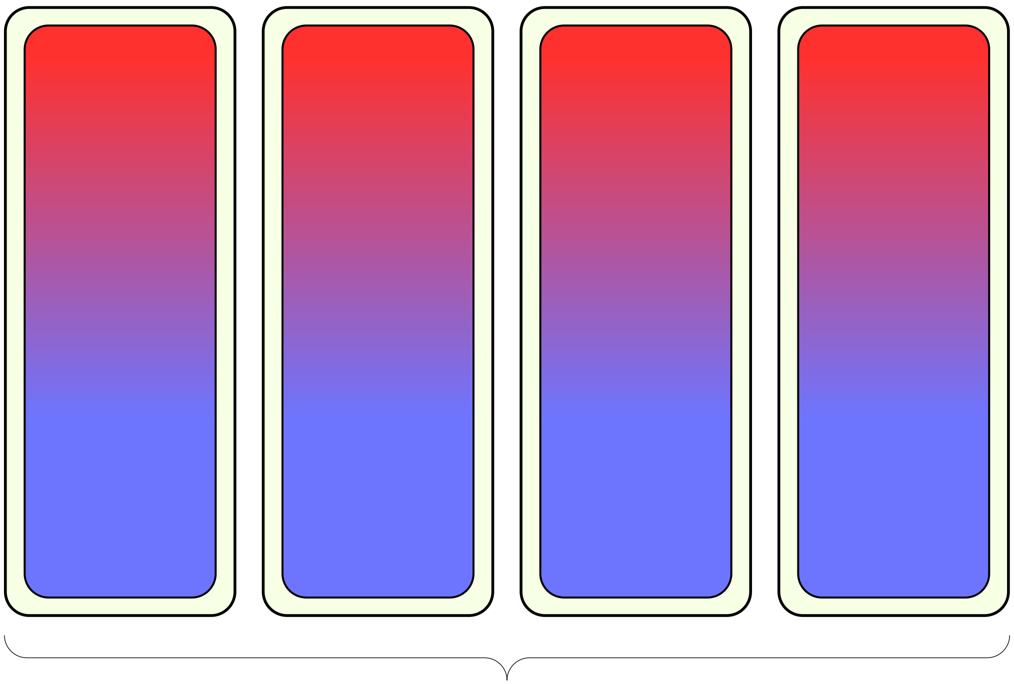




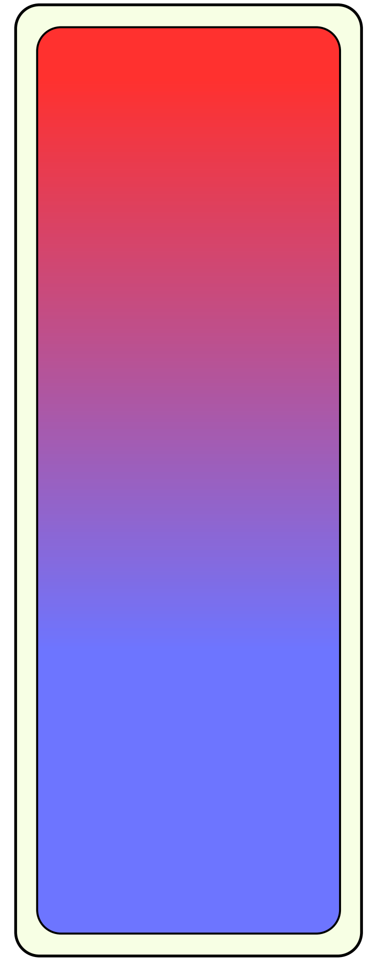
Multiple Storage Tank Arrays

Use of multiple smaller storage tanks.

Consider the surface to volume ratio:



VS



4, 119 gallon tanks, total volume = 476 gallons
h/d ratio = 3
shell diameter = 22.7"
shell height = 68"
total surface area = 4 x 39.3 = 157.2 ft2

1, 476 gallon tank
h/d ratio = 3
shell diameter = 36"
shell height = 108
total surface area = 99 ft2

The 4 small tanks present 59% more surface area than the single large tank

The much higher surface-to-volume ratio of the smaller tanks will significantly increase heat loss from the storage system.

Planning for access, services, possible removal

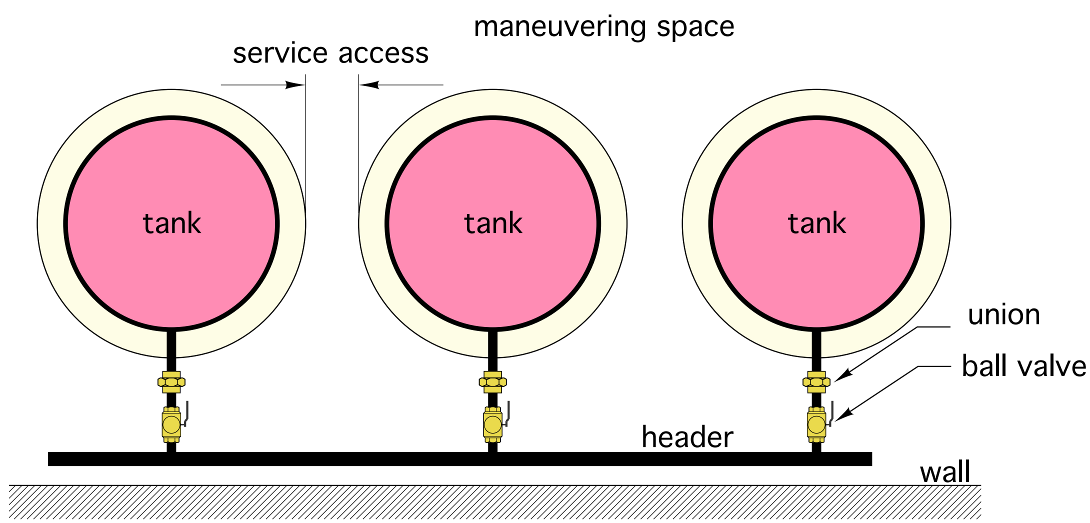
When piping multiple tanks always think about the possibility that one or more of them may have to be removed.

The piping should be planned to that a tank can be removed with minimal disruption of the piping.

Use unions and full port ball valves on all connections.

Overhead piping is one option.

