

FCX Oil-Fired Condensing Boiler



CONDENSING BOILER TECHNOLOGY

**Principles involved, and why it offers
the
most efficient solution
in residential and commercial heating.**

**James Romersberger
Quintessence Corporation**

www.FCXalaska.com

Geminox – France's Leading Manufacturer of Steel Boilers
Part of Bosch Thermotechnik

<http://www.geminox.com/int/instit/instit.asp>

**Lucky Distributing – Exclusive importer of the Geminox FCX
Oil-Fired Condensing Boiler**

John Jansen – President & CEO
Bill McConaughy – Sales Alaska / Canada

**Quintessence Corporation – Fairbanks Master Dealer and
Tech Support**

Jim Romersberger – President
Special Technical Representative

Institutional

To get to know Bosch Thermotechnologie better



Bosch Thermotechnologie is currently the principal French constructor of steel boilers.

The Bosch Thermotechnologie Saint-Thégonnec plant, in Brittany, each year produces over 50,000 boilers, ensuring every phase on-site from conception through to fabrication, from the technical studies to the product assemblies.

Bosch Thermotechnologie exports every year to 12 different countries.

With more than 20 years of experience in the condensation domain, Bosch Thermotechnologie benefits from a universally recognized expertise in the most technologically progressive markets, due to its THRi and Docéane ranges of constant modulation gas condensation boilers.

At the cutting edge of new fabrication techniques, engaged in a rigorous quality approach, the products of Bosch Thermotechnologie offer a high degree of reliability and benefit from ISO 9001 certification.

This seminar is directed to:

- The Builders who want to provide the best for their clients.
- The Mechanical/Plumber who wants to understand the best options for their customers.
- The Home Owner/Builder who wants to learn why this is their best option.
- The retrofitter who needs to evaluate whether this is a solution to his needs.

Seminar Organization

1. Introduction
2. Breaks – About every hour, Pizza for lunch
3. Condensing Technology and Hydronics – how it works and why it is the most efficient choice
4. The FCX and DHW Tanks - Features and Benefits
5. Hydronics - Return Water, Tempering, Pumping, Heat Emitters, Injection Pumping, Baseboard, Handling the Condensate, Controls, Maintenance
6. Break, Coffee, Donuts, Hands on – examine the features discussed
7. New Construction, Retrofits, Testimonials, Warranty and Support
8. Venting/Stacks
9. Optimization
10. Website Tour, Hands on

Science of Condensing

How Heat is Recovered?

There are **Two Processes** by which heat is recovered from the burning of fuel.

Reduction of the burn temperature (sensible heat). Oil burns at about 4000° F, the stack temperature normally is about 350° F. Further reduction leads to the 2nd Process.

Recovering of the latent heat of vaporization (latent from the Greek root word meaning hidden). This is the condensing part.

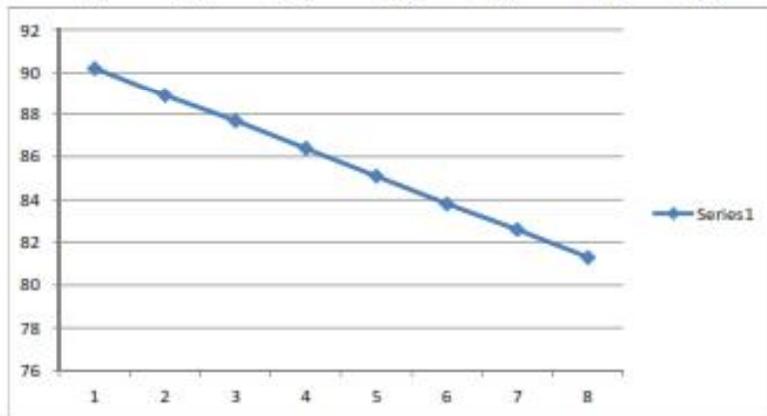
How does Lowering Stack Temperature Make for Greater Efficiency

<https://www.beckettcorp.com/support/tech-bulletins/a-practical-consideration-of-a-f-u-e-ratings-and-burner-adjustment/>

150	200	250	300	350	400	450
90.2	88.9	87.7	86.4	85.1	83.8	82.6
-1.3	-1.2	-1.3	-1.3	-1.3	-1.2	-1.3

NO. 2 FUEL OIL EFFICIENCY CHART

Net Stack Temp. °F



%O ₂	200	250	300	350	400	450	500	550	600	650	700	750	800	%CO ₂
1	89.6	88.4	87.3	86.2	85.1	84.0	82.9	81.7	80.6	79.5	78.4	77.3	76.2	14.7
2	89.4	88.2	87.0	85.9	84.7	83.6	82.4	81.2	80.1	78.9	77.7	76.6	75.4	14.0
3	89.2	87.9	86.7	85.5	84.3	83.1	81.9	80.7	79.4	78.2	77.0	75.8	74.6	13.2
4	88.9	87.7	86.4	85.1	83.8	82.6	81.3	80.0	78.7	77.5	76.2	74.9	73.6	12.5
5	88.7	87.3	86.0	84.6	83.3	82.0	80.6	79.3	77.9	76.6	75.3	73.9	72.6	11.7
6	88.4	87.0	85.5	84.1	82.7	81.3	79.9	78.5	77.0	75.6	74.2	72.8	71.4	11.0
7	88.0	86.5	85.0	83.5	82.0	80.5	79.0	77.5	76.0	74.5	73.0	71.5	70.0	10.3

FIGURE 2.

So, a Reduction of Stack temperature from 450F to 150F is...

$$90.2 - 82.6 = 7.6\%$$

Condensing Technology

What is Condensing?

The products of combustion consist primarily of CO₂ and Water Vapor.

Condensing refers to the cooling of the stack gasses to the point where the water vapor condenses into liquid. It does not refer to the water circulating in the boiler.

Condensing Technology

How does Condensing Make for Greater Efficiency?

- When water changes state from a gas to a liquid (goes from a gas at 212° to liquid at 212°), it gives off heat that is absorbed by the water in the boiler. Think of it as just the opposite of adding heat to make water boil.
- This process recovers the latent (hidden) heat of vaporization, takes place in the condenser, and is added back into the Boiler water.
- *The net result is greater efficiency.*

Condensing vs. Conventional

- Lower Temperatures
- Why is condensing bad for conventional boilers
- How and why condensing occurs

Condensing Technology

Added benefits

Lower Temperatures

Condensing boilers are defined by:

- Lower Stack Temperatures (80° to 175°)
- Lower water supply temperatures (100° to 120°)
- Lower water return temperatures (75° to 100°)

Non-condensing conventional boilers have stack temperatures of 350° to 500° F, and return water temperatures of about 130° F in order not to condense.

Any heat up the stack is LOST

Condensing Technology

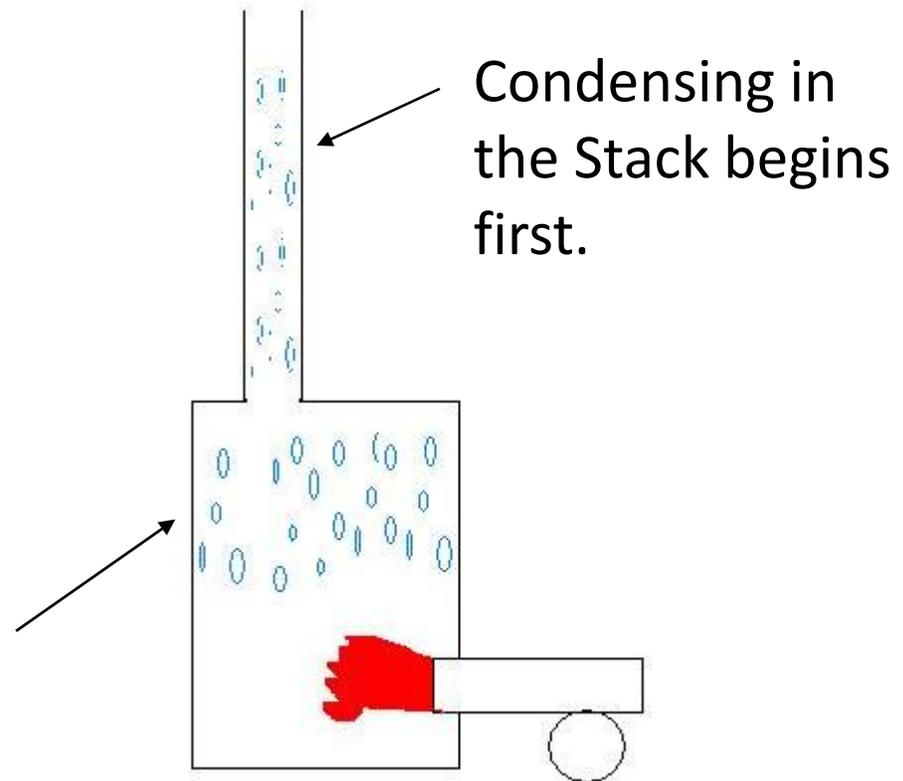
Why is Condensing Bad for Conventional Boilers?

- It's the nature of the condensate, it is slightly acidic.
- Measured values around Fairbanks are about pH 4.
- The stack can be destroyed in year or less, creating a fire hazard. Note that the stainless steel in Metalbestos types of stacks will also fail, because not all stainless steels are created equal.
- Life expectancy of the boiler will be greatly reduced.
- Conventional boilers are not designed to condense.

