Case study - Pellet boiler system for NYSDEC maintenance facility at Lake George

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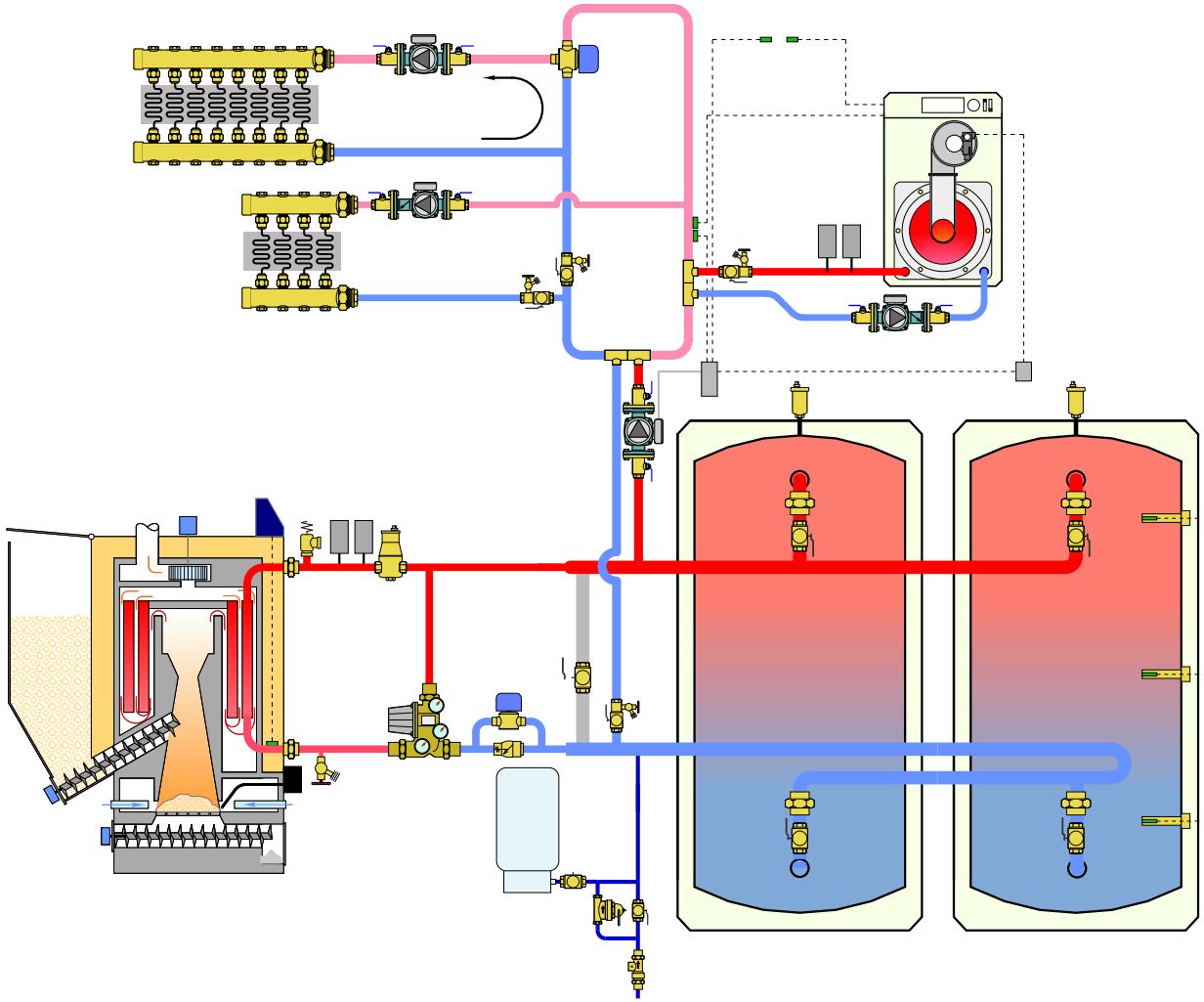

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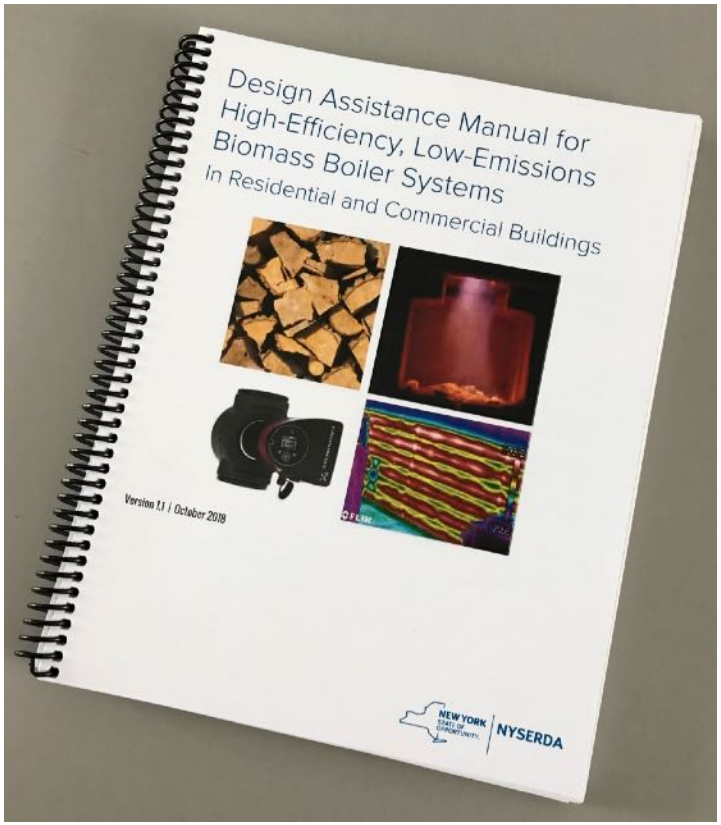
Previous portions of this webinar series (1,2, and 3) will soon be available at the Renewable Heat NY website - under training opportunities.

https://www.nyserda.ny.gov/All-Programs/Programs/Become-a-Contractor/Renewable-Heating-and-Cooling/Renewable-Heat-NY-Contractors

Many of the concepts discussed in previous webinars are applied in this system

- Temperature stacking in thermal storage
- Preventing heat from aux boiler from entering storage tank
- Low temperature heat emitters (heated floor slab)
- Outdoor reset control of supply water temperature to heat emitters
- ΔT control to prevent aux. boiler heat from entering thermal storage
- Anti-condensation protection of pellet boiler - using loading unit
- Draft regulator that seals against positive pressure
- Well-insulated thermal storage
- Good temperature stratification in thermal storage tank
- Variable speed injection mixing
- Constant circulation in high mass floor slab
- Closely-space tees for hydraulic separation

Design Assistance Manual
for High Efficiency Low Emissions Biomass Boiler Systems



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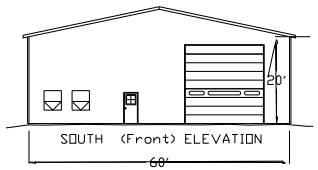
It's available as a FREE downloadable PDF at:

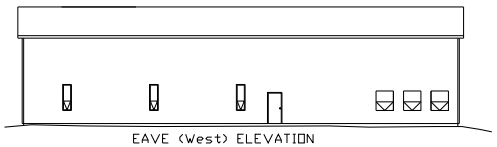
https://www.nyserda.ny.gov/-/media/Files/EERP/Renewables/Biomass/Design-Assistance-Biomass-Boiler.pdf

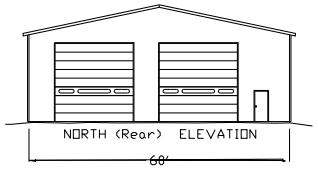
The building is a slab-on-grade 6000 square foot steel arch structure

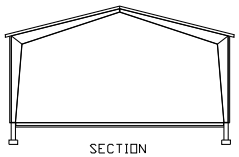
It's located at Bolton Landing on Western shore of Lake George in Adirondacks

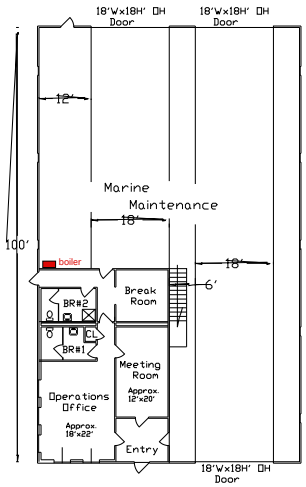
Design phase: 2014
Construction 2015-2016
Operational: 2016