Piping behind the tank is another option

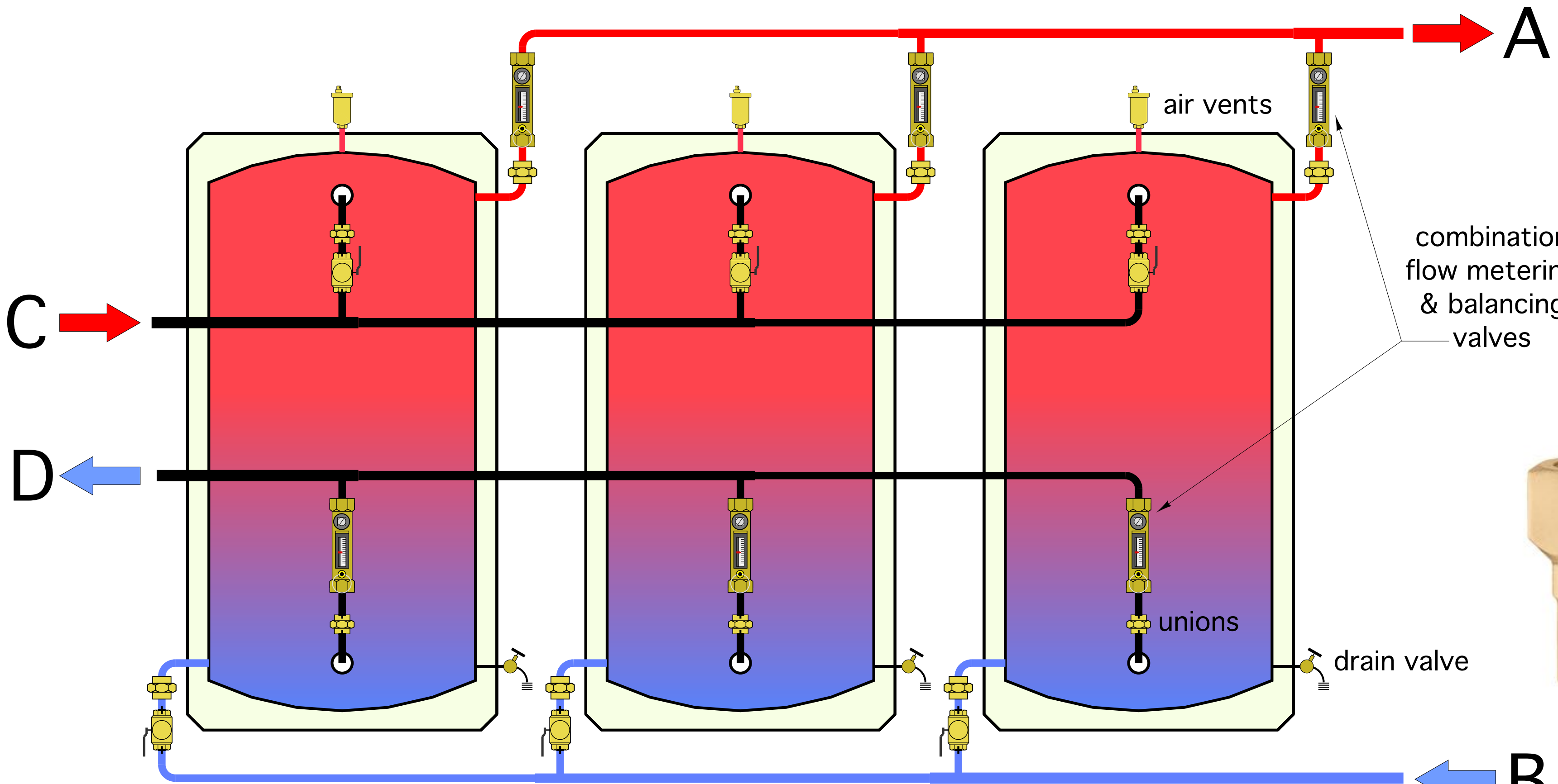


Better - but still not removable without piping mods

Piping to ensure balanced flow in multiple tanks

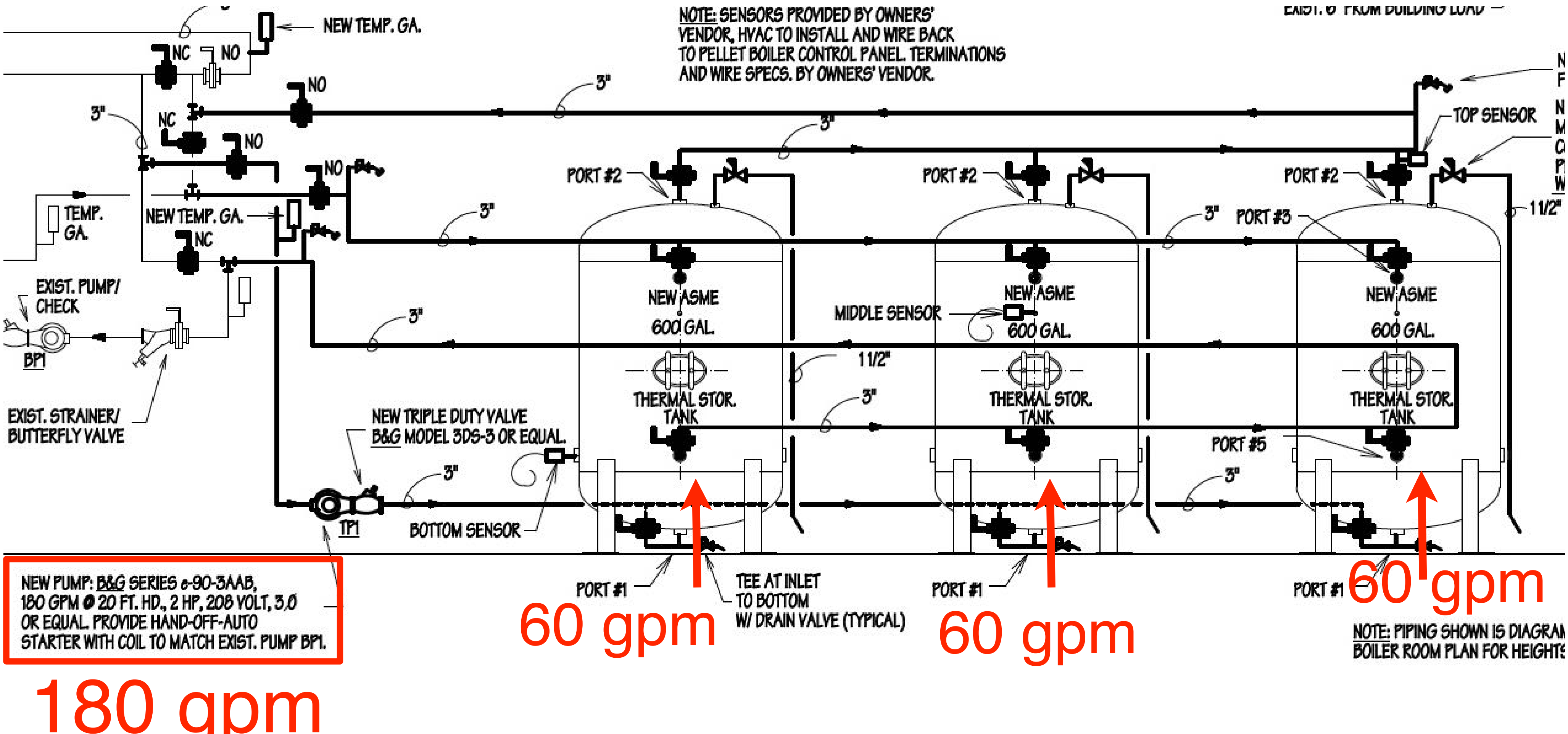
If direct return piping is used always install balancing valves

Be sure piping allows for tanks to be individually isolated and removed if necessary.



courtesy of Caleffi

Three, 600 gallon ASME tanks for storage in pellet boiler system.