Causes for Condensing Conventional Boilers

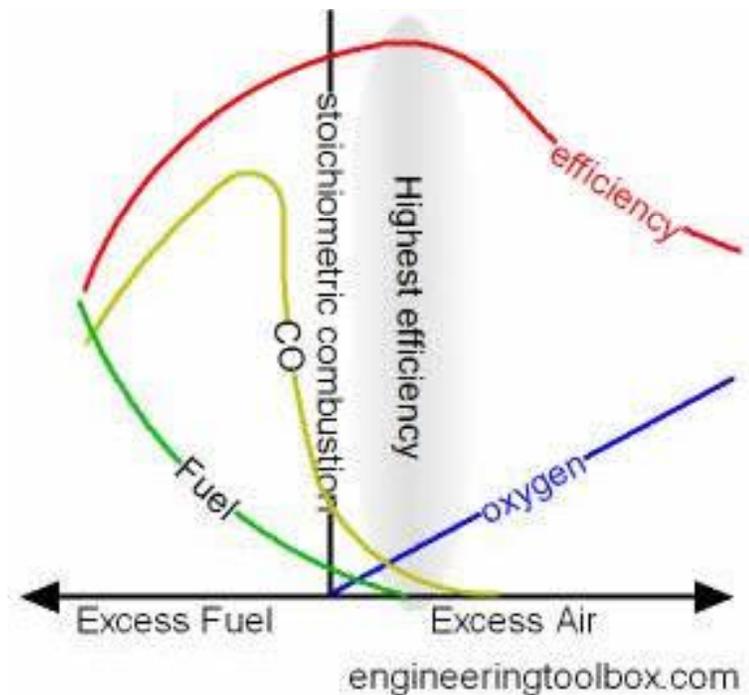
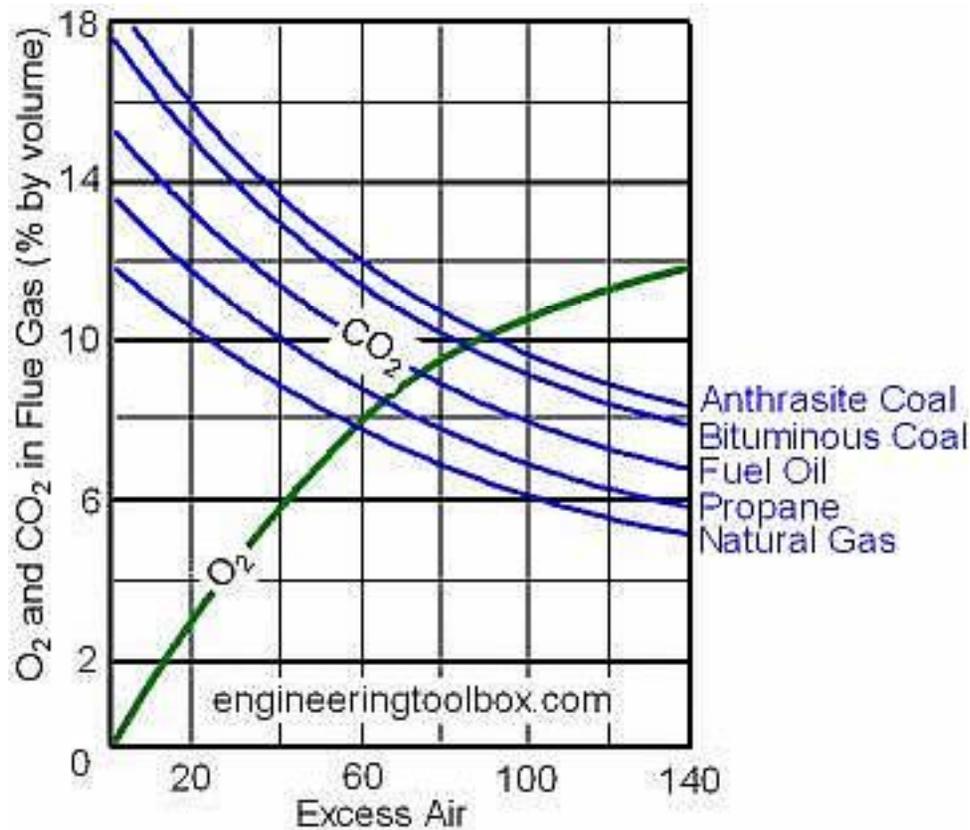
- Note that any boiler can be made to condense
- Causes
 - Under Firing
 - Improper installation
 - Too cool return water
 - Controls not set properly
 - Improper Tuning

Condensing in the Boiler can follow.

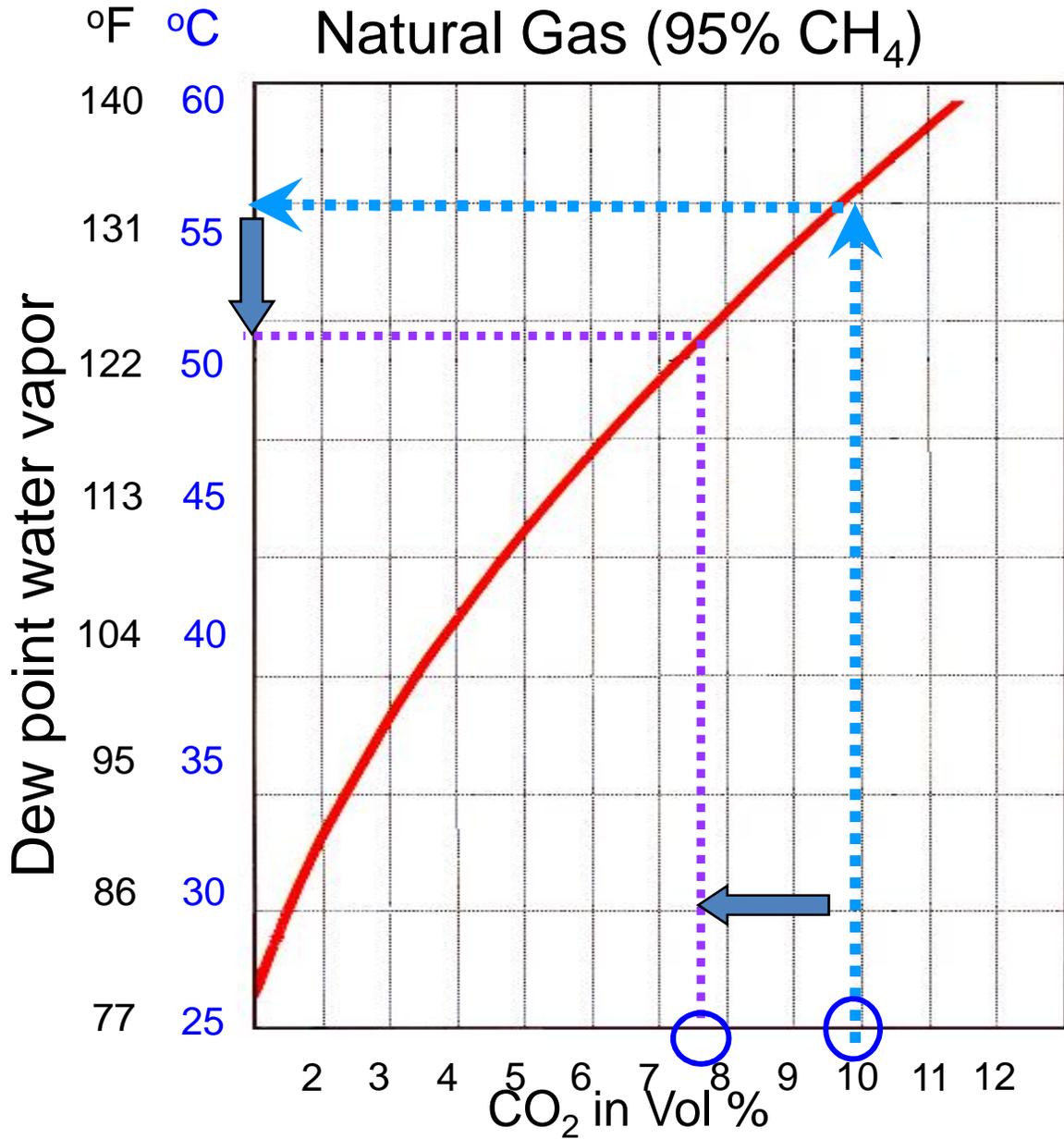


Condensing in a Boiler

CO₂ vs. Excess Air



WATER VAPOR DEW POINT



CO₂% of flue gas influences dew point temperature

Higher CO₂
= Higher Dew point
= More Condensation

Lower CO₂
= Lower Dew point
= Less Condensation

Some Interesting Observations

- Stack Temperatures vs. Boiler Design
- Insulated Stacks
- Conclusions

Condensing Technology

Conventional Boilers – a few FACTS

Fact – Any conventional boiler can be made 5% to 10% more efficient by making it condense. But if this is done, the acidic condensate will destroy them.

Fact – Conventional boilers are designed to run hotter in order not to condense. Efficiency is Secondary

Fact – The primary purpose of the very expensive insulated stove pipe is designed to hold the heat in so the flue gases won't condense.

Fact – The hotter the boiler, the less efficient it runs, and...

Any Heat up the Stack is LOST

Condensing Technology

Conclusions

Lower temperatures mean greater efficiency

Every degree you lower the stack temperature increases both the sensible heat recovery (*from lower stack temperatures*) and the latent heat recovery (*from the condensing effect*). Lowered temperatures are directly translated to \$\$\$ saved.

THE BOTTOM LINE

Any heat up the stack is LOST

Boiler Efficiency Comparisons

The Cheek Test

If You Dare

At the exhaust of the boiler, see how long you can hold your cheek on the stack.

**Hydronics
Unique
To
Condensing**

Hydronics – Unique to Condensing

Return Temperatures are KEY

- The key to greater efficiency
- Return water temperatures must be below 115°F, the threshold where condensing begins
- Brookhaven Laboratory study has confirmed this
- 100 °F or less out and 75 to 80 °F return works best
- 130 °F out and 110 °F provides some condensing

The single most important Principle in condensing boilers

So.....

****Do NOT Temper the Return Water****

The FCX is Immune to Boiler Shock

- No tempering circuits/valves
- No boiler circulation pumps
- No 4-way mixing etc.
- No Injection circulation loops
- No Buffer Tanks
- No Hydraulic Separators

The most important principle in condensing boilers



Mod cons, what's so unique?

Mod-con = modulating, condensing

Most modulate at a 5 to 1 rate,
a few 10-1 IBC for example 15,000 – 150,000 BTU/hr

Condensing mode leads to higher efficiencies,
Low return temperatures are the key

Convert the fuel to heat energy as efficiently as possible

Recover as much energy before the flue gases go out

Small footprint for the output





Future-proof hydronic systems

Low water temperatures are the key.

A tradeoff has always existed between the water temperature at which hydronic heat emitters are sized and their cost. The higher the supply water temperature assumed by the designer, the smaller the required heat emitters and the lower their installed cost. This is why the heat output tables on some baseboards did, and in some cases still do, list heat outputs at water temperatures all the way up to 240° F.

Although I've worked with hydronic heating for more than three decades and designed systems around just about every possible heat source, I would be hard-pressed to predict what might be available as hydronic heat sources 25 years from now. Fifty years from now I doubt that I will be predicting anything. Yet I hope that hydronic heating, in some form, will still exist and may even be the dominant method of heat delivery.

Think about it

By the latter half of the 20th century, the North American hydronics industry got used to the fact that some hydronic heat sources could last for several decades. It was not uncommon for a well-applied cast-iron boiler to have a useful life of 30 to 40 years. These boilers usually became technologically obsolete before they were incapable of operating due to some major failure. This was just fine when fuel prices were reasonably cheap and stable, and product development occurred at a somewhat slower pace compared to today. Back then, most Americans cared little about the "box in the basement," provided that it responded when the dial on the T-86 got turned up in the fall.

Today, some fuel costs are approaching 400% of what they were 15 years ago. Predictably, more consumers are now interested in what's happening within that box in the basement. Our industry

has responded with a wide spectrum of heat sources from boilers to heat pumps to solar collectors. Still, you won't find many manufacturers suggesting that these heat sources are likely to last more than 20 years.

To attain high thermal efficiency, most of these heat sources need to operate with low-temperature hydronic distribution systems. These include radiant floors, walls and ceilings, panel radiators or some of the newer low-temperature baseboard.

The hardware used in these distribution systems includes a wide range of polymer tubing (e.g., PEX, PEX-AL-PEX, PERT, PERT-AL-PERT, PP-R), as well as copper, steel and aluminum. Other materials used in site-built radiant panels include concrete, poured gypsum underlayment, foam insulation, fiberglass insulation and wood. When properly selected and installed, modern hydronic distribution systems made from these materials should last for many decades, perhaps even as long as the building they are installed in.

Planning ahead

So, based on expected life, it appears inevitable that most of the hydronic distribution systems currently being installed will be supplied by different heat sources over their useful life. This raises an obvious question: What can designers do today to ensure that the distribution systems they create are compatible with future heat sources?

The answer should consider the materials used in the system, how the system will be maintained and at what conditions the system will operate.

Regarding materials, most of the present-day polymer tubes, when applied at temperatures and pressures well-below their maximum ratings, should last upwards of 100 years. I've even heard

Low water
temperatures
are the key.

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Hitting a home run

Your solar combisystem will benefit from this easy-to-install heating system design.