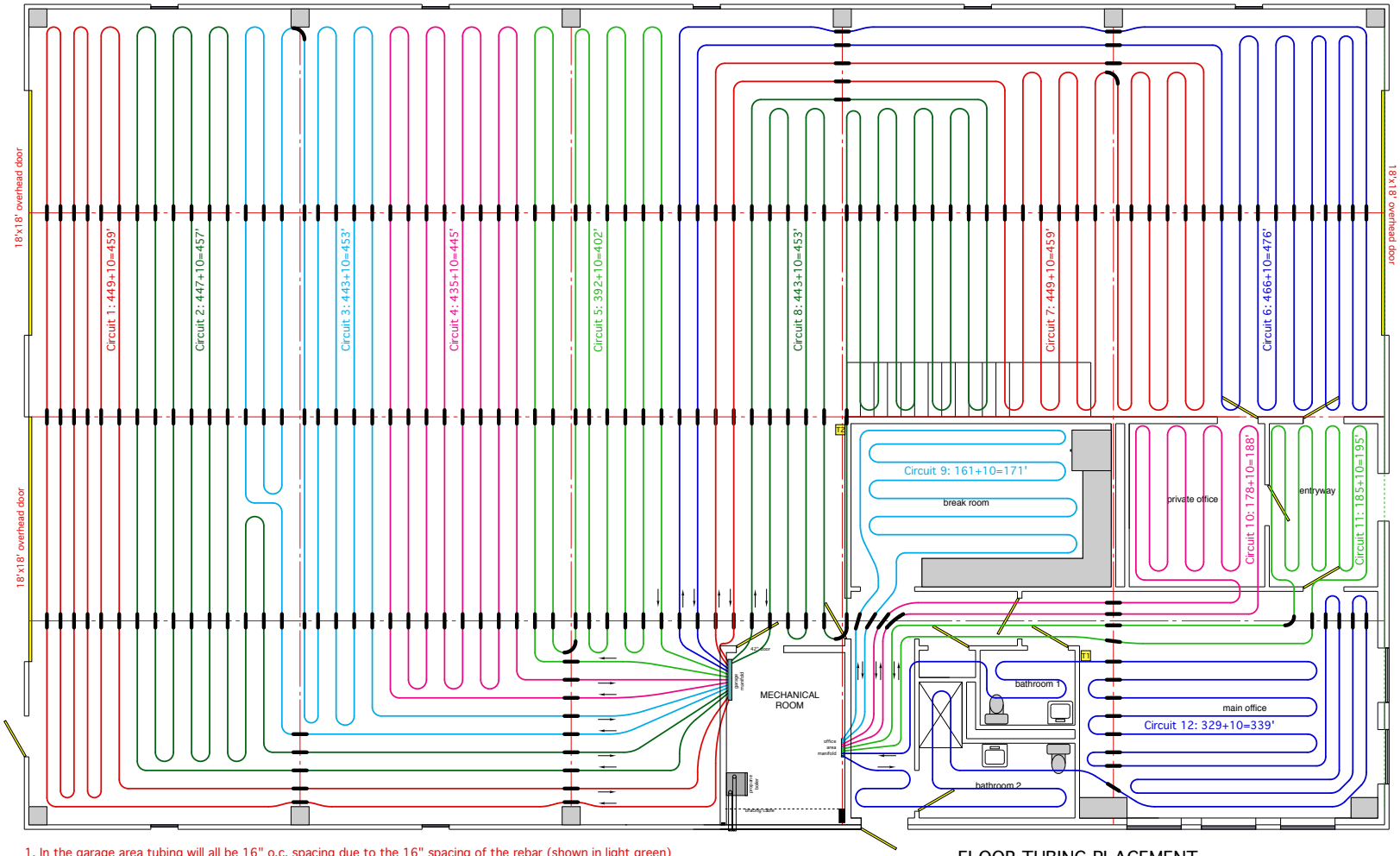


Building Requirements
-Rigid Frame Steel Construction (water resistant finish) Frames shall be sized so an I beam attached between any two frames can handle a 2 ton point load)
-Foam Sandwitch Panel Walls 4" Thickness (Metal-span, Fasteners shall be concealed in the seams)
-Foam Sandwitch Panel Roof 6". thickness (Meti-Span CFR 2" Standing Seam Roof Panels Fasteners shall be concealed at the seam) Panels shall be Kynar coated on the exterior
- 3- 18'Wide X 18' High Overhead Door Openings Framed and Trimmed (ready for door installation)
- 2- 3'X7' Foam Core Steel Man Doors (No Glass)
- 1- 3'x7' Foam Core Steel Man Door (Front Door) (Half-Glass Insulated Tinted Low E)
- 8- Insulview 2060 Project-In Windows w/screens Tinted Low E Insulated Glazing
- 5- Insulview 4046 Project-In Windows w/screens Tinted Low E Insulated Glazing
- Roof Snow Load For Warren County NY
- Roof Pitch 3 on 12
- Snow Guards that attach to the standing seam roof shall be furnished and installed
- Roof Overhang 12" all the way around
- Building shall come with complete Trim Package

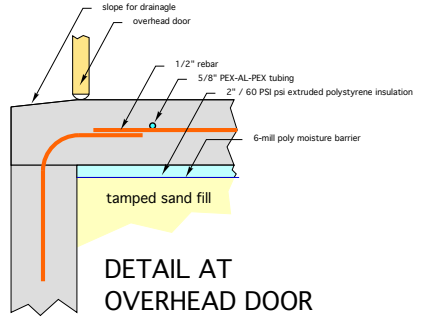
All Doors shall have Commercial Grade Hardware (Best Available)
Lever Latches, panic hardware and door closure
Foundation Design- Frost Wall and Column

GREEN ISLAND MARINE MAINTENANCE

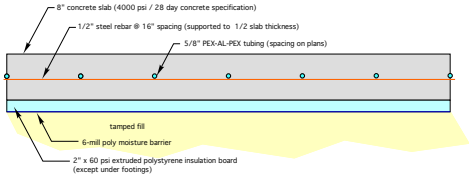
The original plan was floor heating supplied by a propane-fired mod/con boiler



FLOOR TUBING PLACEMENT



DETAIL AT OVERHEAD DOOR IN GARAGE



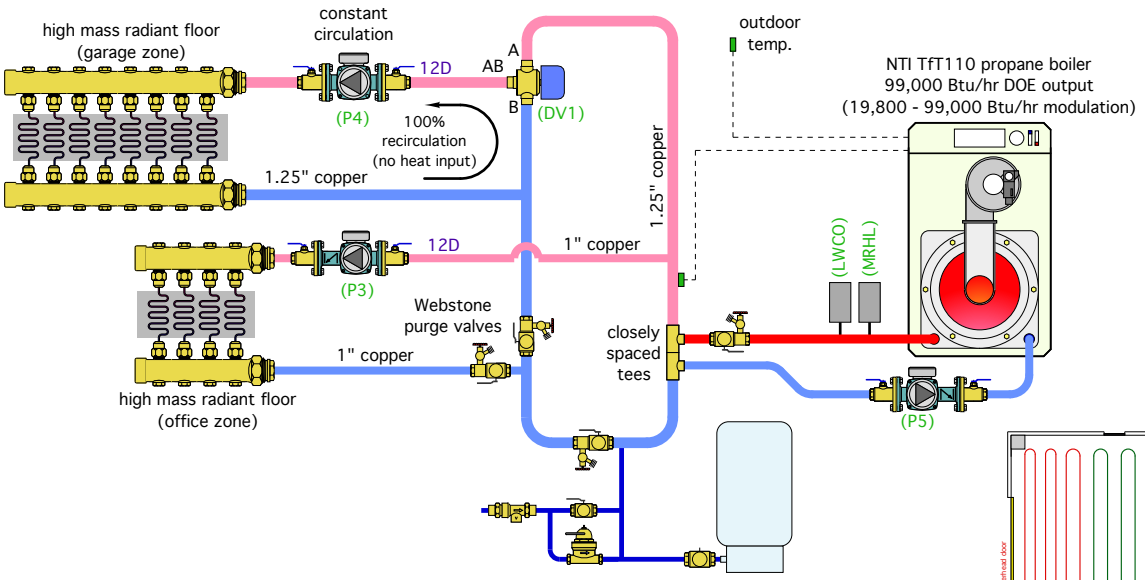
DETAIL OF HEATED SLAB

Circuit 1: 449+10=459'
Circuit 2: 447+10=457'
Circuit 3: 443+10=453'
Circuit 4: 435+10=445'
Circuit 5: 392+10=402'
Circuit 6: 466+10=476'
Circuit 7: 449+10=459'
Circuit 8: 443+10=453'
Circuit 9: 161+10=171'
Circuit 10: 178+10=188'
Circuit 11: 185+10=195'
Circuit 12: 329+10=339'
Total: 4497'

1. In the garage area tubing will all be 16" o.c. spacing due to the 16" spacing of the rebar (shown in light green)
2. Tubing will also be 16" spacing in the break room, private office, and bathrooms.
3. Tubing will be 8" spacing in the entryway, main office, and bathroom 2.
4. Limit circuits to 450 feet (will be using 5/8" PEX-AL-PEX tubing)
5. Can route tubing under interior partitions when necessary
6. Separate circuits for break room, private office, entry way, main office
7. No floor heating in mech. room.

Design heating load = 140,000 Btu/hr

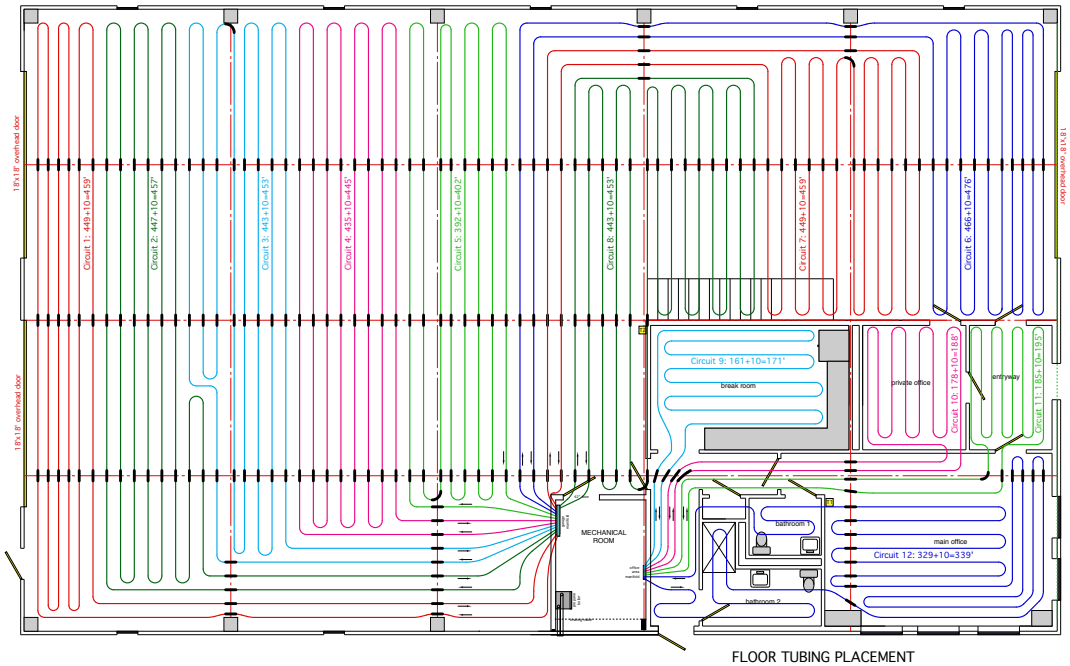
The original plan was floor heating supplied by a propane-fired mod/con boiler



Modulating / condensing boiler operating on propane

Two zones: garage, and office

Constant circulation in garage floor circuits



FLOOR TUBING PLACEMENT

Floor heating tubing being installed

Circuit 1:	449+10=459'
Circuit 2:	447+10=457'
Circuit 3:	443+10=453'
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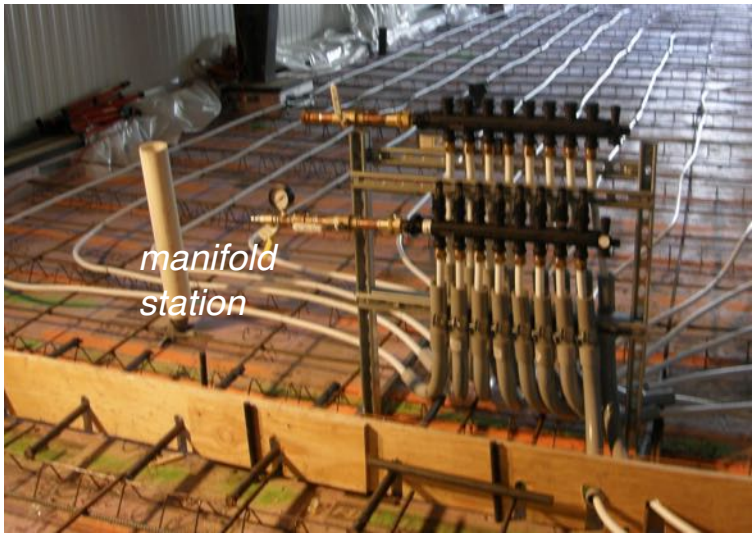
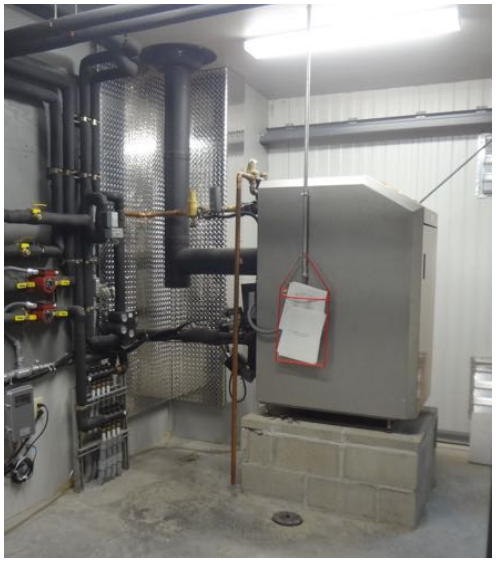


In 2014 , with the RHNY program in place, decision was made to include a pellet boiler system

At the time this system was being planned there was some installer, and boiler manufacturer "pushback" against the requirement for thermal storage in pellet boiler systems.