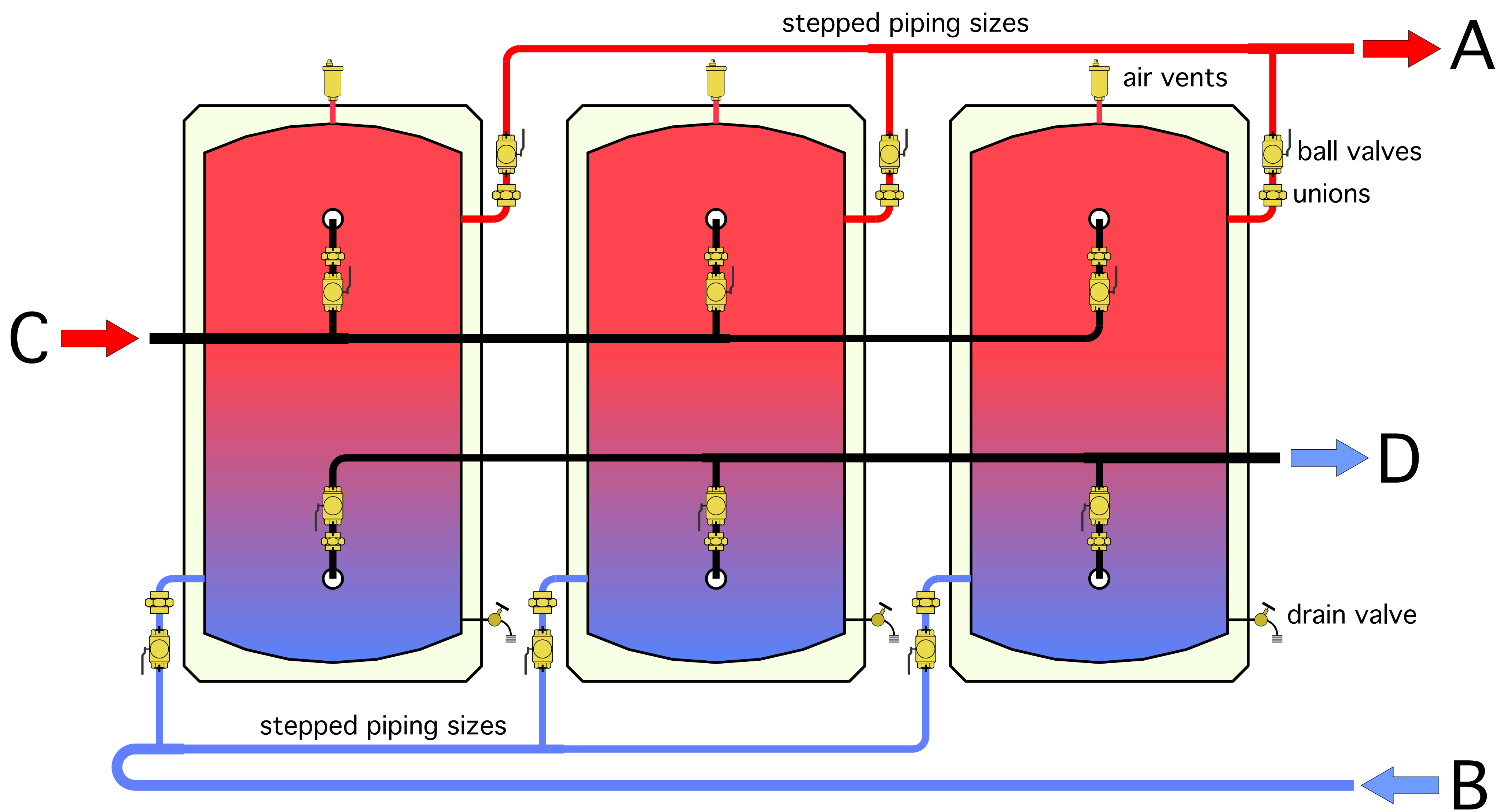


This piping will destroy stratification within the tank(s)

Could one of these tanks be removed - in tact- without disturbing the other tanks or piping?

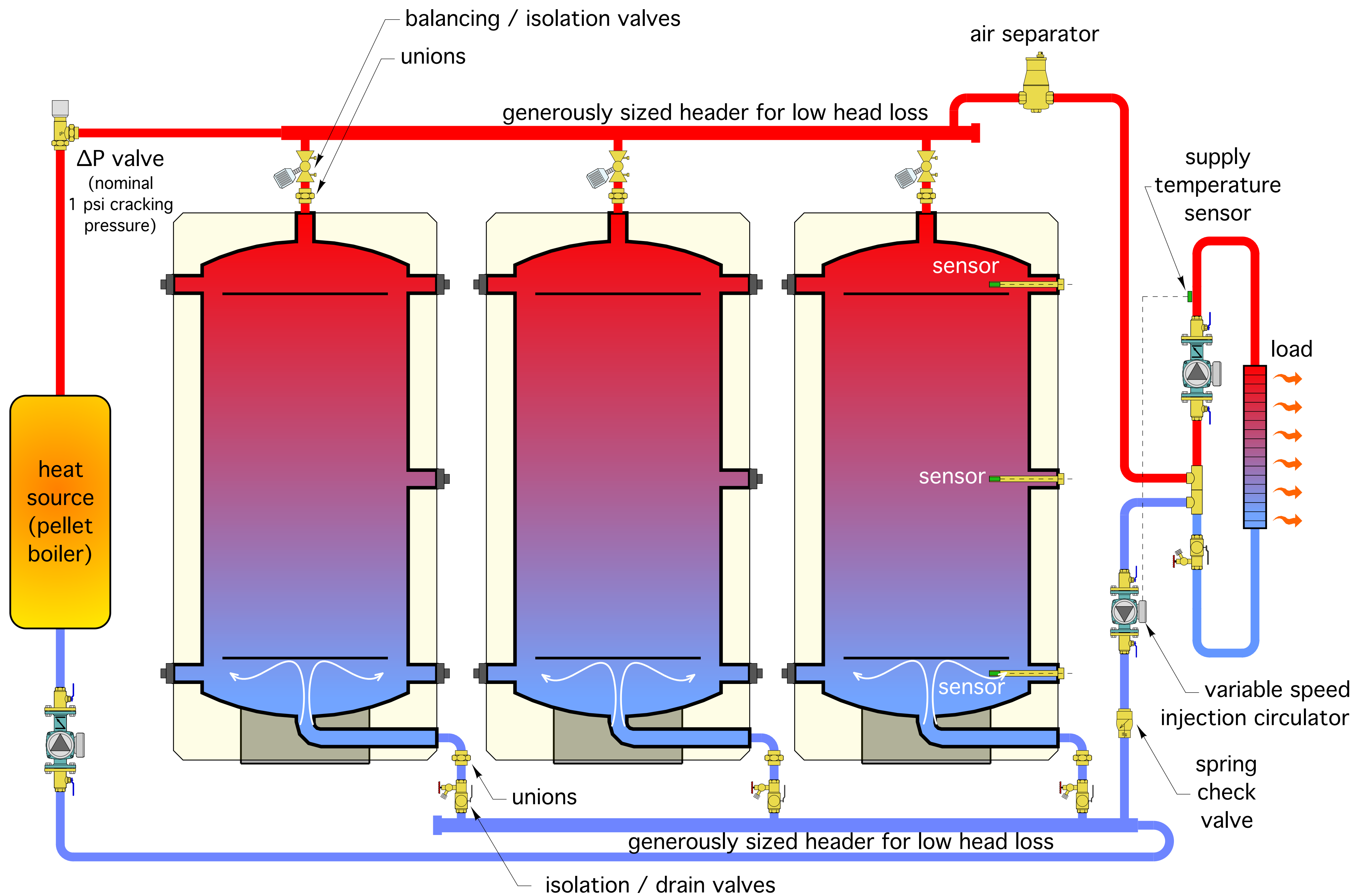
Piping to ensure balanced flow in multiple tanks