After reading my Solar Design Notebook in **pme's** October issue, perhaps you formed an opinion about what's the "best" heat emitter for use with solar thermal collectors. That's fine, but remember no heat emitter can deliver optimal performance without an equally well-thought-out distribution system.

Although many potential piping layouts could serve your purpose, one stands out as the simplest, easiest to install and literally most flexible approach. I refer to it as a home-run distribution system. An example of such a system using panel radiators as heat emitters is shown in Figure 1.

> Figure 1.



Photo courtesy of Cobelli North America

Home-run distribution systems start with a manifold station. Usually it's the same type of manifold station that would be used in a radiant floor heating system. In Figure 1, the manifold station is shown in a recessed wall mounting. It also can be mounted horizontally under the floor provided it remains accessible.

Paired runs of 1/2-in. PEX or PEX-AL-PEX tubing provide the supply and return from the manifold station to each heat emitter. The flexibility of this tubing allows it to be routed through most framing cavities much like an electrical cable. This is particularly nice in a retrofit situation where the use of rigid tubing would otherwise require some "Sawzall surgery" to walls, ceilings, etc.

Figure 2 shows a home-run system in schematic form. It adds a thermal storage tank as the heat source and a variable-speed pressure-regulated circulator.

Variable-speed pressure-regulated circulators have been in use for more than a decade in Europe and are now available in North America from companies including Grundfos, Wilo, Taco and Xylem. These circulators all use microprocessor-controlled, electronically commutated motors that can operate over a wide range of speeds and in different control modes depending on the application.

For a home-run system, the circulator would be set to operate in a "constant differential pressure" mode. As such, it varies its speed whenever necessary to maintain a constant (installer-set) differential pressure between its inlet and outlet ports. The relationship between the pump curves at different speeds and the various system head loss curves (depending on which zones are active) is shown in Figure 3.

Notice how the yellow dots, which represent hydraulic equilibrium between a given system head loss curve and a given pump curve, all stay on the same horizontal line. This line represents the differential pressure across the manifold of a home-run circuit under design load conditions. Because these points stay on a horizontal line, the differential pressure across the manifold remains constant at this setting regardless of which zones are active. This ensures stable flow rates in all zones at all times.

At full speed, circulators with ECM motors operate on about 50% of the electrical wattage required by standard hydronic circulators of equal capacity. This characteristic, in combination with "intelligent" speed control, delivers annual electrical energy savings of 60% or higher relative to standard wet-rotor circulators. These circulators are quickly raising the performance bar in all types of hydronic systems. Their energy-saving characteristics make them particularly attractive for solar thermal applications where minimizing electrical energy use is a key design goal.

The combination of a home-run distribution system, heat emitters equipped with thermostatic radiator valves and a variable-speed pressure-regulated circulator is a simple yet elegant subsystem for pairing with solar thermal collectors, as well as an auxiliary boiler for those days when the sun isn't shining so brightly.

The thermostatic radiator valves shown on each panel radiator in Figure 2 constantly monitor the air temperature of the room in which the panel is located. If that temperature drops 1° F or more below the TRV's temperature setting, the valve's stem slowly begins

> Figure 2.



Courtesy of Smith Environmental Products

Making it happen

Hopefully you're now convinced that low water temperature distribution systems enhance the performance of solar thermal combisystems. My suggestion is to create your distribution systems so the supply water temperature under design load conditions doesn't exceed 120°F. With that in mind, let's look at some heat emitters that love to operate under these conditions.

First, it's critically important to understand what determines the water temperature in any hydronic distribution system.

Some designers, including an embarrassingly high percentage of HVAC professionals, think it's the heat source that controls the water temperature in a hydronic heating system. This notion stems from the fact many boilers come with a control device that has a dial (or perhaps digital interface) on which the installer "sets" a water temperature. Many think by setting this temperature they are "guaranteeing" the heat source will produce it. This is not the case. The set temperature is only a limit on how high the water temperature leaving the heat source might climb.

The water temperature in any hydronic distribution system only climbs high enough for that system to achieve thermal equilibrium — where the rate of heat release from the distribution system exactly balances the rate of heat input from the heat source. Once this condition is achieved, there is no "thermodynamic incentive" for the water temperature to climb higher, and it won't!

It's the design of the hydronic distribution system, including the selection and sizing of the heat emitters, that determines the water temperature at which the system will operate.

Anyone who designs a heating system wants to maximize its thermal efficiency. Today, that means moving away from high water temperatures by specifying heat emitters with larger active surfaces, or other details that increase both convective and radiative heat transfer. This allows thermal equilibrium to occur at relatively low water temperatures during both maximum load and partial load conditions.

Emitter evolution

There are several ways to design modern hydronic distribution systems around the low water temperatures that enhance the performance of renewable energy heat sources.

Let's start with the heat emitters. That term refers to any device intended to remove heat from water flowing through it and release that heat into the room where it is located.

Many building owners in heating-dominated climates are used to the look of fin-tube baseboard. While most don't relish it as a visual enhancement of the room, they understand its purpose and accept it as a necessary part of the building.

The latest development in low temperature fin-tube baseboard is shown in Figure 2 with a product called Heating Edge that is currently made in the UK, but available in North America.

From the outside it looks very similar to other fin-tube baseboard, but what's "under the hood" is very different. Heating Edge baseboard has much larger fins than traditional baseboard. The fin area is about three times larger, almost filling the entire space within the enclosure. It also has two 3/4-in. copper tubes running through those fins. The tubes can be piped either for parallel flow or in series. In the latter case, the hottest water flows down the upper tube, makes a U-turn at the end and flows back along the lower tube.

Assuming an average water temperature of 110°F, this baseboard releases about 290 Btu/hr./ft., when the two pipes are configured for parallel flow and the total flow rate through the element is 1 gpm (0.5 gpm through each tube). This increases to about 345 Btu/hr./ft., with a total flow rate of 4 gpm (e.g. 2 gpm per tube). If the two tubes are configured for series flow (hot along top and return along bottom), the output at 1-gpm flow rate drops about 10%.

Consider a 12-ft. by 16-ft. room in a well-insulated home with a maximum heating load of 15 Btu/hr./ft.² The room's maximum heating load is thus 2,880 Btu/hr. This could be handled by a 10-ft. length of Heating Edge baseboard operating at an average water temperature of 110°F and 1-gpm flow rate. To produce equivalent output, a 10-ft. length of conventional residential baseboard would require an average water temperature of about 150°F. The latter temperature would dramatically lower the efficiency of solar thermal collectors.

Radiant panel solutions

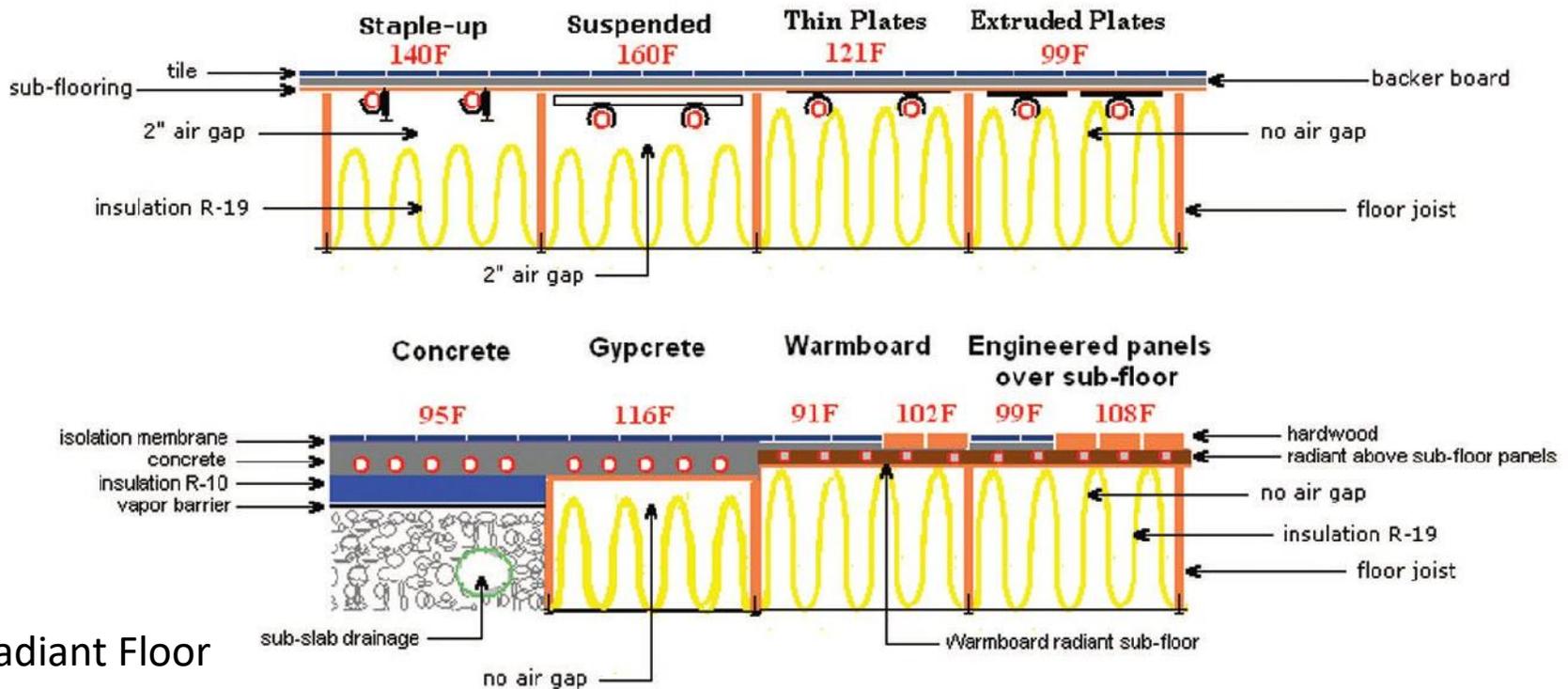
The key to achieving low water temperature operation is using heat emitters with large heated surface areas. The greater the heated surface area, the lower the required water temperature for a given rate of heat output.

By embedding tubing in floors, walls and ceilings, it's possible to create very large heat surfaces within a room. Radiant floor heating is undoubtedly the best-known form of radiant panel heating. It can be installed in several proven ways that allow it to operate at relatively low water temperatures.

Typical Floor Types

The Major Factor: "The lower the systems temperature requirements, the better the overall system-wide efficiency, which will ensure the lowest possible operating costs for fuel and power." [and the Most Condensing and Lowest Stack Temperatures]

Water temperatures required to meet the required 80F floor surface temperature.



HYDRONIC SYSTEMS

A PERFECT MARRIAGE

Comfort and economy of operation are linked with well-designed and properly installed hydronic radiant floor systems.

Providing thermal comfort by transferring energy from point-of-source to point-of-use in hydronic (water-based) systems is achieved by a wide variety of radiant-floor installation methods and each requires varying degrees of water temperature to deliver the same results. The radiant floor temperature boundary for human comfort revolves around maintaining a floor surface temperature below 85° F.

The human body loses heat in four basic ways: radiantly (your body radiates heat); convectively (air currents); conductively (direct contact — barefoot on an unheated tile floor); and perspiration (latent heat of evaporation). Skin surface temperature averages 85°. A floor surface temperature above 85° upsets the balance between the four and will cause people to be uncomfortably warm.