(NYSERDA required 2 gallons of water storage per 1000 Btu/hr of pellet boiler capacity)



The slab in this building is 8" thick. It's total concrete volume is 4000 ft^3

The thermal mass of this slab is ***huge*** (117,600 Btu/^oF)

For comparison, a 210 gallon thermal storage tank has a thermal mass of 1749 Btu/^oF Btu/^oF

The thermal mass of the floor is about 67 times greater than a single 210 gal. thermal storage tank.

In theory - 1^oF change in slab temperature is equivalent to a 67^oF change in water temperature for a 210 gallon tank.

Goal to create a system that could operate with (or without) thermal storage.

Other design objectives / requirements

- Outside pellet storage, 8.5 ton polyethylene silo
- EVO World P120 boiler (nominal 120,000 Btu/hr output)
- 2 zones of floor heating (garage & office)
- Constant circulation in garage area (to prevent cold spots near large overhead doors
- Full outdoor reset of supply water temperature to floor circuits. (extended temperature draw down on thermal storage)
- Incorporates two 210 gallon thermal storage tanks to get storage ratios of 1.75 and 3.5 gallons per 1000 Btu/hr of pellet boiler capacity.
- Be able to operate system with 1, 2, or no thermal storage tanks
- Retain originally-planned mod/con boiler for back up heating
- Develop good temperature stratification within thermal storage

The new building was very close to another building. The pellet storage silo was installed between them.

Translucent PE pellet silo shows remaining pellet volume

Snow cleats on metal roof to prevent “avalances” from damaging silo

Several changes were made during construction

• Size of mechanical room was increased after floor heating manifolds were in place. **Not ideal, but workable.**

• Contractor wanted to prefab as much of system as possible - **added quite a bit of piping, and repositioned equipment.**

• Pellet boiler supplier requested use of “loading unit” for anti-condensation control rather than 3-way motorized valve. **Easy to accommodate given size of boiler**

• Wanted to use a positive pressure sealing draft regulator (non-UL). **Sought and obtained permission from NYS chief boiler inspector to do so.**

• Tekmar 356 Injection mixing controller called for aux boiler activation at only 30% injection pump speed (instead of about 95% speed). This setting was in the firmware and could not be changed.

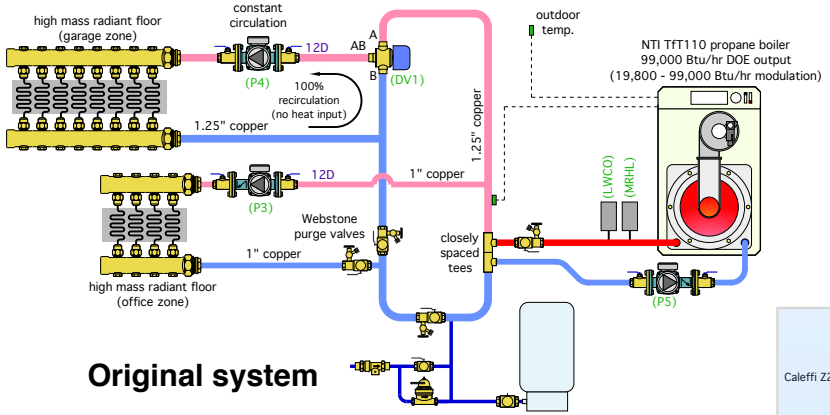
This “called” for aux boiler circulator to be on even though aux boiler didn’t fire.

Work-around: Added another controller that prevented the aux boiler circulator (and burner) from operating unless supply water temperature was 5 ºF below target temperature for injection mixing controller.

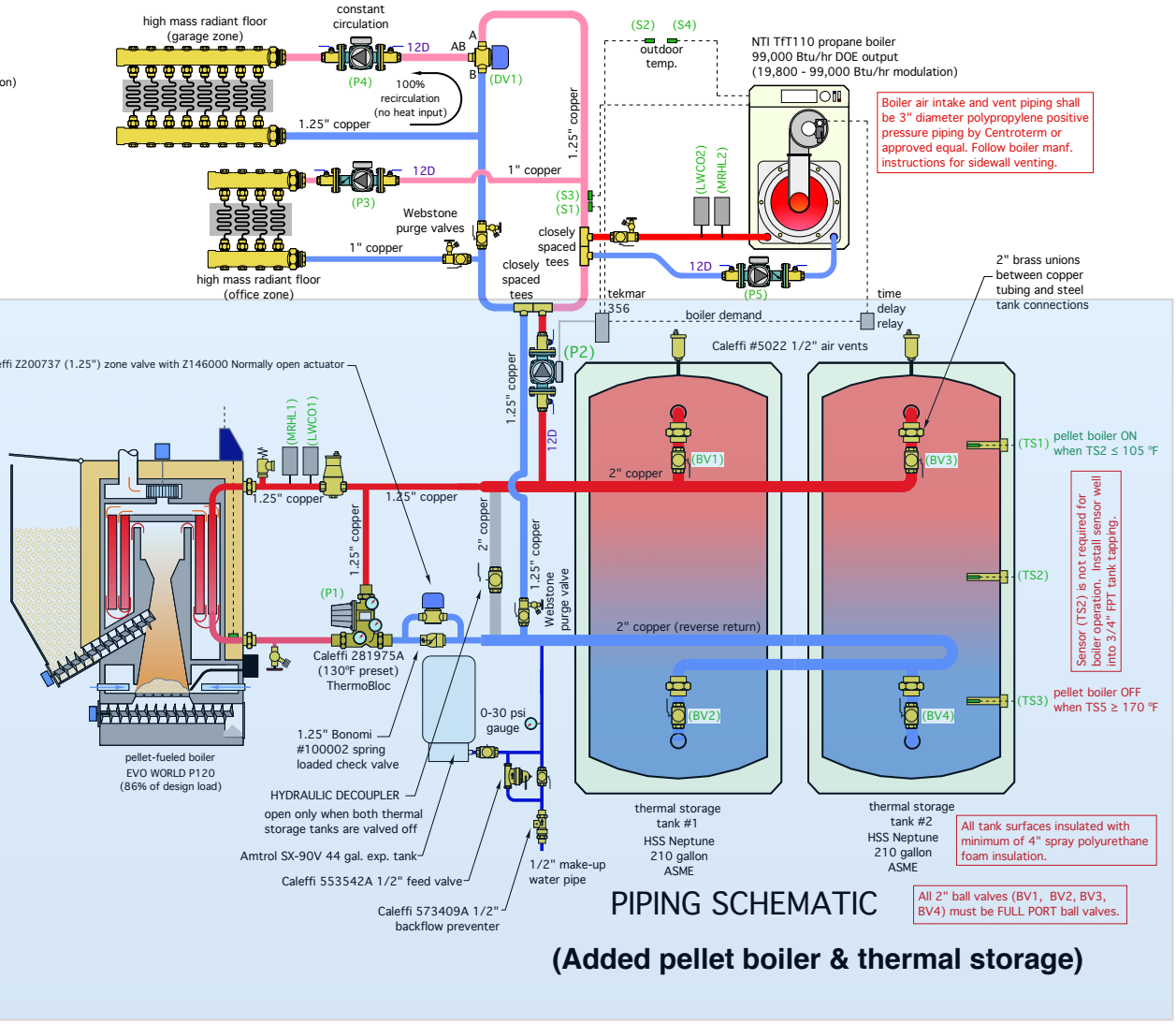
210 gallon “Neptune” thermal storage tank ASME certified

Two 210 gallon thermal storage tanks with factory-applied 4” spray foam insulation and intumescent coating ASME certified

Piping schematic for overall system



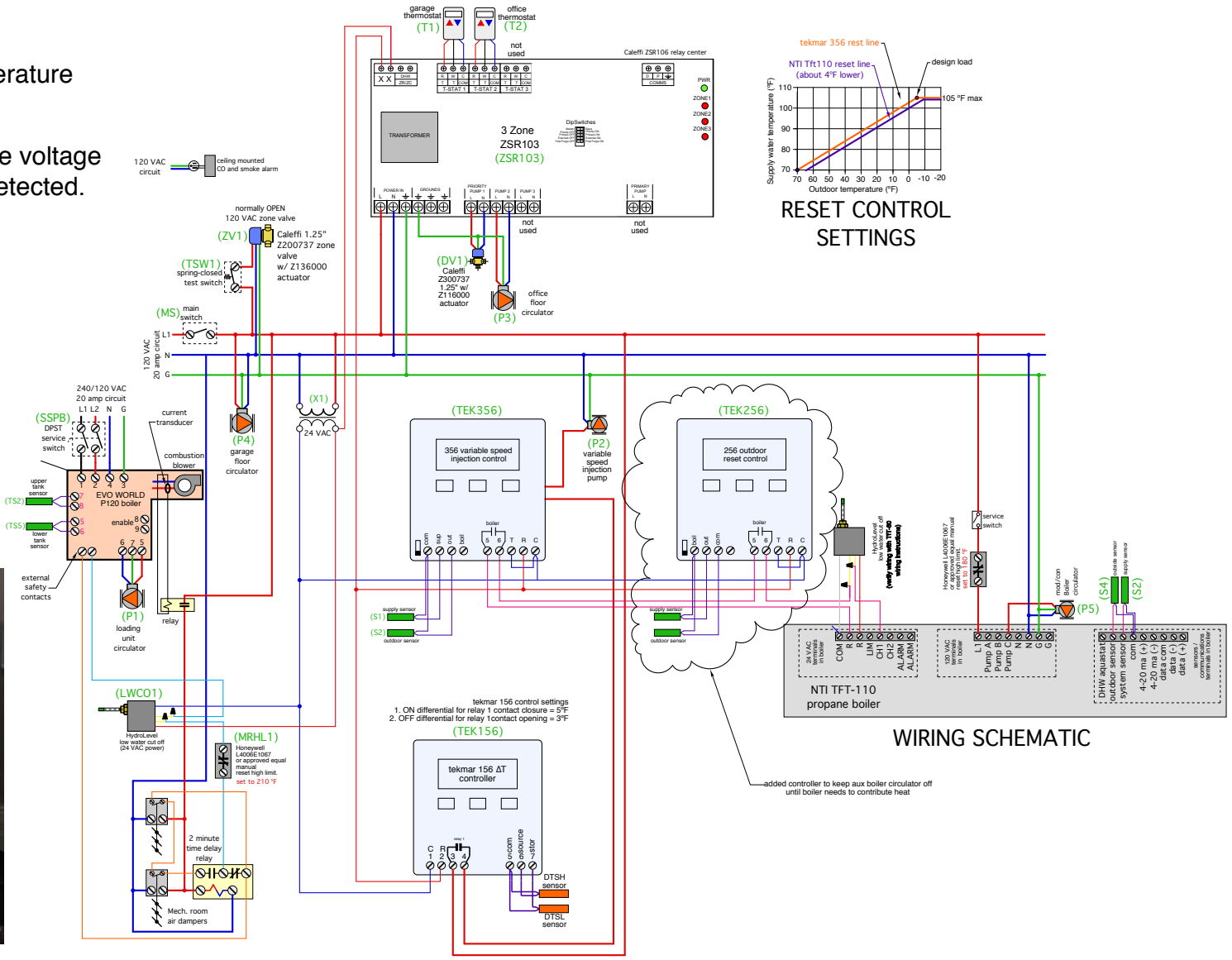
Original system



(Added pellet boiler & thermal storage)