Reverse return piping with stepped header sizes

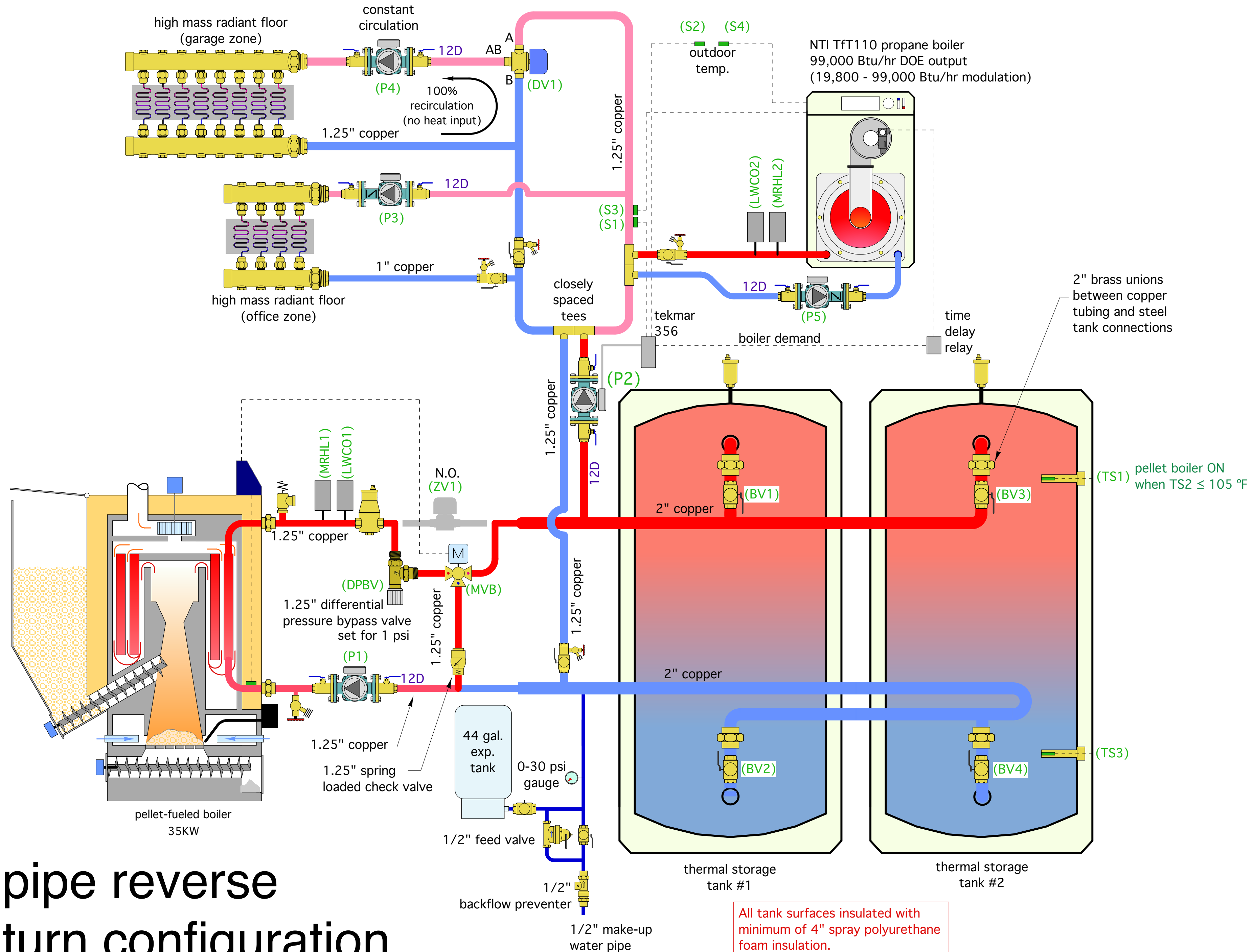


If using this piping be sure to plan for possibility of individual tank isolation and removal.

2-pipe reverse return configuration



NYSDEC boat maintenance facility - Lake George, NY



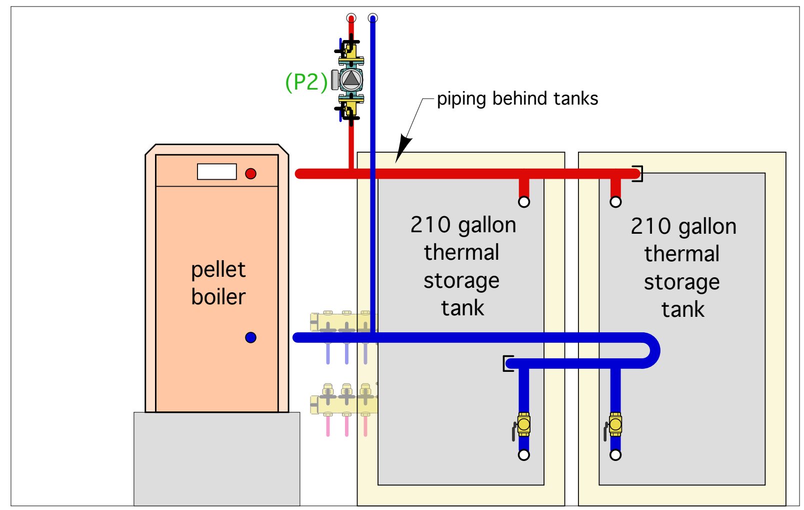
2-pipe reverse return configuration

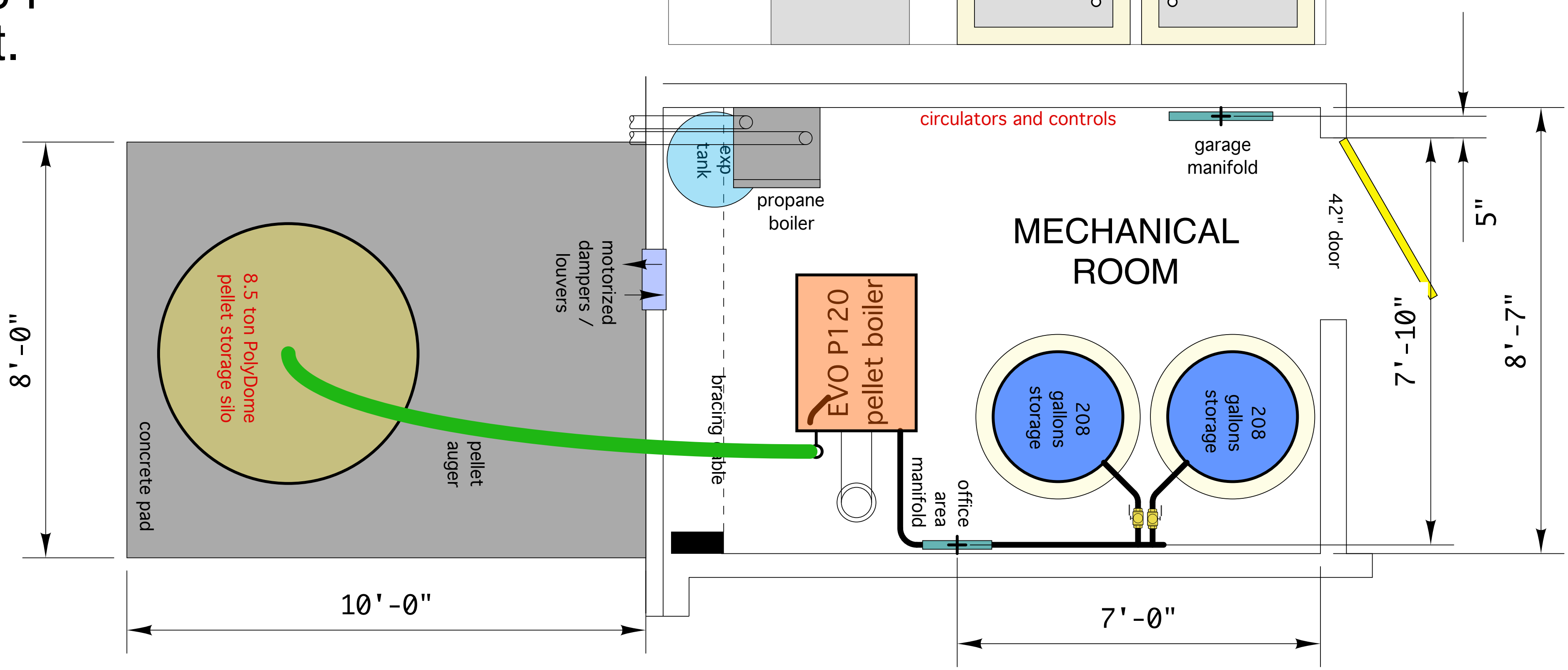
NYSDEC boat maintenance facility - Lake George, NY