A general misconception about radiant floor warming is that the 85° design limitation was required to protect hardwood flooring. If that was true, hardwood floors heated to well above 100° while baking in direct

solar gain would be easily and permanently damaged!

Radiant floors are often a perfect marriage with all types of hardwood floor coverings and all available floor surface materials are compatible with hydronic radiant heating. Modern hydronic radiant design programs provide the system designer with the ability to "install" virtually any type of floor covering over the radiant floor panel, which provides an ability to determine compatibility and the required water delivery temperatures to offset the heat loss.

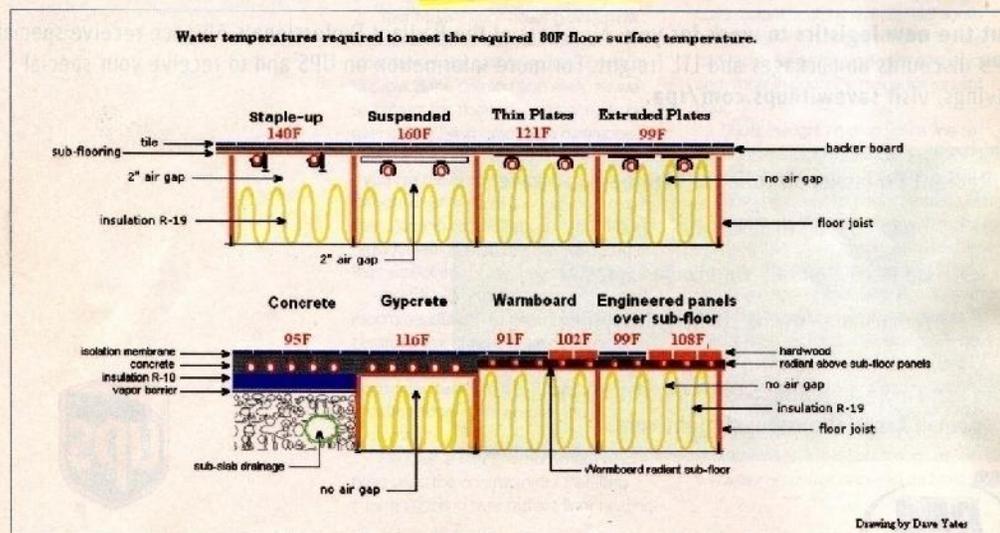
It is not unusual for room-by-room designs to require a wide variety of water delivery temperatures. Numerous reliable methods are available to precisely control multiple-temperature delivery from a single-temperature source or from blended systems where multiple- and varying-temperature energy sources are incorporated.

Comfort and economy of operation are inexorably linked with well-designed and installed hydronic radiant floor systems. Low-temperature designs offer

the greatest opportunity to blend a wide variety of energy sources, maintain peak operating efficiencies (especially true for geothermal or air-to-water heat pumps), and to incorporate alternative energy sources such as wind, solar photovoltaic and solar thermal. The lower the system's temperature requirements, the better the overall system-wide efficiency, which will ensure the lowest possible operating costs for fuel and power.

The majority of hydronic radiant systems, certainly the better-designed ones, will employ a control strategy that will alter water temperature based upon whatever Mother Nature is giving us outside. The building's heat loss will be greater as outdoor air temperatures fall. Conversely, system water delivery temperature will be increased to transport more comfort-energy to the radiant floors — the colder it gets outdoors, the hotter the water.

How hot depends on the installation method used for the floors, the materials between the radiant tubing and/or panels and the room served, the desired

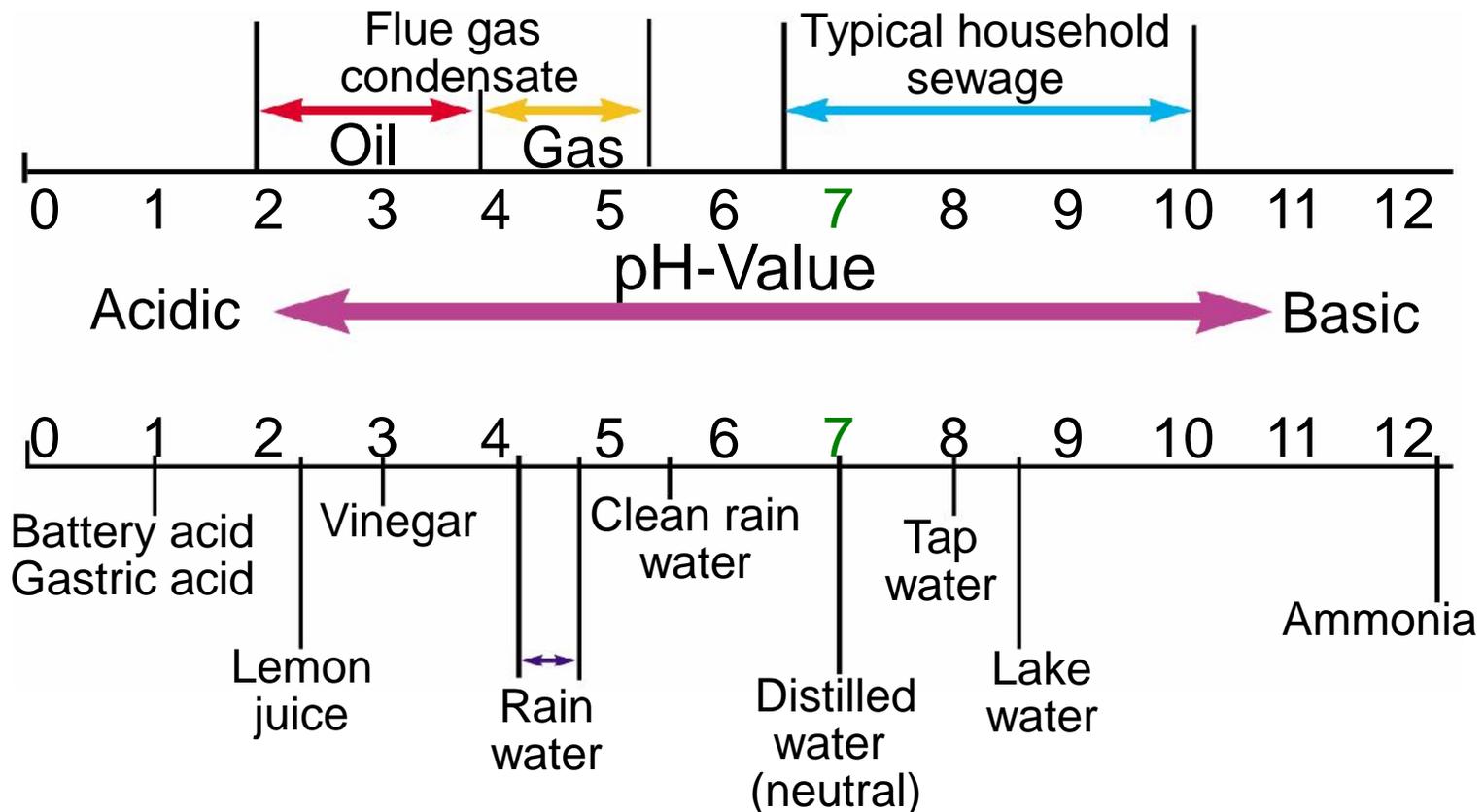


Handling the Condensate

Handling the Condensate

pH VALUES OF VARIOUS FLUIDS

Condensate – the NON-Issue



Handling the Condensate

Actual Measurements
after several months
indicate a ph level of 7.0
Neutral.

Unless required by code
this is not really
necessary.

Covered in the Geminox
Manual.



Twin Boilers - Lifewater Shop, Office, & Appts - 8000 SF



Handling the Condensate

Neutralization and Disposal

- **Neutralization**
 - Traps - how to do it
 - Is it necessary?
- **Disposal**
 - Down the drain
 - Pump it away
 - Cold drains



The FCX Oil-Fired Condensing Boiler



**92-97%
Efficient**

The Most Efficient Oil-Fired Boiler

FCX – Defined

**All BOILERS in Alaska are required to be
UL 726 certified**

Is the FCX UL 726 ASME Certified?

NO

**The FCX is UL 732 Certified
And is Exempt**

2016 Alaska Statutes

Title 18 - HEALTH, SAFETY, HOUSING, HUMAN RIGHTS, AND PUBLIC DEFENDER

Chapter 18.60 - SAFETY

Article 03 - BOILERS

Sec. 18.60.180 Regulations.

Sec. 18.60.190 Effect of regulations.

Sec. 18.60.200 New boilers and unfired pressure vessels.

Sec. 18.60.210 Exemptions.

Sec. 18.60.220 Duties of the Department of Labor and Workforce Development.

Sec. 18.60.230 Appointment of deputy inspectors.

Sec. 18.60.235 Approved inspectors.

Sec. 18.60.240 Appointment and qualifications of special inspectors.

Sec. 18.60.250 Compensation for special inspectors prohibited.

Sec. 18.60.260 Duty of special inspectors.

Sec. 18.60.270 Report of inspection.

Sec. 18.60.280 Right of inspection.

Sec. 18.60.290 Examination for deputy and special inspectors.

Sec. 18.60.300 Revocation or suspension of state commission.8.60.210

Sec. 18.60.310 Replacement of lost or destroyed certificate or commission.

Sec. 18.60.315 Inspection standards.

Sec. 18.60.320 Inspection of boilers and unfired pressure vessels.

Sec. 18.60.330 Rules of inspection.

Sec. 18.60.340 Inspection certificates.

Sec. 18.60.350 Suspension of inspection certificate.

Sec. 18.60.360 Inspection fees.

Sec. 18.60.370 Appeals.

Sec. 18.60.380 Creation of boiler fund. [Repealed, Sec. 3 ch 29 SLA 1968].

Sec. 18.60.390 Inspection certificate required; penalty.

Sec. 18.60.395 Licensing of boiler operators; fees.

Sec. 18.60.210.Exemptions

AS 18.60.210. Exemptions.

•AS [18.60.180](#) - [18.60.390](#) do not apply to the following:

[Items (1) thru (8) not shown to save space and because not pertinent.]

(9) automatic utility hot water heaters that are used for space heating using the potable system, if the hot water heater

(A) is equipped with a safety relief valve and operational controls required by the latest Boiler Construction Code published by the American Society of Mechanical Engineers that has been adopted by the Department of Labor and Workforce Development under AS [18.60.180](#) ;

(B) contains only water;

(C) does not exceed 120 gallons in capacity, a water temperature of 210 degrees Fahrenheit, a pressure of 150 pounds of square inch gauge pressure, or a heat input of more than 200,000 BTU an hour; and

(D) contains a tempering valve that will regulate the outlet domestic water temperature at not more than 140 degrees Fahrenheit.

(b) The following boilers and unfired pressure vessels are exempt from the requirements of AS [18.60.320](#) - [18.60.360](#):

(1) boilers and unfired pressure vessels located on farms and used solely for agricultural purposes;

(2) steam and hot water heating boilers, used exclusively for heating purposes, that are located in private residences or in apartment houses of fewer than six families;

[Item (4) thru (6) not shown]

8 AAC 80.900. Definitions

(a) In this chapter and in AS 18.60.180 - 18.60.395, unless the context requires otherwise

(20) "automatic utility hot water heater," as used in AS18.60.210 (a)(9), means a potable hot water heater

How are Water Heaters Defined

IMC 1002 - 2015
SECTION 1002
WATER HEATERS

1002.1 General. Potable water heaters and hot water storage tanks shall be listed and labeled and installed in accordance with the manufacturer's instructions, the *International Plumbing Code* and this code, All water heaters shall be capable of being removed without first removing a permanent portion of the building structure. The potable water connections and relief valves for all water heaters shall conform to the requirements of the *International Plumbing Code*. Domestic electric water heaters shall comply with UL 174 or UL

1453, Commercial electric water heaters shall comply with UL 1453, **Oil-fired water heaters shall comply with UL 732.** Solid-fuel-fired water heaters shall comply with UL 2523, Thermal solar water heaters shall comply with Chapter 14 and UL 174 or UL 1453.