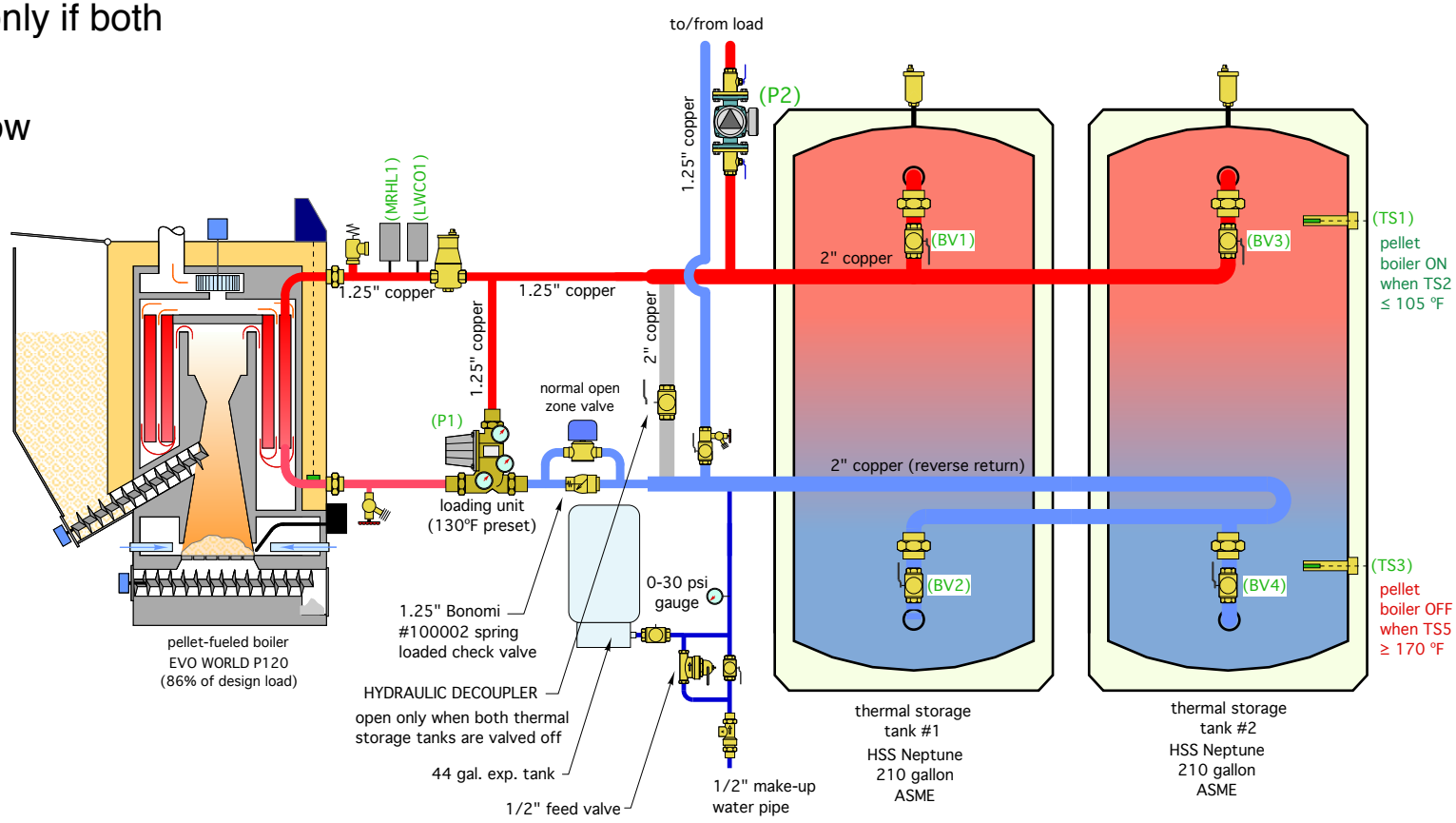
Electrical controls schematic

- Pellet boiler is fired based on two temperature sensors in thermal storage tank.
- Fresh air dampers are opened when line voltage associated with firing the pellet boiler is detected.
- Upper storage tank temperature must be at least 5 ºF above return temperature from floor circuits to enable injection pump.
- Aux boiler is enabled to operate when supply water temperature to floor circuits is 5 ºF or more below target supply water temperature.



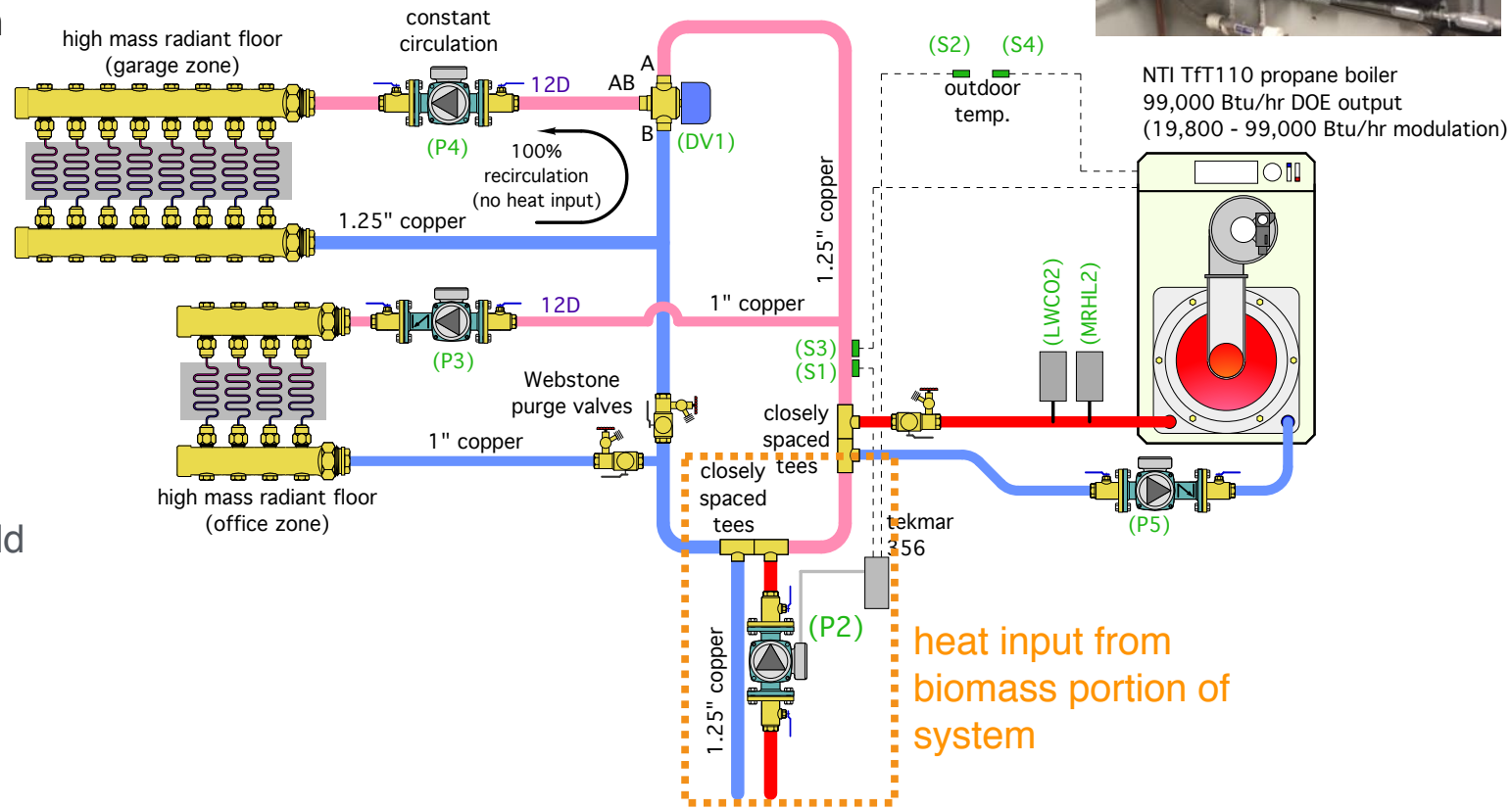
Pellet boiler & storage piping

- Thermal storage piped as a “2-pipe” configuration
- Loading unit provide boiler circulation & anti-condensation protection
- Hydraulic decoupler open only if both tanks are off-line
- Reverse return balances flow through tanks
- Boiler turned on/off by upper and lower tank sensors, when at least on tank is online
- Spring check stops reverse thermosiphon and inhibits flow through boiler when it is off, but load is on
- Normally open zone valve opens upon power failure to all thermosiphon b/w boiler and tanks



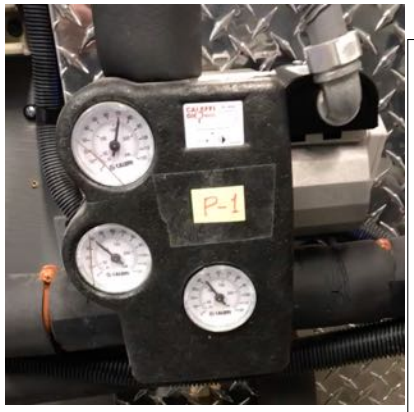
Auxiliary boiler and distribution piping

- Thermal storage connects ***upstream*** of aux boiler connection
- Aux boiler is hydraulically separated using closely-spaced tees
- Garage floor slab operates with constant circulation. 3-way valve controls heat input
- Both manifold stations are in parallel with each other
- Circulator (P2) provides injection mixing for both manifold stations, based on outdoor reset control
- Aux boiler also operates from self-contained outdoor reset control
- Purge valves on both manifold branches