Two, 210 gallon ASME thermal storage tanks

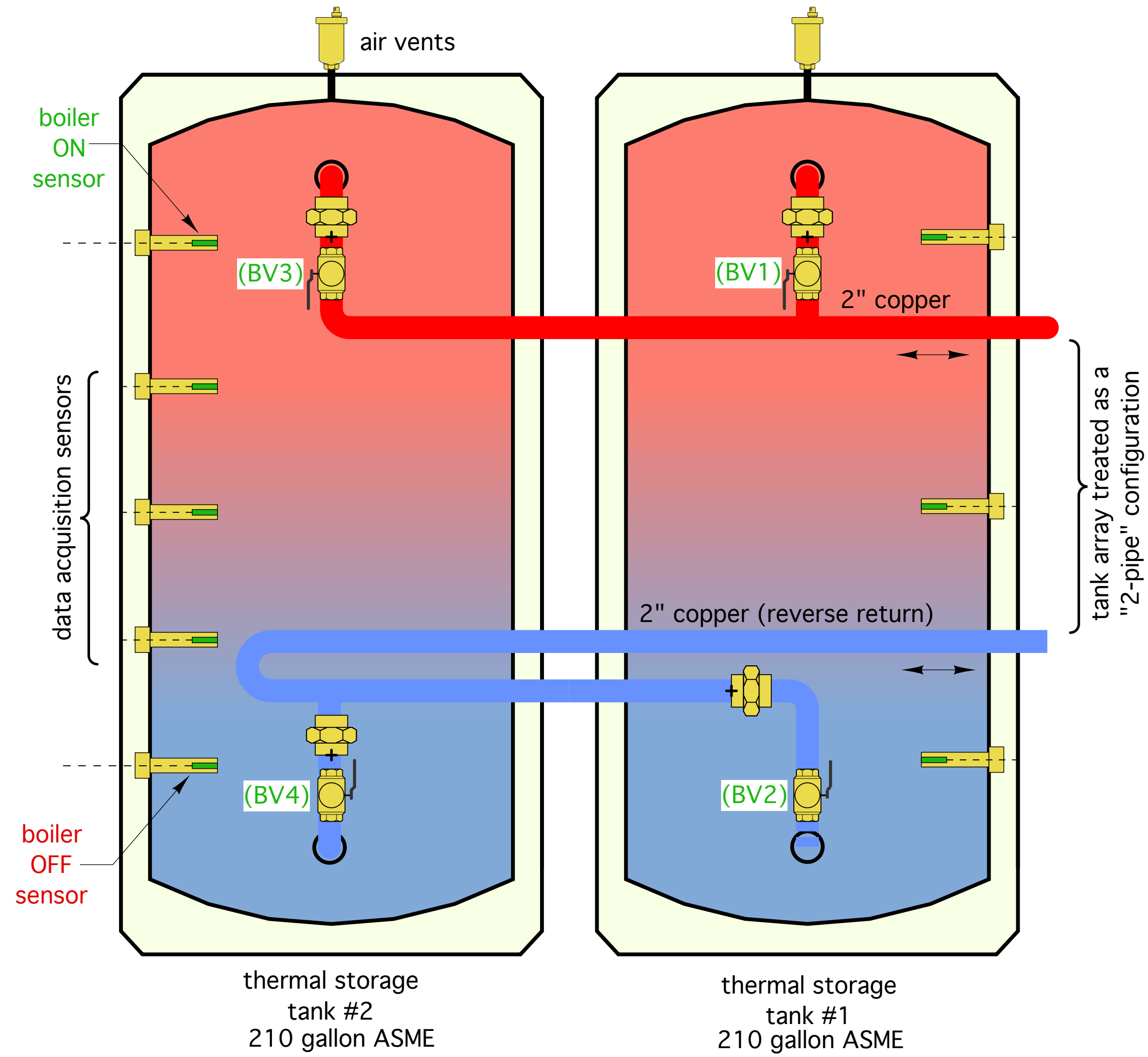
Original piping - both tanks are accessible

Last-minute changes to the building moved the tanks, making possible access more difficult.