1002.2 Water heaters utilized for space heating. **Water heaters utilized both to supply potable hot water and provide hot water for space-heating applications shall be *listed* and *labeled* for such applications by the manufacturer and shall be installed in accordance with the manufacturer's instructions and the *International Plumbing Code*.**

Features & Benefits

The FCX Boiler

Features and Benefits - 1

- Small footprint, attractive, very quiet
- Two sizes 76 Kbtu and 104 Kbtu Output
- Riello Burners – the most reliable name in the Industry
 - High pressure pump
 - In-line oil heater
 - Dual air adjustments – coarse & fine
 - Blocked vent safety

The FCX Boiler

Features and Benefits -2

- **Built-in features:**

- Expansion tank
- Mixing valve
- Grundfos pump
- Plug and play to your manifolds.

- **Two Temperature circuits**

- Mixed for low temperature radiant
- High temperature that does not contaminate the cooler return water with the hot return water.
- The advantage of a separate secondary condenser

The FCX Boiler

Features and Benefits - 3

- Stack: Less expensive, easily worked plastic, many options
- Additional standard safeties not required for residential boilers
 - High water temperature safety
 - High stack temperature safety
 - SPDT switches on above safeties for add on alarms
- Built for radiant heat, but can work with baseboard
- Close technical support to the designer, installer, and servicer
- Comprehensive Installation Manual

The FCX Boiler

Features and Benefits - 4

- **Efficiency & Fuel Savings**
- **Savings you can expect replacing a conventional boiler**

30% to over 50%

What about gas conversion?

Heat Transfer and the FCX

How it works

Counter Flow vs. Parallel Flow



[In Parallel Flow] "...the temperature of the cold fluid exiting the heat exchanger never exceeds the lowest temperature of the hot fluid [gases]. This relationship is a distinct disadvantage if the design purpose is to raise the temperature of the cold fluid."