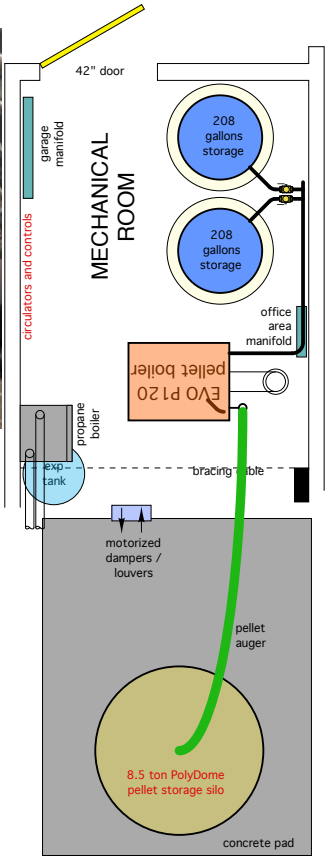


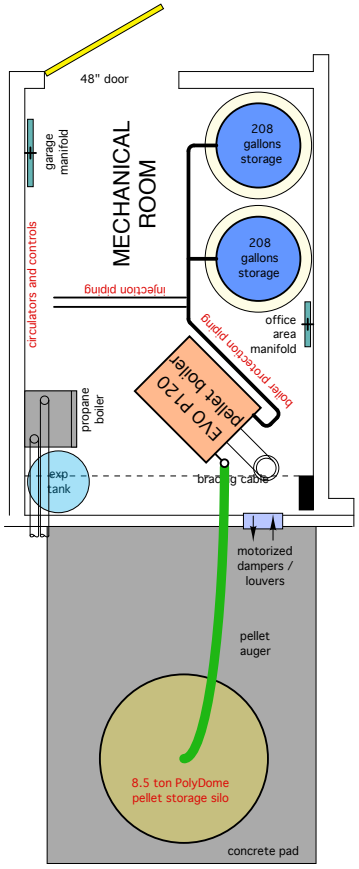
Other system details

Snow cleats on roof
and braced chimney

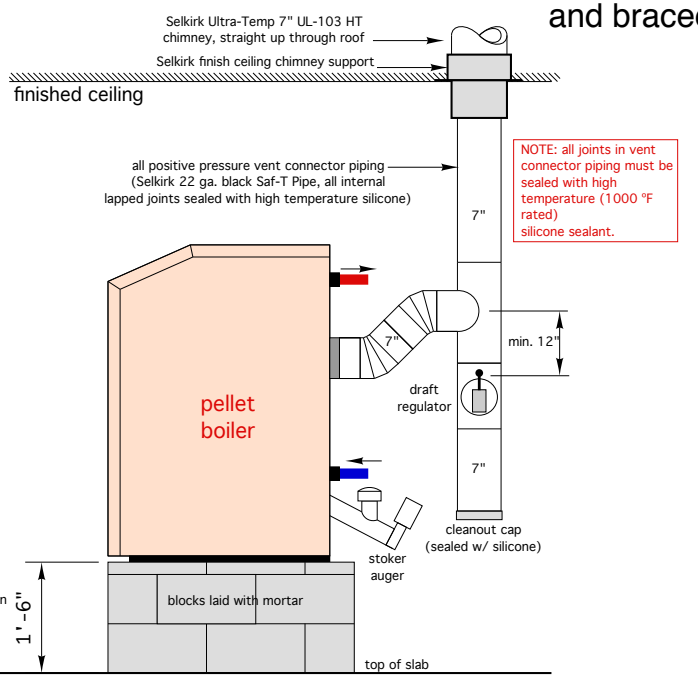


loading unit
anti-condensation &
boiler circulation





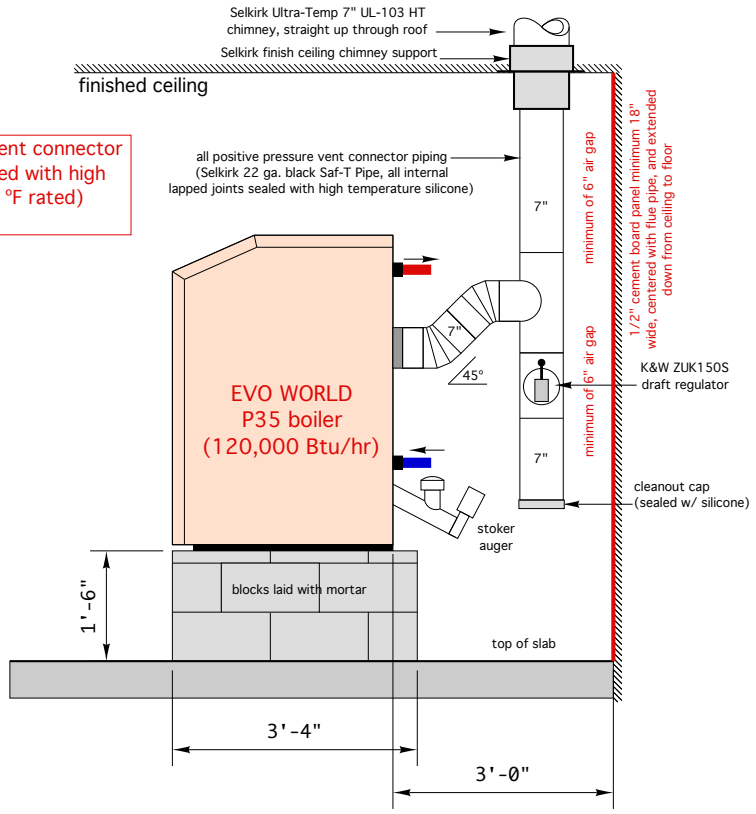
Several trial layouts of equipment
prior to expanding mech. room



pellet receiver at
base of silo

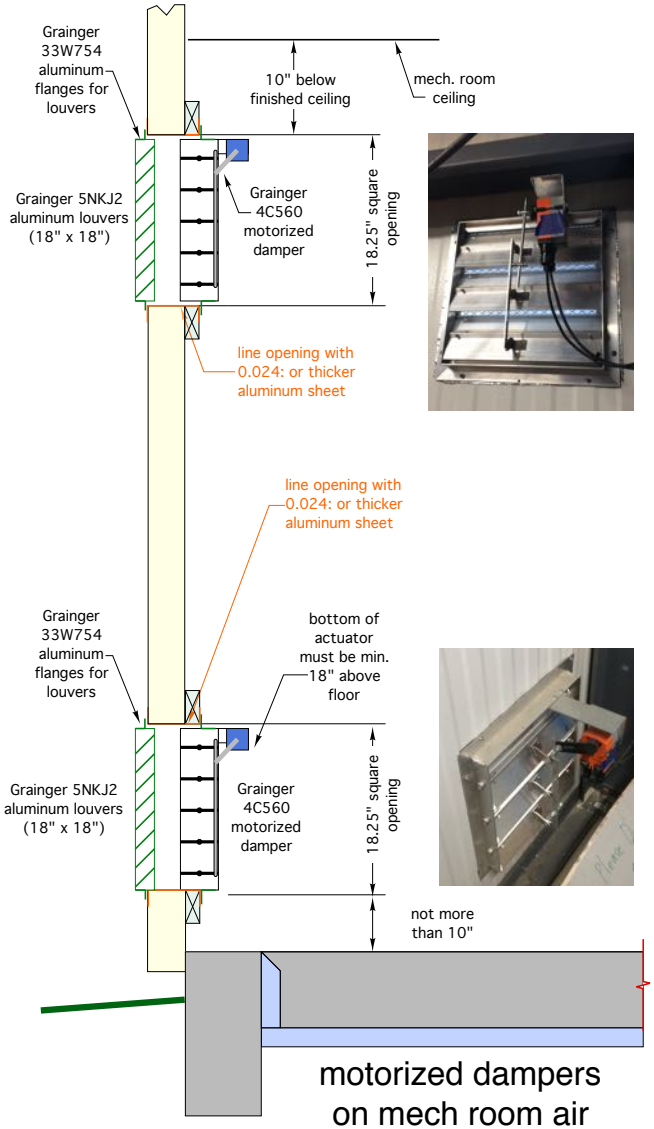
Other system details

NOTE: all joints in vent connector piping must be sealed with high temperature (1000 ºF rated) silicone sealant.



K&W ZUK150S
draft regulator

Positive pressure
sealing draft regulator
below boiler breaching tee



motorized dampers
on mech room air
intake and relief

Lessons learned

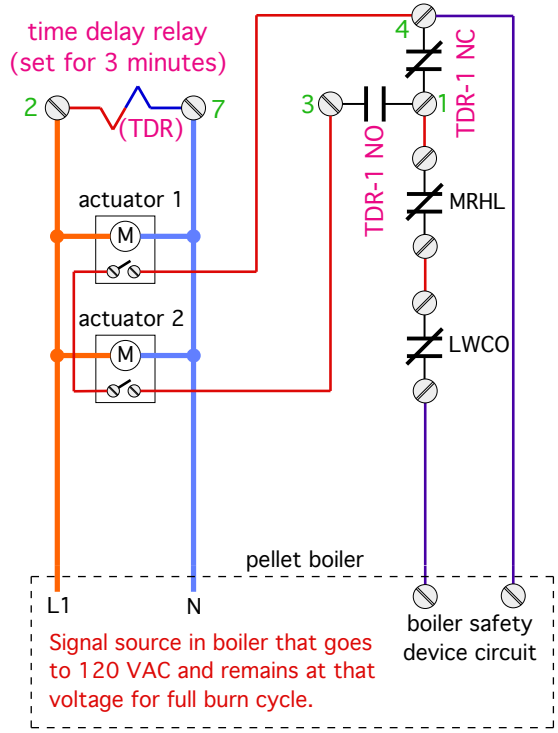
Boiler room ventilation air

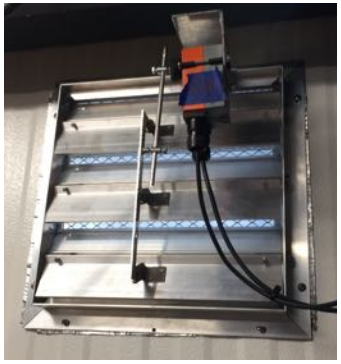
The actuators must keep the dampers open whenever combustion is occurring.

This must be verified by end switches in each damper actuator.

This circuit allows a nominal 2 minute time delay for the dampers to open and verify, or else it opens the boiler safety circuit for shut down.

Grainger 23NU95 time delay relay
(can be set for 3-300 seconds)
in Grainger 5X852 socket





Lessons learned

Be sure size of mechanical room is set before installing radiant heating manifolds.

Be certain that precipitation cannot enter any portion of pellet storage or supply system.