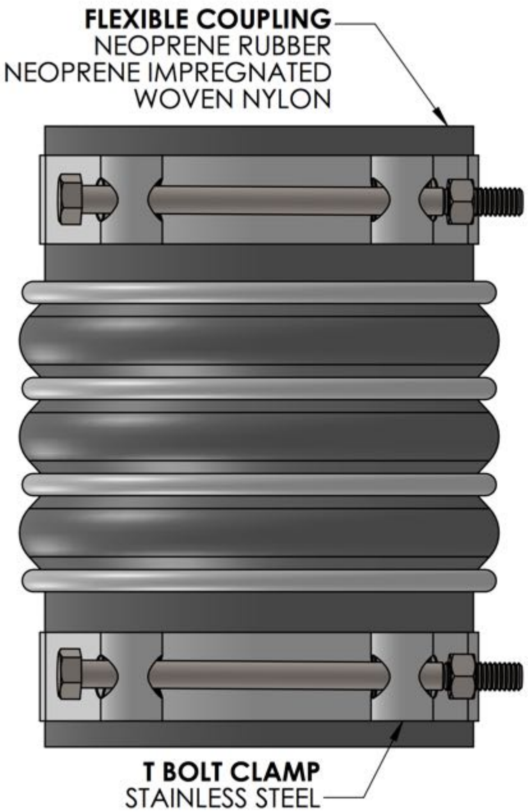




Two, 210 gallon ASME tanks being piped for reverse return



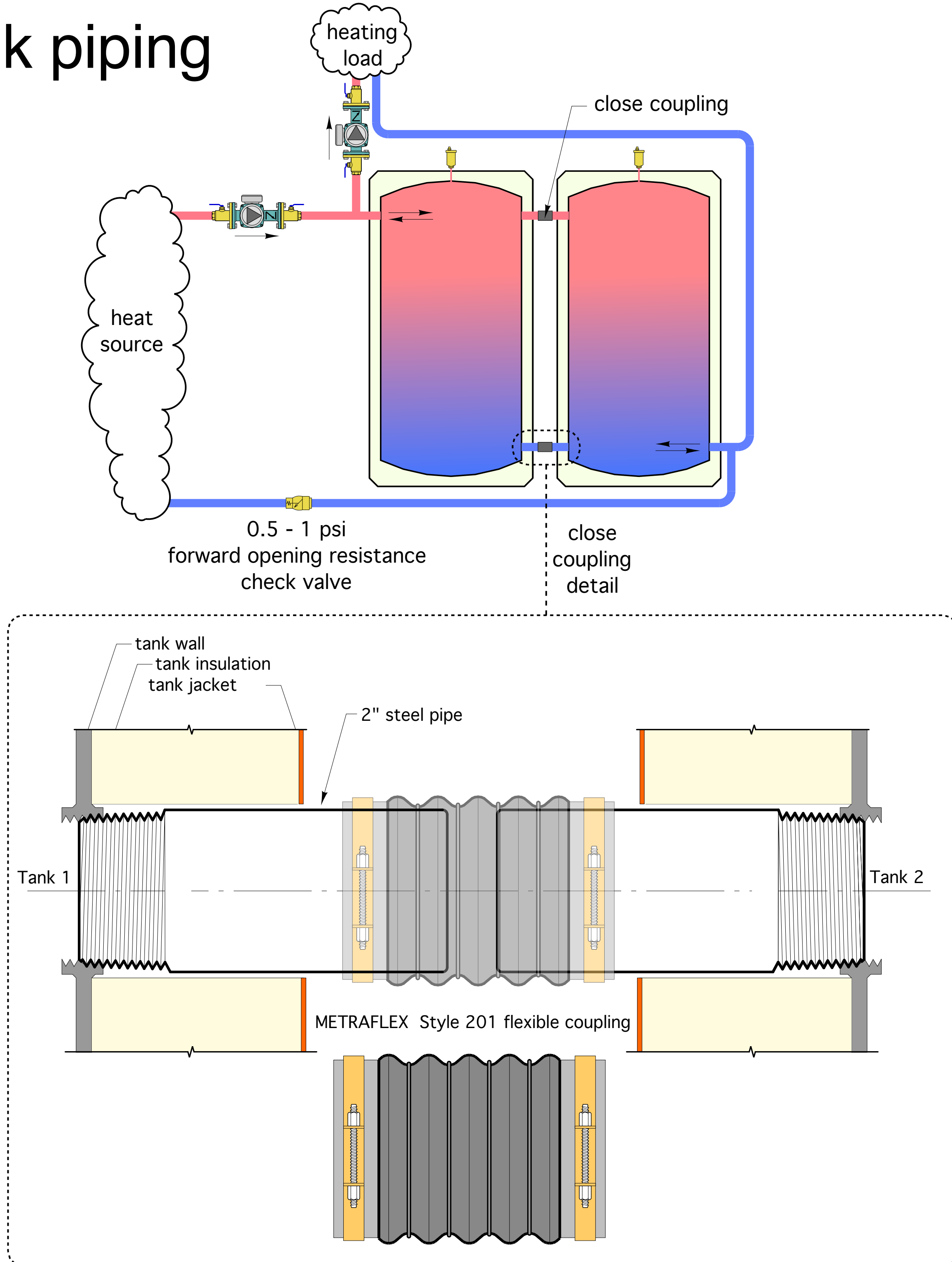
Hybrid parallel / series tank piping



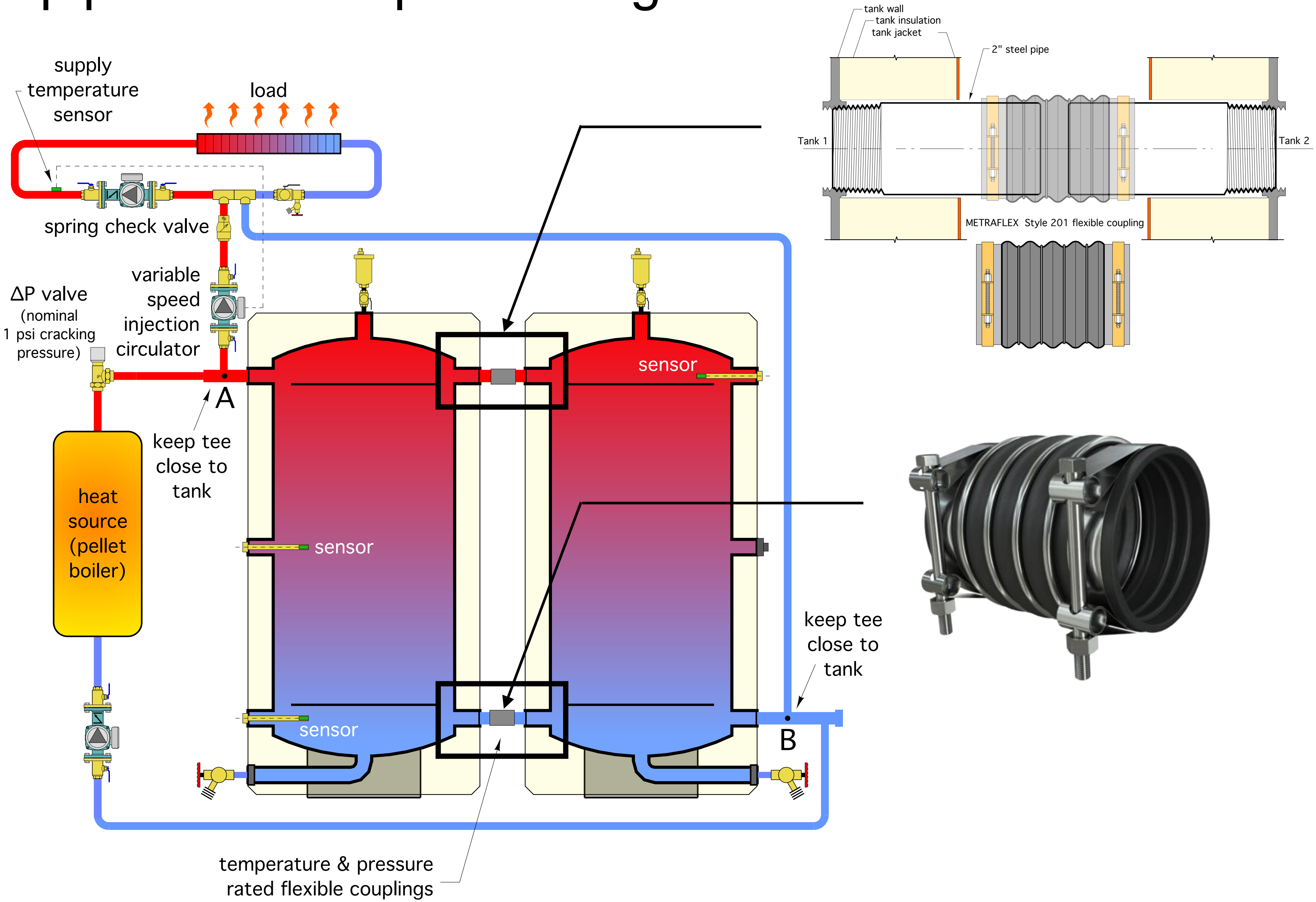
Metraflex Style 201 coupling

Rated to 225 °F / 75 psi

for pipe sizes 2” -12”