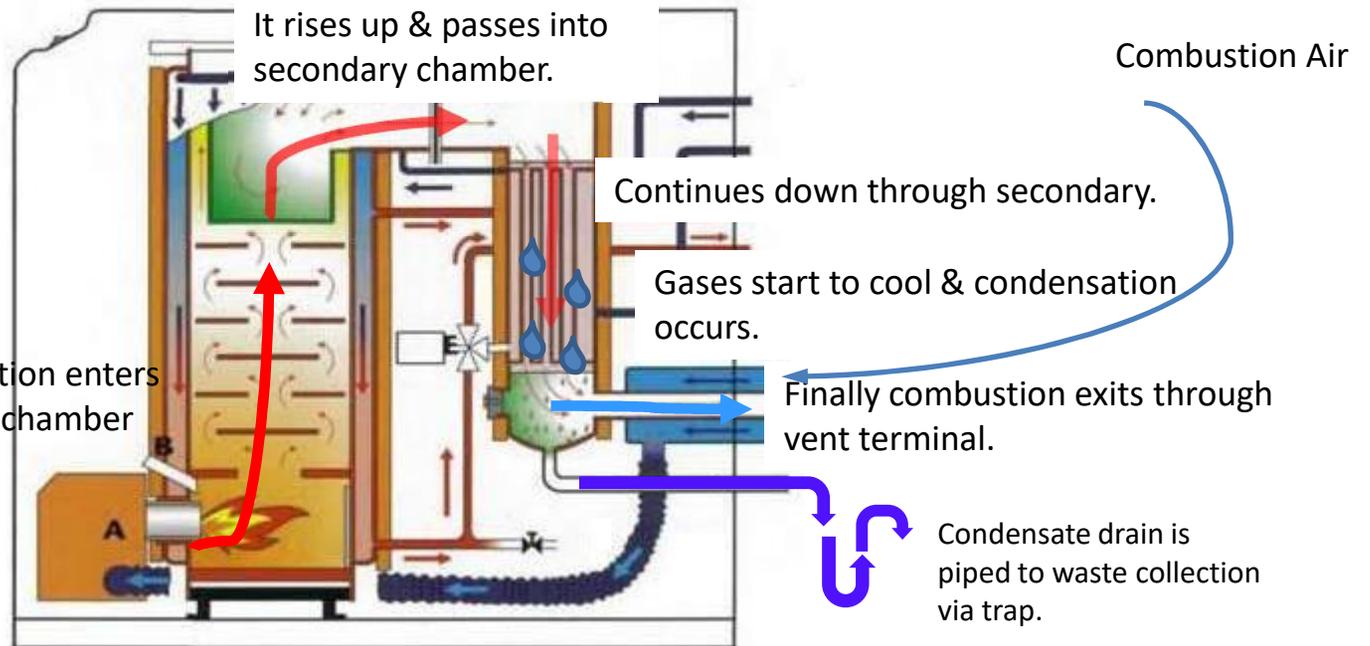


http://www.engineersedge.com/heat_transfer/parallel_counter_flow_designs.htm

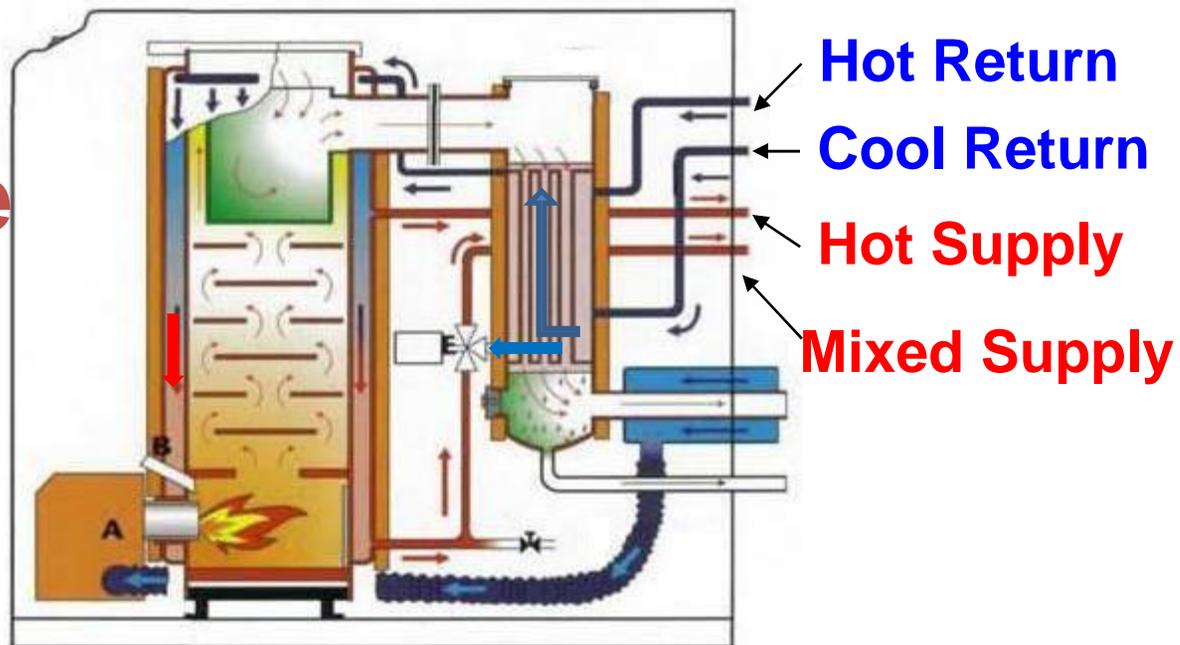
Counter Flow Heat Exchange

Combustion Gas Flow →

Combustion enters primary chamber

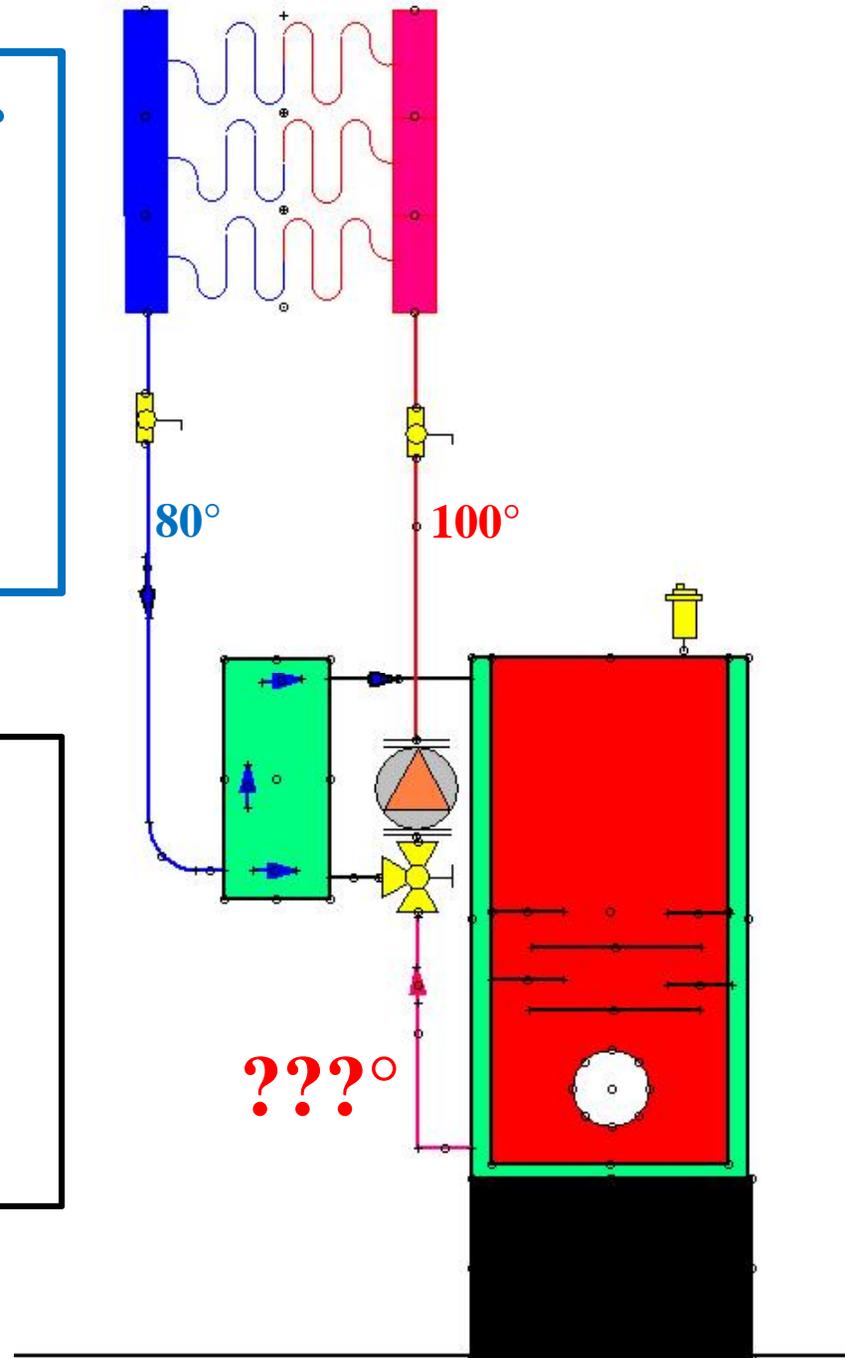


Water Flow →



The Effects of Boiler Temperature on Mixing Efficiencies

Supply Target 100°
Return Temp 80°
Boiler Supply 160° vs. 120°



Compare

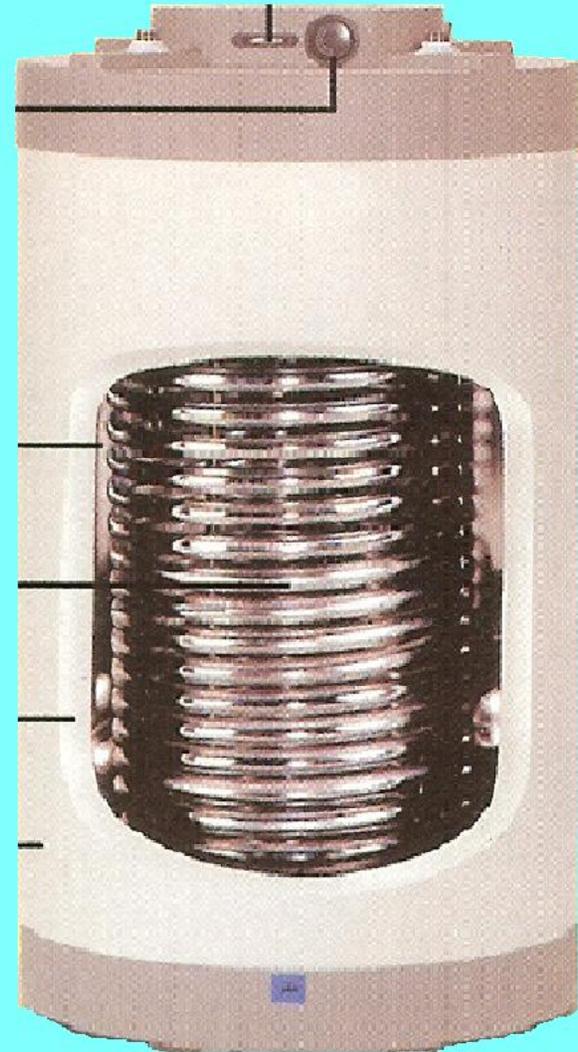
$$[120 - 100] / (120 - 80) = 20 / 40 = 50\%$$

$$[160 - 100] / (160 - 80) = 60 / 80 = 75\%$$

DHW

DWH Tanks

- Sizes Available
 - 25, 40, 50, & 80 Gallon
- Thermometer
- Aquastat
- 100% 316 L Stainless Steel
- Special connection for hot recirculation
- Built for low temperature boilers
- Comparison of recovery rates & Sizing
- Works on 120-130° water



Venting

- Stack temperatures are so low that plastic is used.
- Zero Clearance to Combustibles.
- Huge Savings in both Materials & Labor



Warranty & Support

10 Years for Heat Exchangers and DHW Tanks

2 years on other parts

2 year Riello warranty

Comprehensive installation manual

Close technical support for the designer, installer, and serviceman

Fairbanks – Initial setup and tuning included

Application

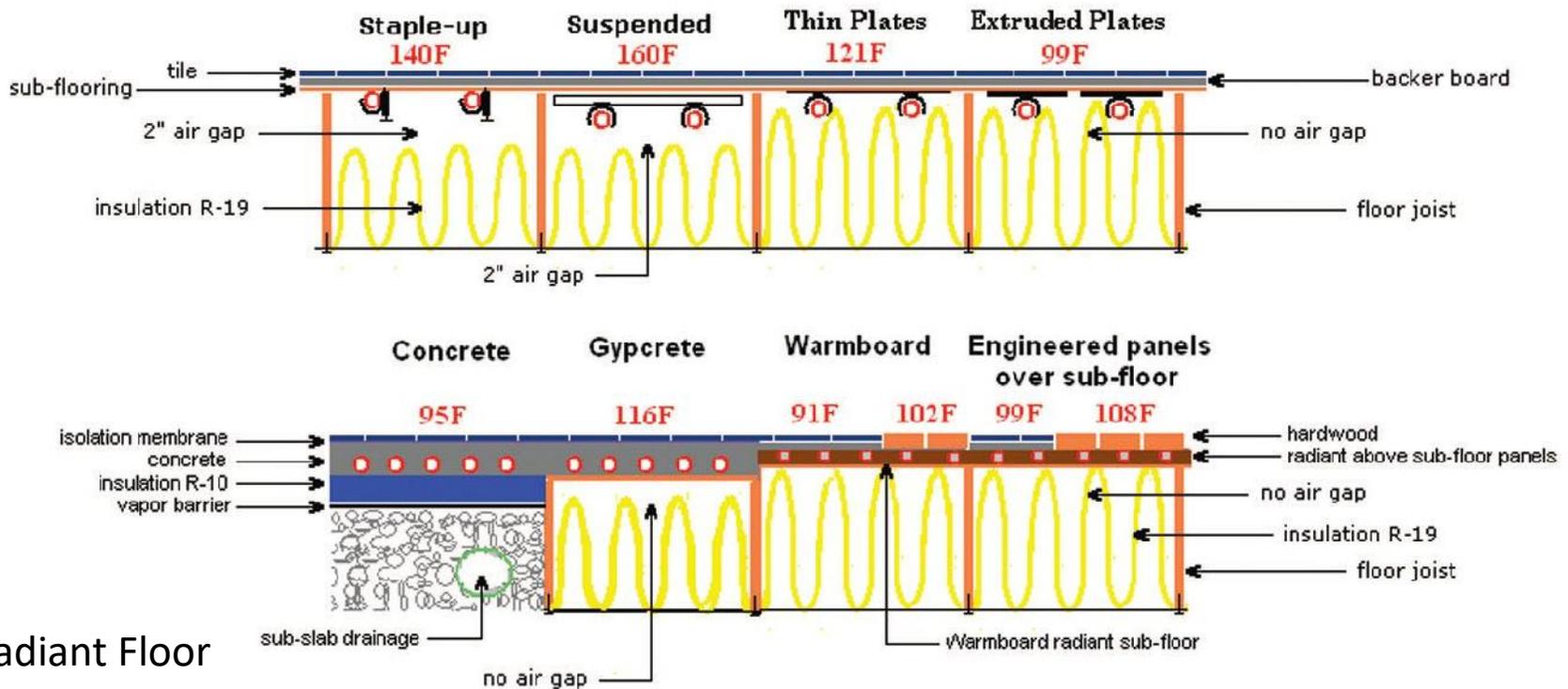
New Construction

- No Brainer

Typical Floor Types

The Major Factor: "The lower the systems temperature requirements, the better the overall system-wide efficiency, which will ensure the lowest possible operating costs for fuel and power." [and the Most Condensing and Lowest Stack Temperatures]

Water temperatures required to meet the required 80F floor surface temperature.



What Every New System Should Have

- **A Condensing Boiler**
- **Radiant Floors or Low Temperature Emitters (example Heating Edge, Eco Panels, etc.)**
- **Controls that allow the boiler to go cold when there is no call for heat**
- **Smart Pump (ECM/VFD) that can control flow and/or temperature**

Retrofits

Options & Limitations

Considerations:

- Is the boiler big enough?
- Can you extract adequate heat from the boiler at lower temperatures?
- Auxiliary heat sources
- Old construction radiant – it will generally work if high mass, not with staple-up
- Can you use lower water temperatures

Factors Affecting the Need for High Water Temperatures

Factors:

- Poor insulation
- Bad Windows
- Air Leaks
- Few heat emitters
- Location – Hills or Holes

Heat Emitters and Controls

The more you have the lower the water temperature needed, thus the lower the return water Temperature.

And the better the controls, the more Efficient.

**The most
important thing is
return water
temps so...how do
we do it?**



Testimonials & Examples

Proof Positive Boiler Comparisons

30% to 50% Savings

How Can This Be?

Why do Actual Results Differ with AFUE

Standby

- Drafting through the boiler
- Jacket Losses
- Damper Loses
- Over Sizing

Operating

- Short Cycling
- High Stack Temperatures – 1.3% per every 50 degree drop
- Tuning - AFUE vs. Actual – under/over Performing, CO₂, Excess Air, Stack Temps
- Boiler Temperatures - 1% loss per 10 degree
- Return Water Temperatures
- Condensing Effect
- Cold Starting
- Side Arms

A Practical Consideration Of A.F.U.E. Ratings And Burner Adjustment

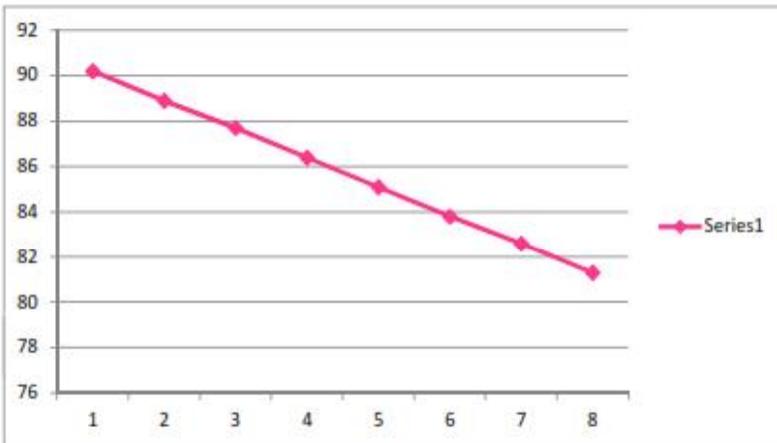
<https://www.beckettcorp.com/support/tech-bulletins/a-practical-consideration-of-a-f-u-e-ratings-and-burner-adjustment>,

Reducing stack temperatures from 450 to 150 will result in an increase in efficiencies of 7.6 %

150	200	250	300	350	400	450	500
90.2	88.9	87.7	86.4	85.1	83.8	82.6	81.3
-1.3	-1.2	-1.3	-1.3	-1.3	-1.2	-1.3	

NO. 2 FUEL OIL EFFICIENCY CHART

Net Stack Temp. °F



%O ₂	200	250	300	350	400	450	500	550	600	650	700	750	800	%CO ₂
1	89.6	88.4	87.3	86.2	85.1	84.0	82.9	81.7	80.6	79.5	78.4	77.3	76.2	14.7
2	89.4	88.2	87.0	85.9	84.7	83.6	82.4	81.2	80.1	78.9	77.7	76.6	75.4	14.0
3	89.2	87.9	86.7	85.5	84.3	83.1	81.9	80.7	79.4	78.2	77.0	75.8	74.6	13.2
4	88.9	87.7	86.4	85.1	83.8	82.6	81.3	80.0	78.7	77.5	76.2	74.9	73.6	12.5
5	88.7	87.3	86.0	84.6	83.3	82.0	80.6	79.3	77.9	76.6	75.3	73.9	72.6	11.7
6	88.4	87.0	85.5	84.1	82.7	81.3	79.9	78.5	77.0	75.6	74.2	72.8	71.4	11.0
7	88.0	86.5	85.0	83.5	82.0	80.5	79.0	77.5	76.0	74.5	73.0	71.5	70.0	10.3

FIGURE 2.