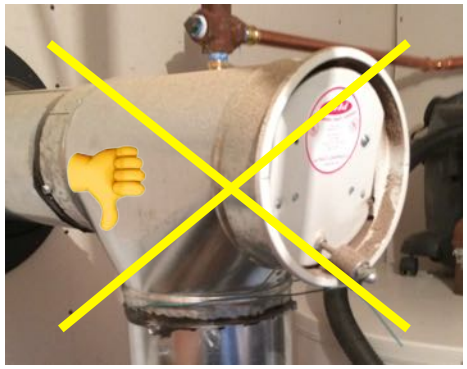
Seal all joints in venting piping with high temperature sealant.

Use a draft regulator that can seal against positive pressure in the vent.

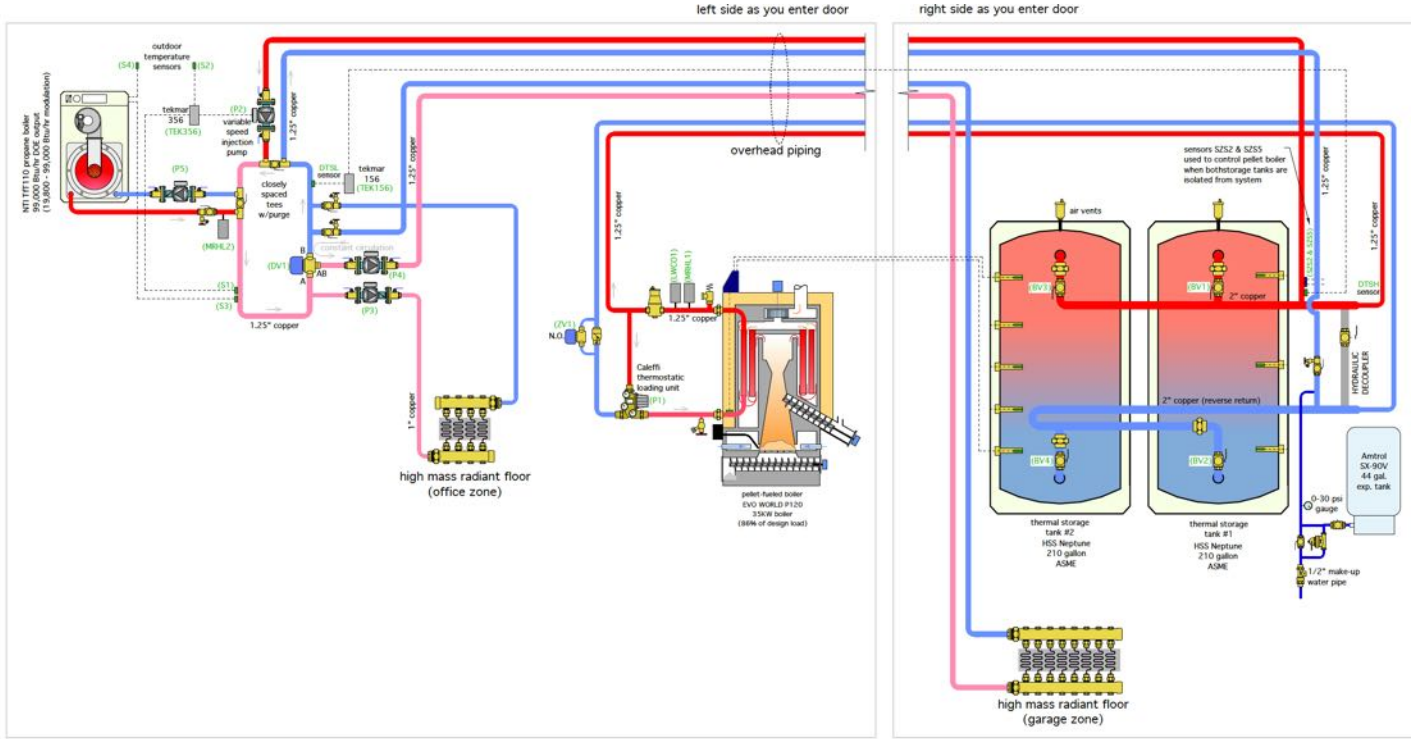
Tanks insulated with spray foam may be ugly, but they worked well with the piping shown.

Excess fines in the pellet supply can jamb flex auger assembly.

Verify voltage output from boiler to circulator matches circulator voltage (240 VAC output from pellet boiler to 120 VAC circulator.

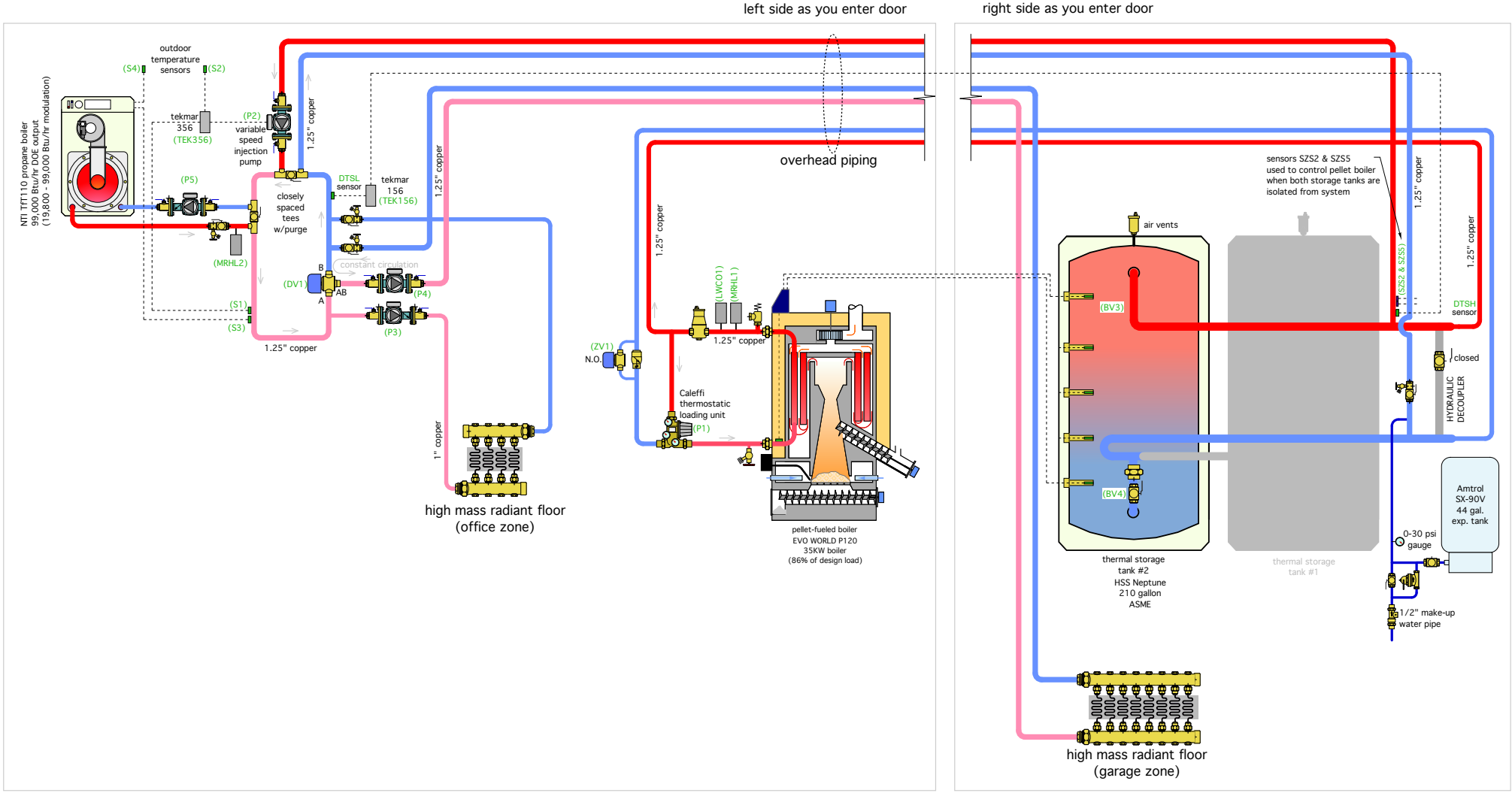


DEC Boat Garage, as built schematic (both tanks online)

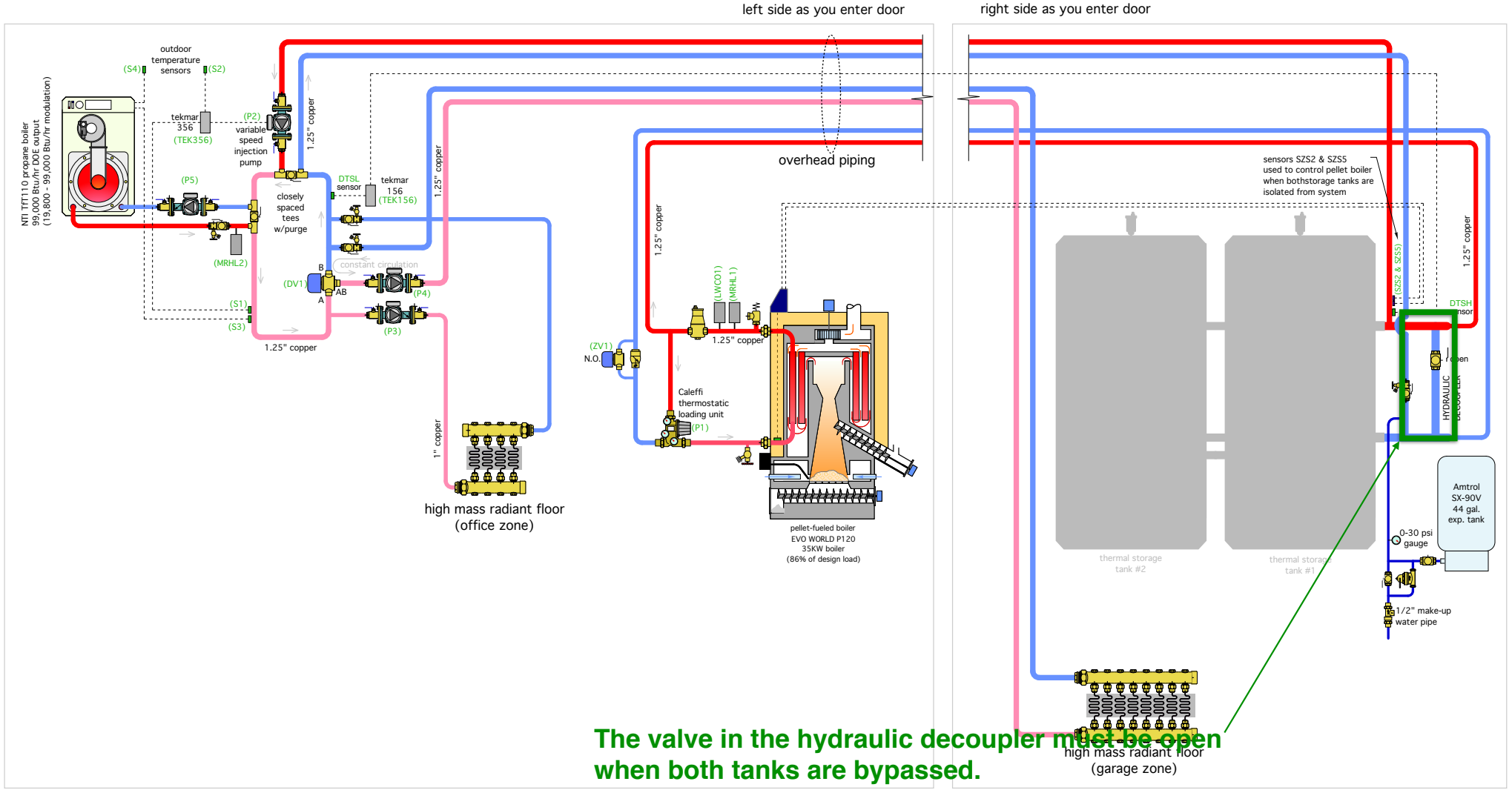


NYSDEC
Bolton Landing Boat Garage
"AS BUILT" PIPING SCHEMATIC
(October 2016)