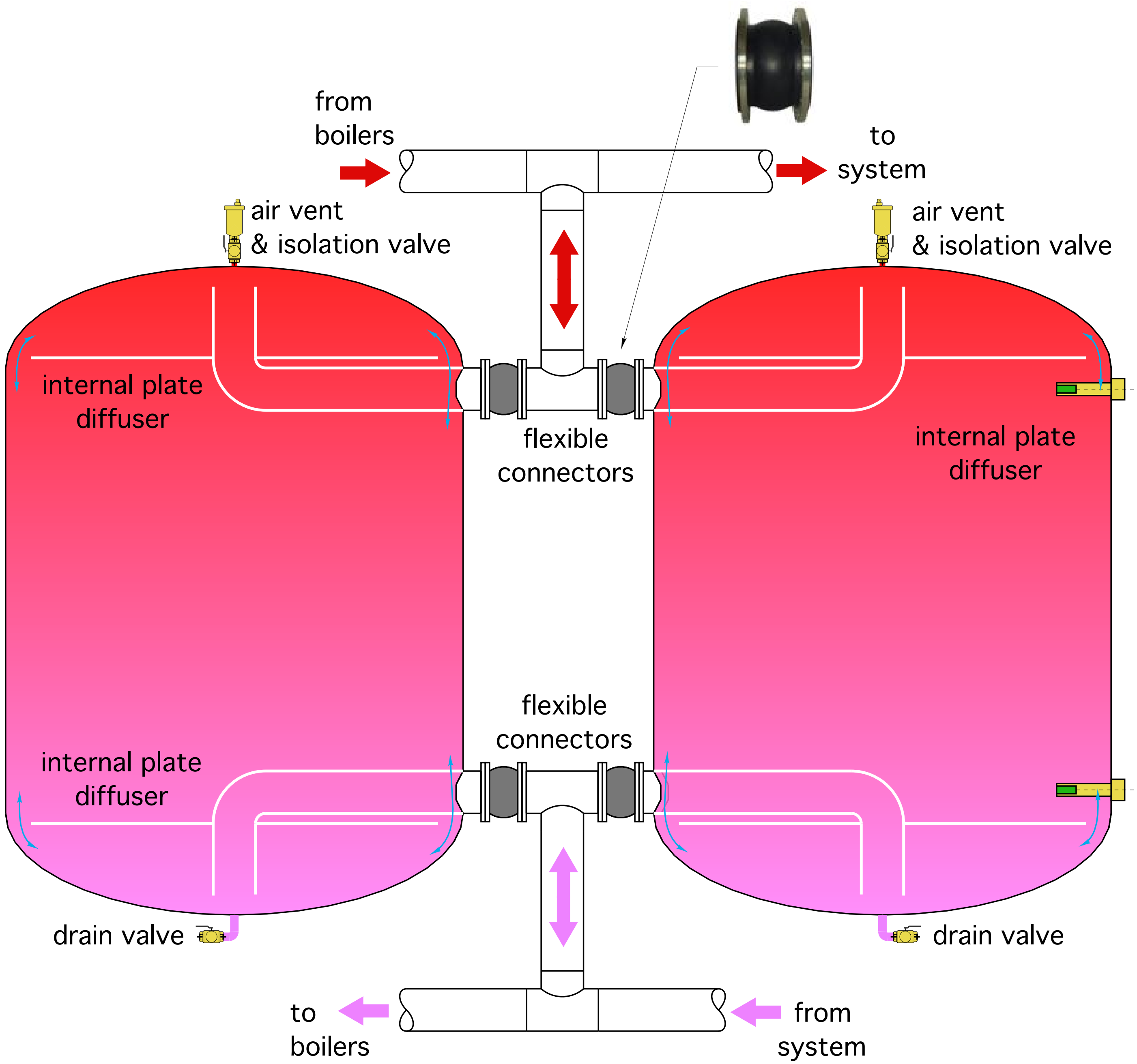


2-pipe close coupled configurations



Multiple tank / 2-pipe configurations

Side connections due to height restrictions



Flow rate from biomass boiler to strorage

One undesirable situation that has been observed on several biomass boiler systems is excessively high flow rate between the boiler and thermal storage.

High flow rates entering the tank create mixing currents that tend to break up temperature stratification, and reduce the temperature difference between the top and bottom of the thermal storage tank.

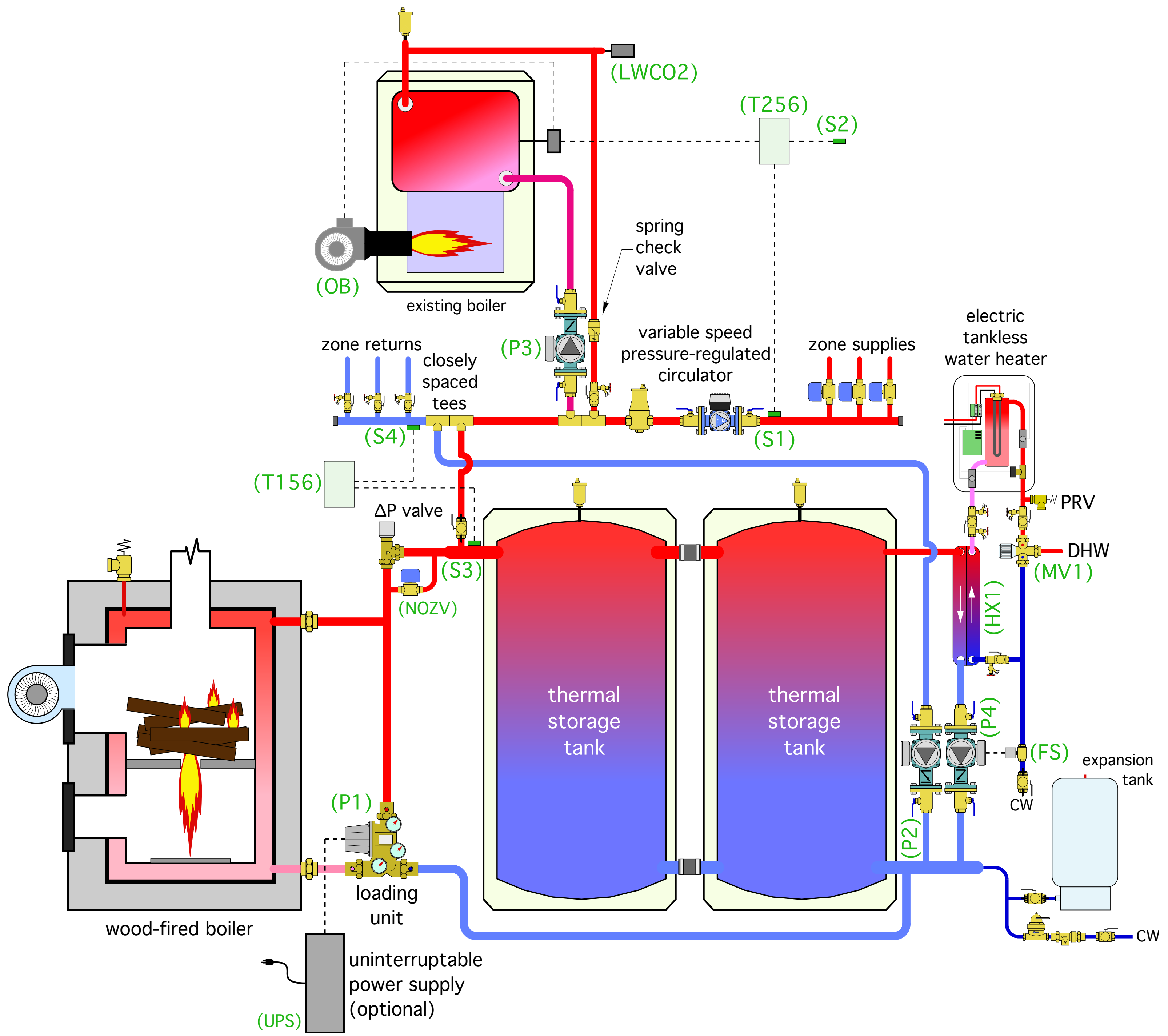
$$f = \left[\frac{Q}{c \times \Delta T} \right]$$

Where:
f = boiler flow rate (gpm)
Q = rated boiler output (Btu/hr)
ΔT = temperature rise across boiler (°F)
c = 500 (for water), 479 (for 30% glycol), 450 (for 50% glycol)