Quotes from Becket:

If the burner is set up at the 13.0% CO₂ and No. 1 smoke level, which gives the highest steady-state efficiency in the above example, operating problems could result.

Experienced contractors view the A.F.U.E. ratings as a valuable tool for comparison purposes, but they do not attempt to set the burner to operate at the CO₂ and smoke levels that were used in the D.O.E. controlled Laboratory procedures.

Tim Sonnenberg, owner of TS Construction, believes the only way to really compare efficiency is to simultaneously install boilers in identical structures in similar places. This he has done using the FCX, Viessmann, and Buderus. All three are duplexes of about 3700 to 3800 SF structures. The results:

Tim says, “The FCX significantly outperforms every boiler I have installed. **In similar time frames in the winter of 2012, the Buderus used an average 6.89 GPD, the Viessmann 5.88 GPD, and the FCX 4.27 GPD ***. This calculates to a savings advantage of 1.61 GPD over the Viessmann and a 2.62 GPD over the Buderus. **Not only that, percentage-wise, the Viessmann used 38% more fuel than the FCX, and the Buderus used over 60% more fuel than the FCX.**

The results in my shop are as good. Even when I expanded my shop by 1,400 SF, with 16-foot walls to 6,000 SF, replacing my existing boiler reduced my fuel consumption by 19%.

Additionally, the simplicity of installation due to built-in features and inexpensive zero clearance plastic for the stack, drastically reduces labor, making this the most competitive choice. Based on fuel savings I am considering removing my other boilers and replacing them with FCX’s”



Baseboard Home #1

My Home:

- 3,000 SF heated, 2,000 shop and basement built into a hill, with residual heat only
- 2x8 walls with blown-in fiberglass, and triple pane windows, 1000 ft elevation
- 108 ft baseboard, no radiant, no unit heaters, pumping 120 to 130 °F water
- All return water goes through a DHW heat exchanger gets 10 °F temperature
- 35 ft x 4 inch plastic stack serves as stack robber, 80 to 120 °F exit flue temperature, depending on burn cycle
- Bacharach measurements: at boiler 91.5%, at top of 3rd floor exit 96%
- 53 gallon Burnham DHW indirect heater on Zone no priority – never out of hot water
- House Heat Recovery – adequate, no setback used



Baseboard Home #2

Chris Swaim:

- 1,545 SF + 900 SF Garage, all heated
- 2 x 6 walls with fiberglass batts, double pane windows, 650 ft elevation
- 151 ft baseboard, no radiant, unit heater in garage
- 4 inch plastic stack retrofitted in a 8" metalbestos stack
- FCX 22 pumping 120 °F to 150 °F water
- Geminox BS50 DHW indirect heater on separate pump – never out of hot water
- Grundfos Alpha on baseboard
- House Heat Recovery – No setback used, increases temperature manually when needed
- Plans to install radiant in sunken living room
- Reduced fuel consumption by 50%



Baseboard Home #3

Flory and Cathy Shalk:

- 2,400 SF 800 SF per level, 2 story living, 800 SF crawl space all heated
- 2 x 6 walls with fiberglass batts, and double pane windows, 950 ft elevation
- 126 ft baseboard, no radiant, no garage
- Concentric sidewall vented
- FCX 22 pumping 120 °F to 140 °F water
- Geminox BS50 DHW indirect heater on separate pump
- Taco Bumble Bee pump on baseboard
- House Heat Recovery – No setback used



A Case For Multi-Heaters

Bob Tsigonis:

- 4000 SF 100% actively heated
- 12” (2 x 4 offset, 12 “ fiberglass) walls with blown-in fiberglass, and triple pane windows.
- Radiant basement, garage, entryway. Baseboard in lower bedrooms, forced air for main living area, unit heater in garage.
- FCX 30 boiler running temperature 130 °F
- 4 inch plastic stack retrofitted in a 8” metalbestos stack
- DHW indirect heater on Zone, no priority – never out of hot water
- House Heat Recovery – good

Before and After



Buckland

Insulated foam raft foundation, integrated truss combines floor, walls and roof into a single piece for easy framing, polyurethane spray foam, diagonal ridge roof, metal siding.



FCX 22 and 25 gal indirect DHW

Heating coil located in air handler, HRV provides delivery to rooms. By design, no heat can be provided unless HRV is in operation.



Habit for Humanity - Baseboard



Habit for Humanity - Baseboard



**Design
&
Installation**

**The most
important thing is
return water
temps so...how do
we do it?**

The Ill Effects of Hydraulic Separation **What not to do!!**



Pay Attention to Piping Details

Hydraulic separation is provided by
The closely spaced tees and the large pipe size

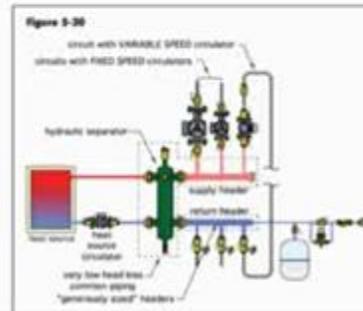
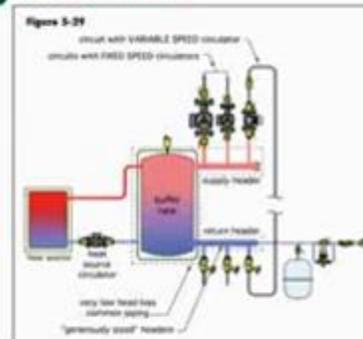
To function properly both the spacing and
The pipe sizing need to be considered

The goal is to provide a means for the
various pumps to operate without conflict



Installation work by Harvey Youker

CALEFFI
Hydronic Solutions



Hydronics – Unique to Condensing

Heat Emitters

- High Mass – the best for condensing
 - Lowest temperatures needed
- Staple Up – don't do it, requires water 30°F greater water temperature
- Radiant Panels – pricey, but can use lower water temperatures
- Baseboard and Super Baseboard
- Unit Heaters and other low mass