DEC Boat Garage, as built schematic (1 tank online)

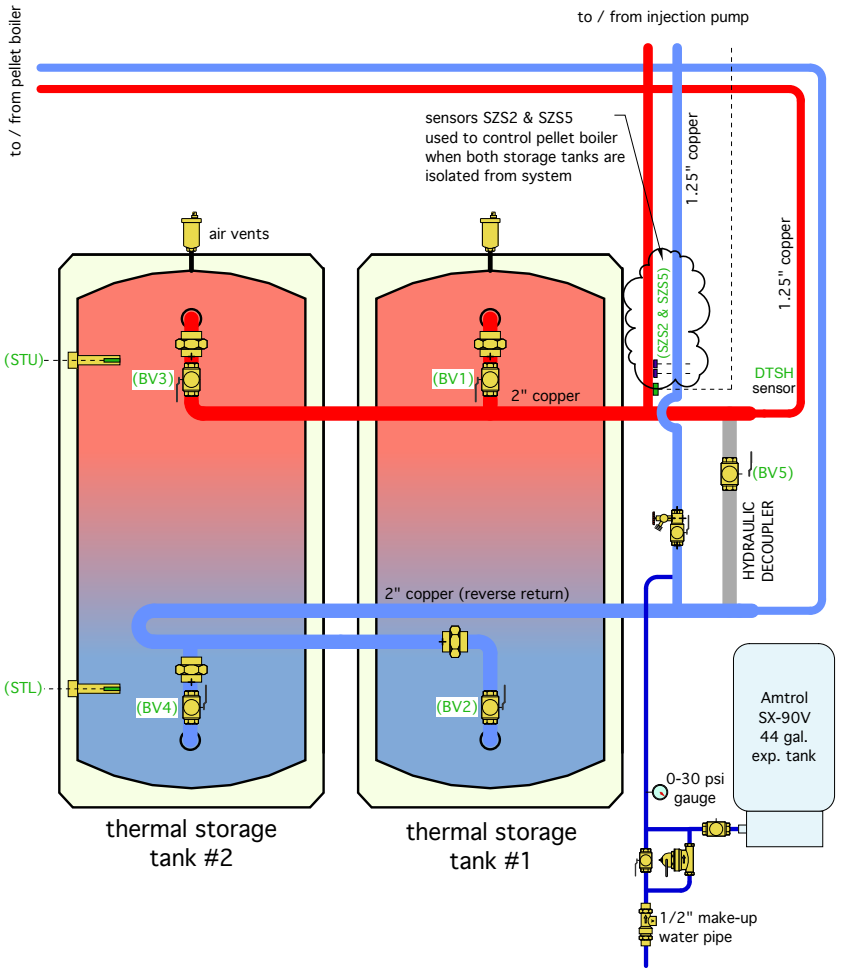


DEC Boat Garage, as built schematic (NO tanks online)



The valve in the hydraulic decoupler must be open when both tanks are bypassed.

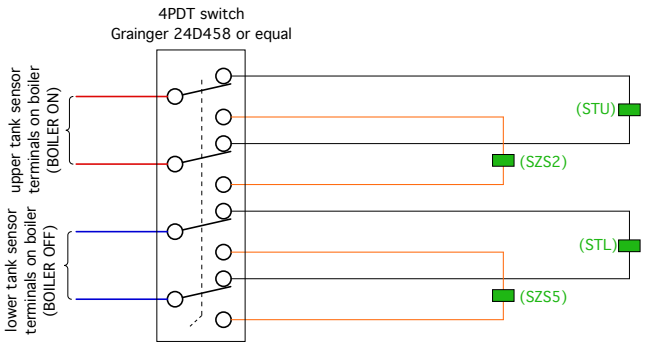
Provisions to operate pellet boiler with both tanks offline



1. BOTH THERMAL STORAGE TANKS IN OPERATION:
Valves (BV1, BV2, BV3, BV4) all open
Ball valve (BV5) closed
upper and lower temperature sensor in tank #2 (STL, STU)control pellet boiler

2. ONE TANK (tank #2) IN OPERATION:
Valves (BV1 closed) (BV2 slightly open just to allow pressure equalization)
Valves (BV3, BV4) open
Ball valve (BV5) closed
upper and lower temperature sensors in tank #2 (STL, STU) control pellet boiler

3. BOTH TANKS OFFLINE
Valves (BV1 closed) (BV2 slightly open just to allow pressure equalization)
Valves (BV3 closed) (BV4 slightly open just to allow pressure equalization)
Ball valve (BV5) in hydraulic decoupler must be open in this mode.
pellet boiler controlled from sensors (SZS2 and SZS5), both sensors mounted on copper piping adjacent to each other, strapped to pipe with 2 high temperature pull ties, and fully wrapped with insulation.
Wired back to boiler through 4PDT switch.
Do not change the control settings for boiler on and boiler off in the pellet boiler controller when using these sensors.

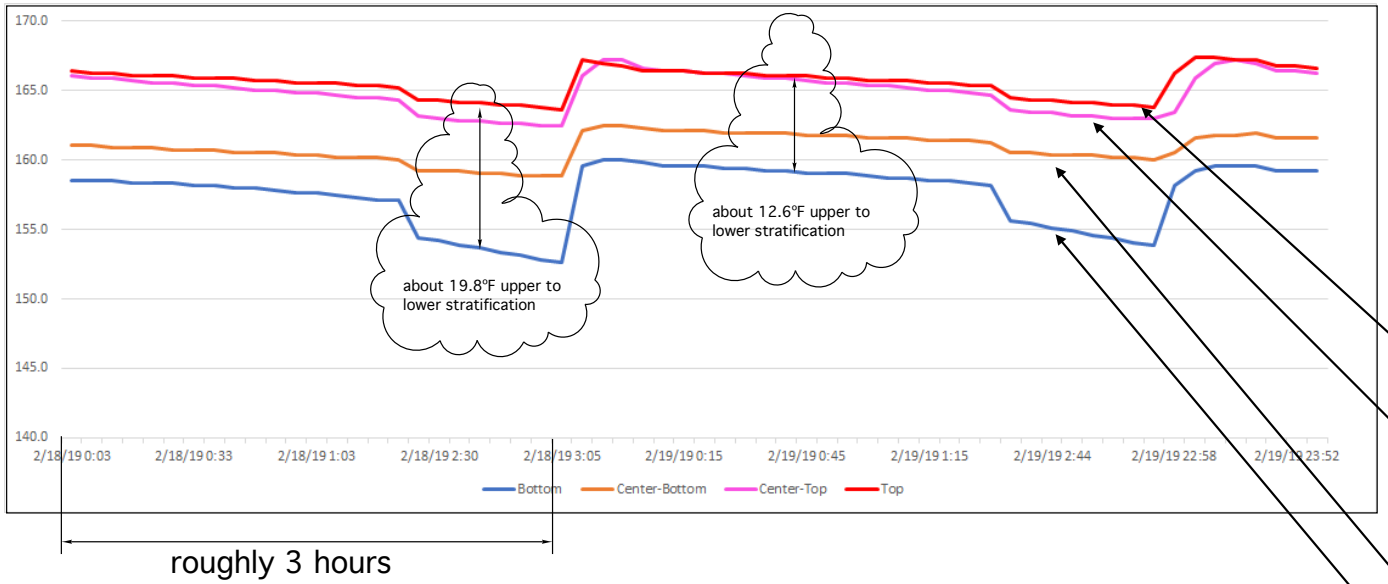


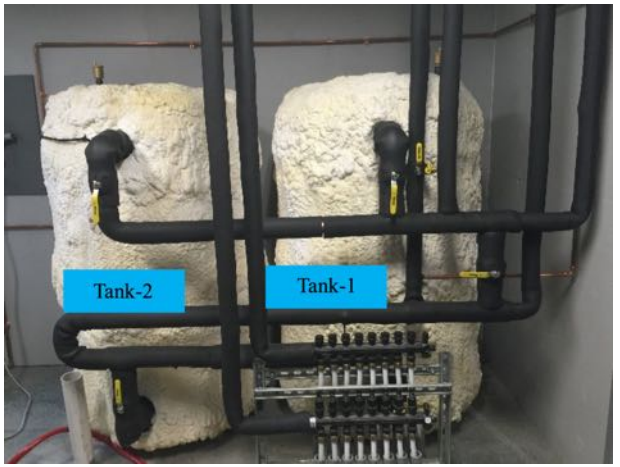
switch in one position routes (STU) & (STL) to boiler terminals
label this position as "tank sensors control pellet boiler"

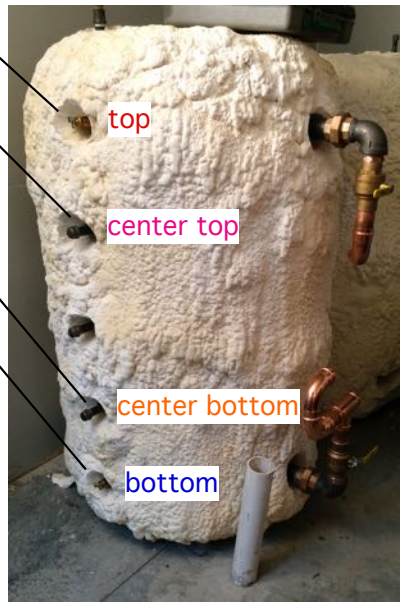
switch in other position routed (SZS2) & (SZS5) to boiler terminals
label this position as "strap on pipe sensors control pellet boiler"

Performance monitoring - temperature stratification & pellet boiler cycling over 10 days

- Top to bottom temperature stratification in thermal storage tank varies between about 20 ºF and 13 ºF