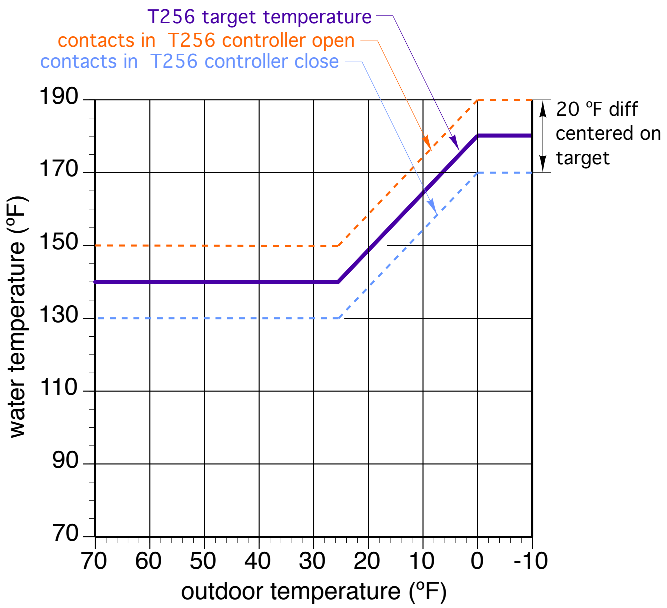
For example, a boiler rated at 150,000 Btu/hr, and operating with a 30 °F temperature rise (e.g., difference between inlet and outlet temperature), in a water system, would require a flow rate of:

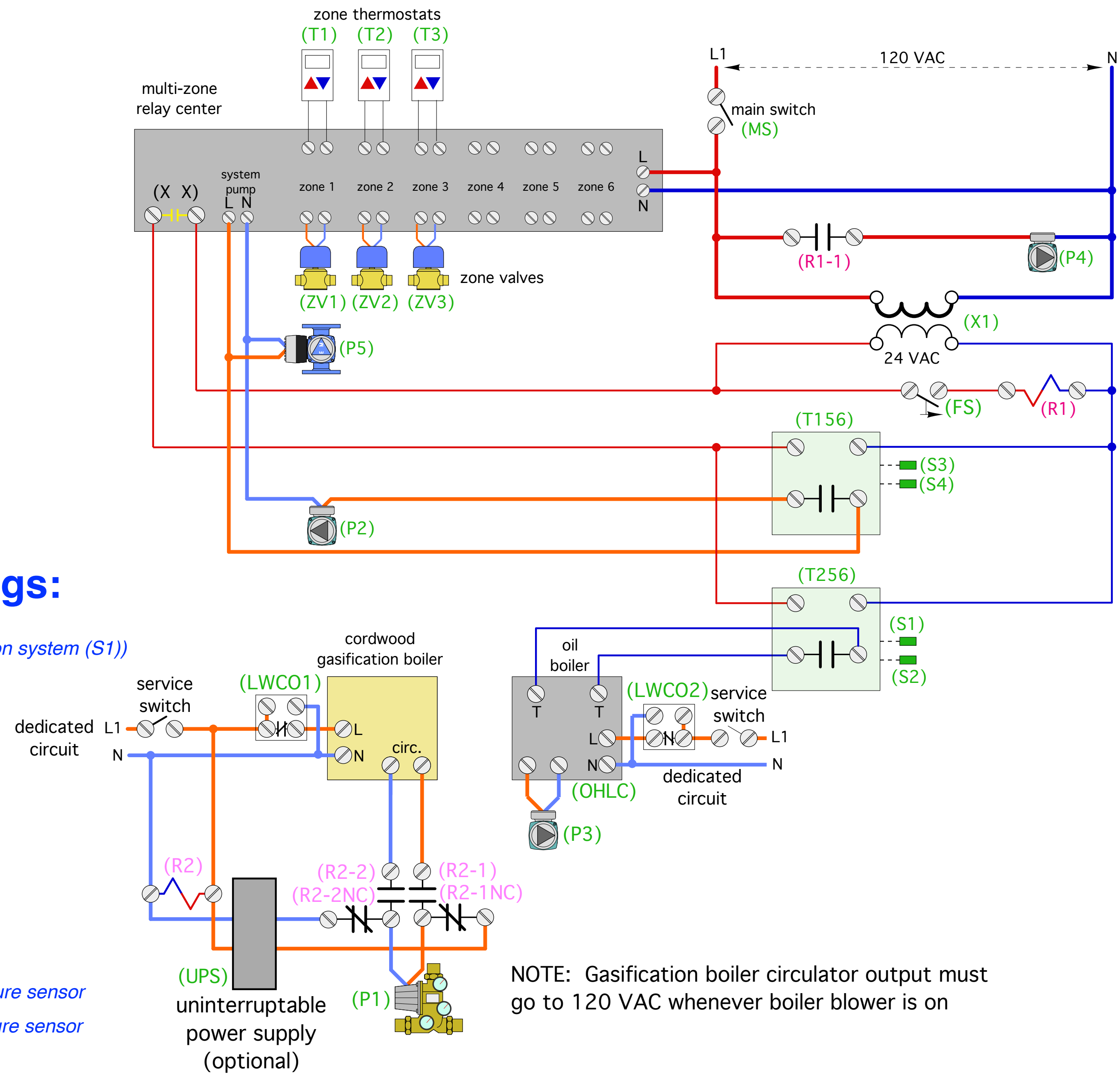
$$f = \left[\frac{Q}{c \times \Delta T} \right] = \left[\frac{150{,}000}{500 \times 30} \right] = 10\, gpm$$

Example System: heat + DHW w/ cordwood boiler + Aux boiler



System #4: heat + DHW w/ cordwood boiler + Aux boiler





NOTE: Gasification boiler circulator output must go to 120 VAC whenever boiler blower is on

Suggested initial controller settings:

- *T256 outdoor reset controller (monitors supply temp. sensor for distribution system (S1))*
  - *Outdoor design temperature = 0 °F*
  - *Supply water temperature at outdoor design = 180 °F*
  - *Maximum supply water temperature = 180 °F*
  - *Minimum supply water temperature = 140 °F*
  - *Outdoor temperature at no load condition = 70 °F*
  - *Supply water temperature at no load condition = 70 °F*
  - ***Differential = 20 °F (centered on target temperature)***
- *T156 differential temperature controller*
  - *contacts close if high temperature sensor ≥ 5 °F above low temperature sensor*
  - *contacts open if high temperature sensor ≤ 3 °F above low temperature sensor*
- *Cordwood gasification boiler high limit temperature = 200 °F*
- *Oil-fired boiler high limit temperature = 195 °F*
- *Oil fired boiler differential = 20 °F (below target temperature)*

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
<u>or</u>
$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>

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.

July 1, 2021
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.

September 9, 2021
Title: Multiple Pellet Boiler Systems
Description: Just as larger capacity heating systems often use multiple fossil-fuel boilers, it's possible to build systems around multiple pellet boilers. This webinar shows how such boilers would be piped and controlled. It also discusses concepts such as using pellet boilers of different heating capacity to better match variable heating loads.

October 14, 2021
Title: Adapting a pellet boiler to a forced air heating system
Description: The majority of houses in NY have forced air heating systems supplied by furnaces operating on fossil fuels. The webinar shows how a pellet boiler could be integrated into those systems to displace much of the fossil fuel used for space heating, and provide domestic hot water.

November 18, 2021
Title: Case study: Designing from scratch: What's possible when a pellet boiler is planned into new building construction
Description: Many of the previous webinars have focussed on adapting a pellet boiler into an existing hydronic heating system. This webinar describes an unfettered design development when a pellet boiler is incorporated into new construction. Details that leverage low temperature distribution systems, and optimal configuration of thermal storage for providing space heating and domestic hot water.

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

QUESTIONS ?