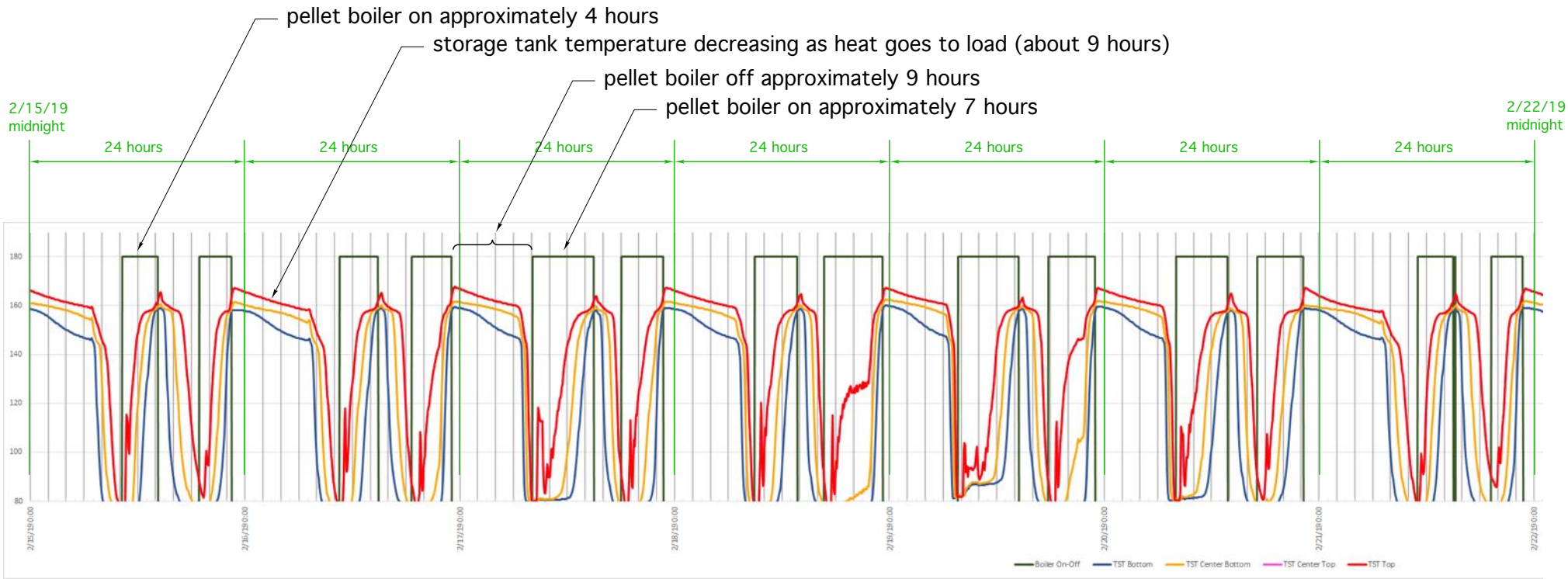






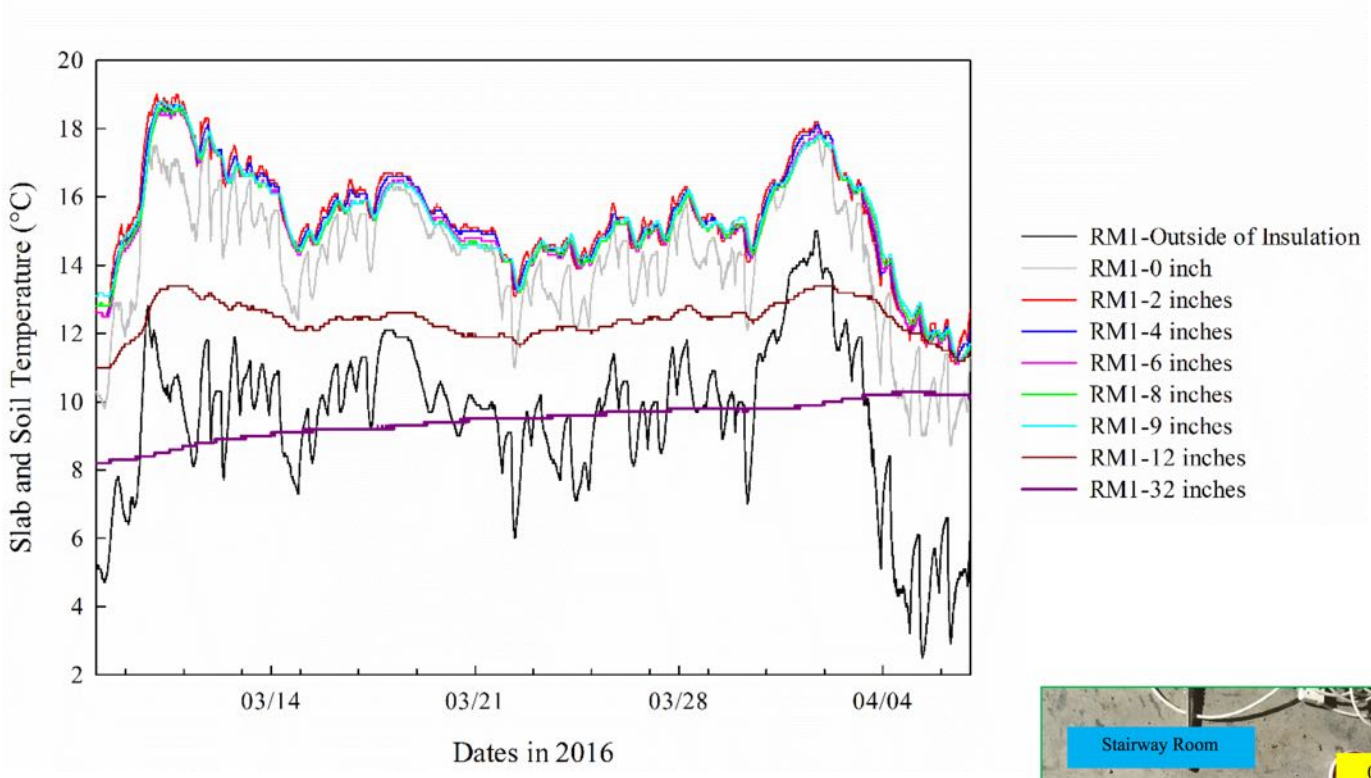
Performance monitoring - temperature stratification & pellet boiler cycling over 10 days

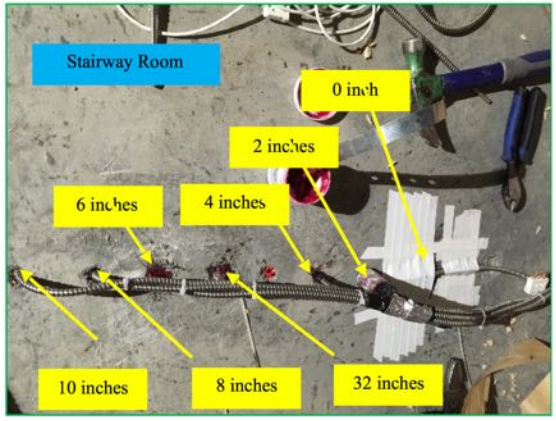
- Typically 2 pellet boiler cycles per day in mid-February
- Top to bottom temperature stratification in thermal storage tank varies between about 20 ºF and 13 ºF
- About 80ºF tank “draw down” during pellet boiler off cycle

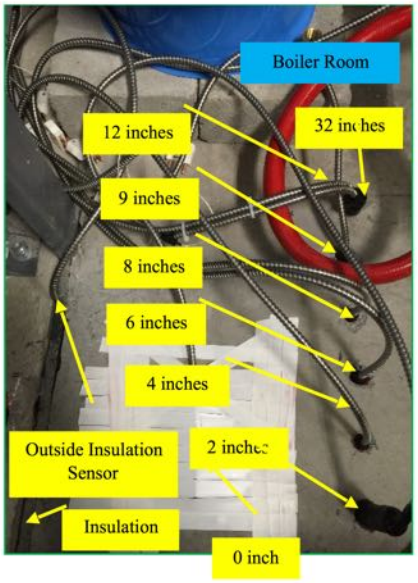


Thanks to Bob Fiorini (Hilltop Heating) for analysis of the data

Performance monitoring - floor heating temperatures







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="4">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="4">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="3">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>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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Future training opportunities

Watch the RHNY website for announcements of webinars and - hopefully - face-to-face training on biomass boiler system during 2021.

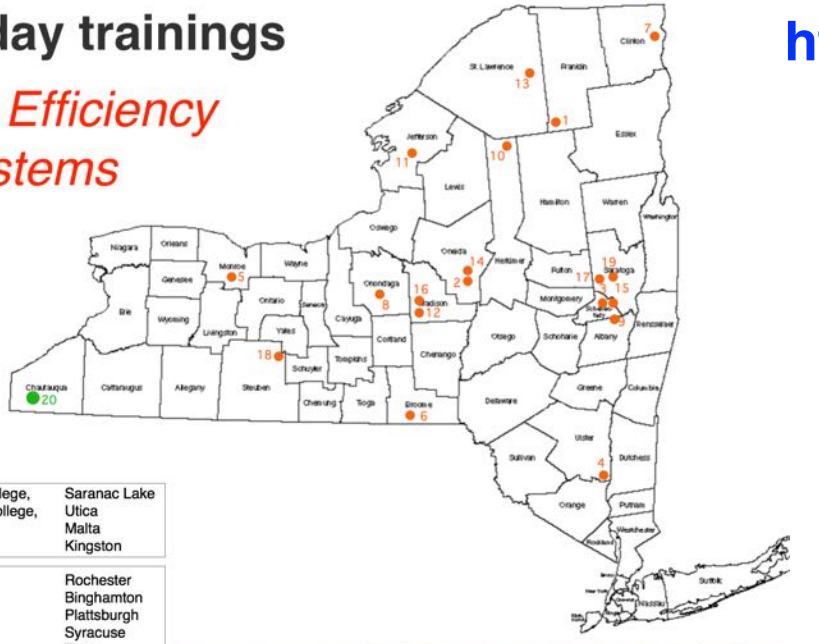
Locations of full day trainings

Hydronics for High Efficiency Biomass Boiler Systems

June 2014 - present

19 training sessions

Over 300 attendees



2014	June 19	North Country Community College,	Saranac Lake
	September 9	Mohawk Valley Community College,	Utica
	September 16	TEC-SMART	Malta
	November 20	Kingston, NY	Kingston
2015	February 19	Rochester, NY	Rochester
	April 8	Binghamton, NY	Binghamton
	May 20	Clinton Community College	Plattsburgh
	June 16	SUNY ESF	Syracuse
	September 17	Johnstone Supply	Troy
	October 15	Wild Center	Tupper Lake
2016	January 13	Jefferson Community College,	Watertown
	March 14	SUNY Morrisville,	Morrisville
	March 23	SUNY Canton,	Canton
	June 13	SUNY Polytechnic Institute,	Utica
2017	March 30	TEC-SMART,	Malta
	October 10	SUNY Morrisville,	Morrisville
	October 24	Clean Energy Economy Conference	Glens Falls
2018	March 30	Cornell Cooperative Extension,	Ithaca
	October 23	Clean Energy Economy Conference	Glens Falls

https://www.nyserda.ny.gov/All-Programs/Programs/Renewable-Heat-NY

QUESTIONS ?