The Key is lower water return temperatures

Controls

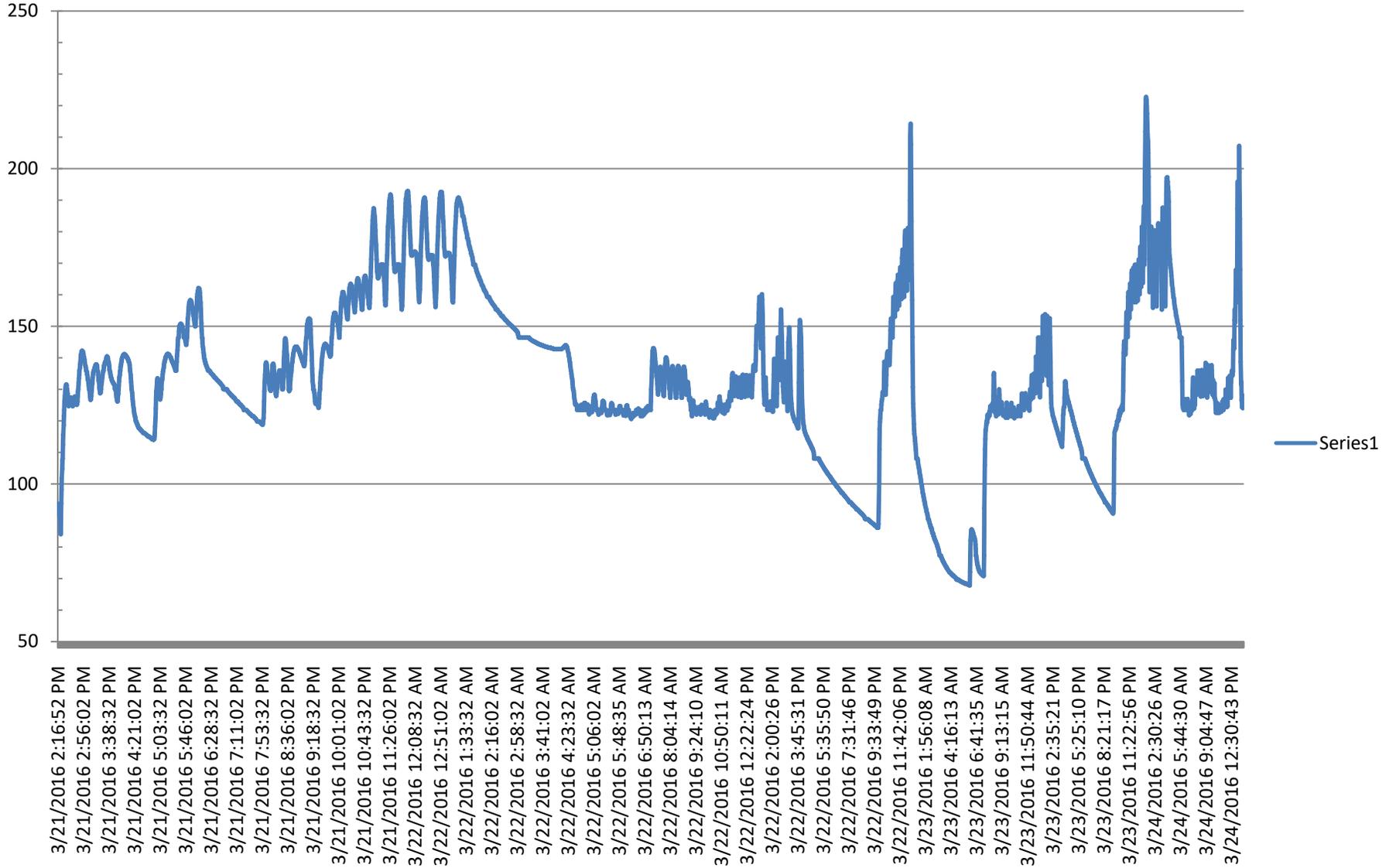
Control Options

The FCX is a plug and play Boiler....but

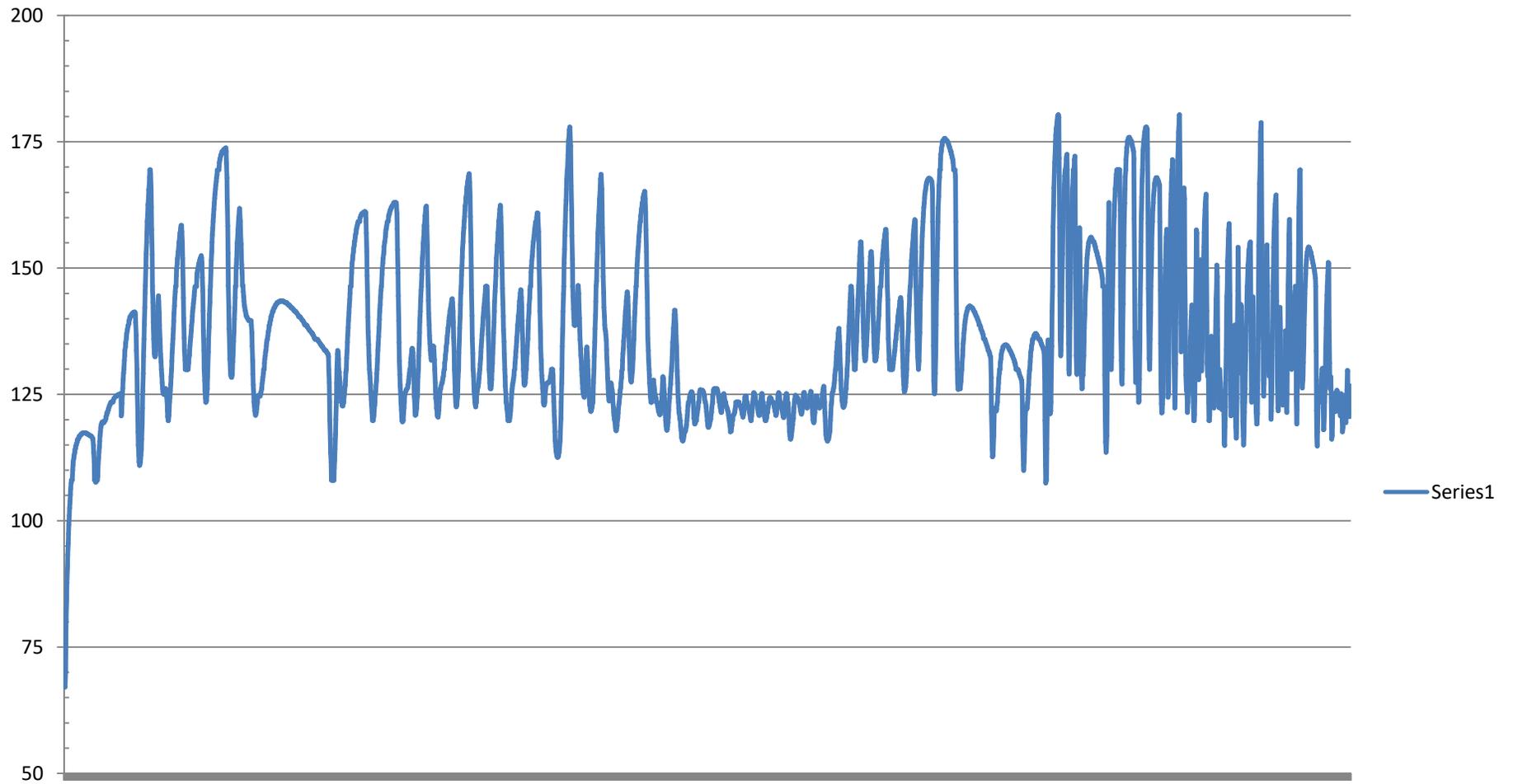
- 1. None / Built-in**
- 2. Zone Controllers**
- 3. Switching Relays with Digital Temperature Control**
- 4. Outside Reset with Indoor Feedback**

Why Digital Controls

Data Logger every 3 minutes for about 3 days Capillary Type Aquastat Gone Wild



Johnson 419 Controller on a Baseboard House



Why Use Third Party Controls

- **FCX can just be plugged in so....why?**
- **Better temperature control**
 - Core boiler temperature
 - Mixing temperature
 - Delta T functionality
 - Reset Capability – needed???
 - Indoor feedback
 - DHW priority and reset – needed???
- **Boiler protection – Sustained condensing**
 - Too much throughput

Recommendations

Match the Control to the Application

- **Two Basic Types**

- **Basic on/off which allow for**

- Cold Start capability
- Multiple pumps that activate the boiler
- DHW Prioritization
- Add digital temperature control (419 Johnson)
- Simple and Inexpensive

Taco SR502...506 Series

- **Outdoor Reset with Indoor Feedback**

- Does all of the above, plus
- Controls boiler temperature and mixing valve temperature
- Uses outdoor reset as a starting point
- Thermostats that measure temperature and send data to control
- Self adjusts to the lowest water temperature needed

Tekmar 402 / 403 Series

Combine with Smart Pump Technology

Boiler and Pump Control

Minimum recommended for new construction w/radiant or low temp emitters.

Johnson a421 Digital
Temperature Controller



The Johnson provides more accurate temperature control of the boiler core and led read out.

Taco SR502-4 Series



The Taco allows for cold starting the boiler and the control of multiple pumps.

Manual Mix Control

The Cadillac

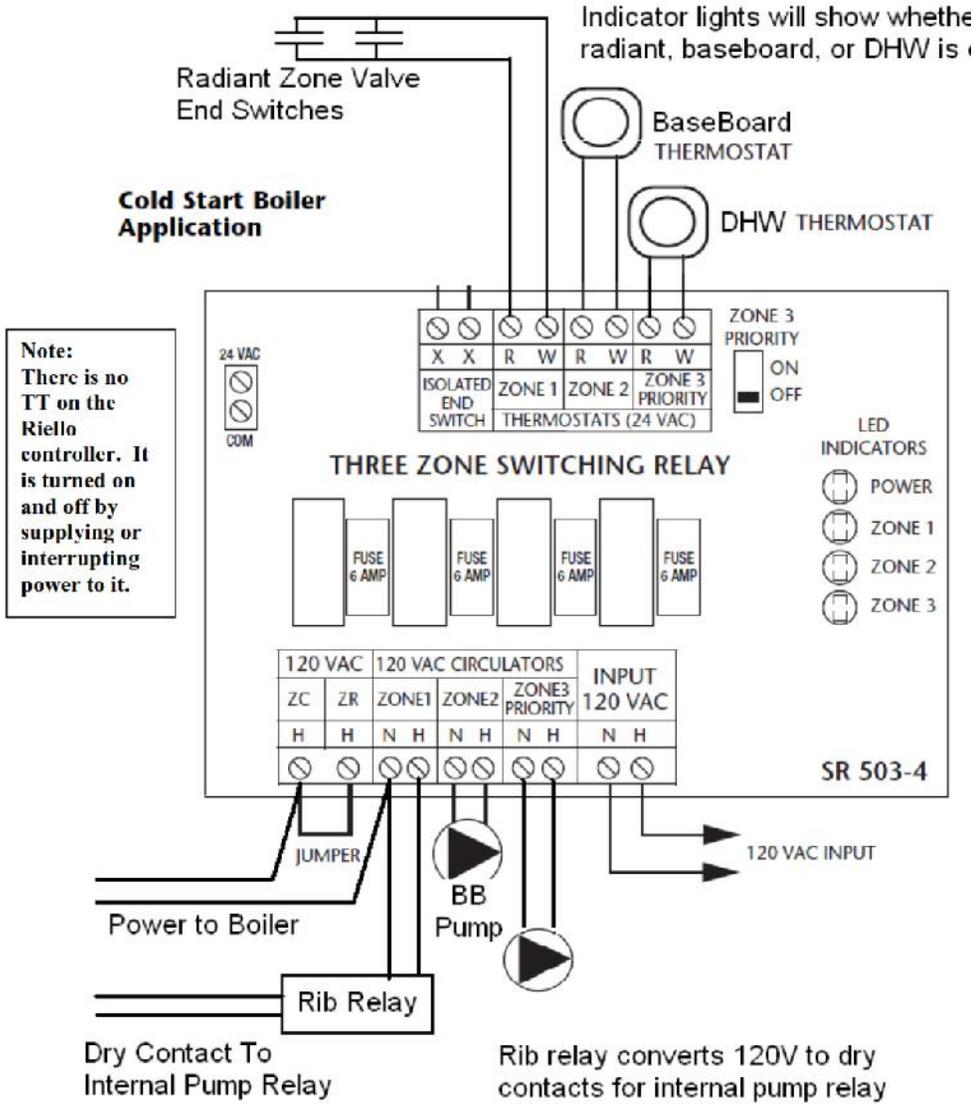
Tekmar Digital Controller
Boiler / Mixing Valve / Pump / Temperature



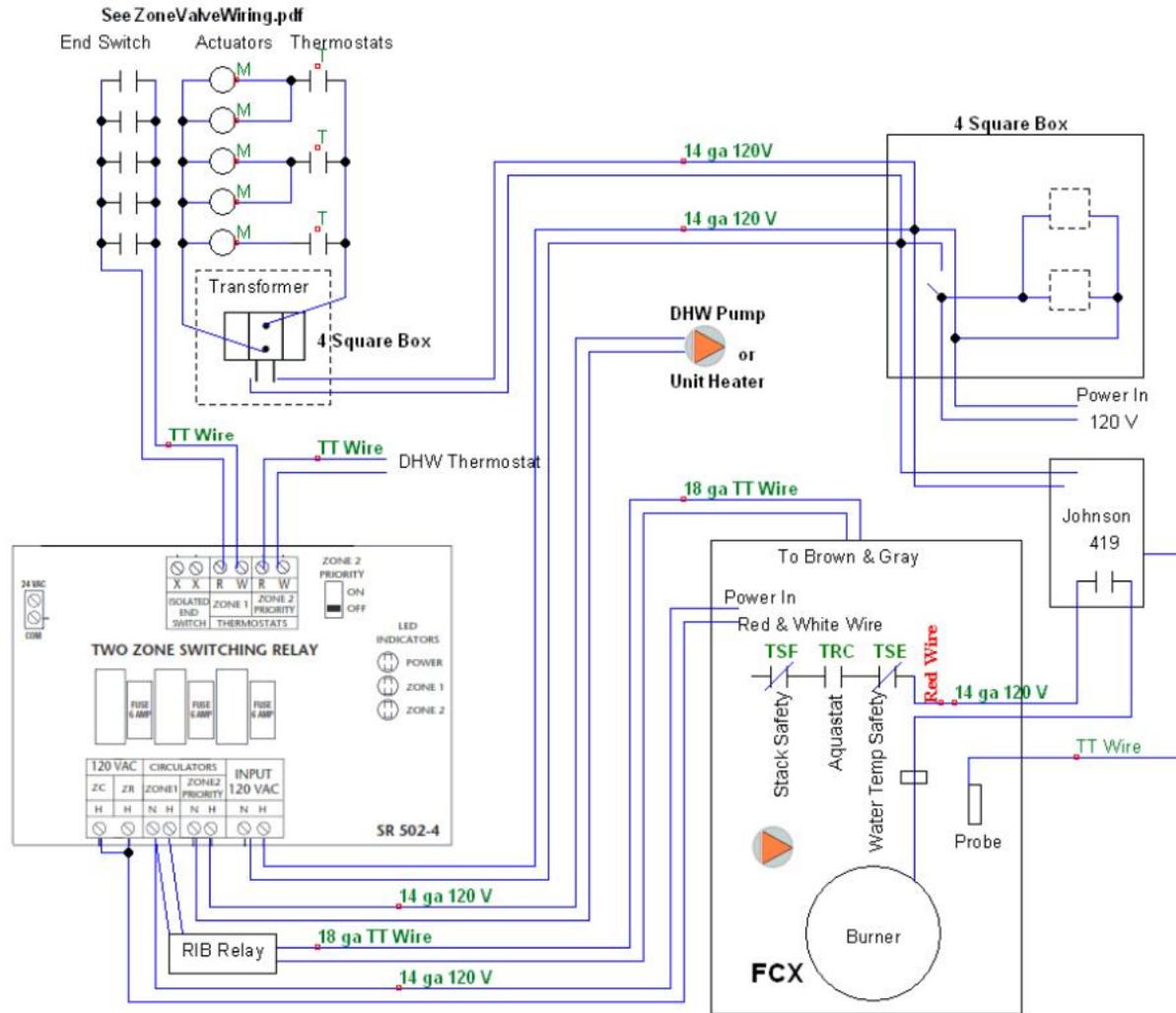
This control is a must when retrofitting a Base Board House

How to Wire

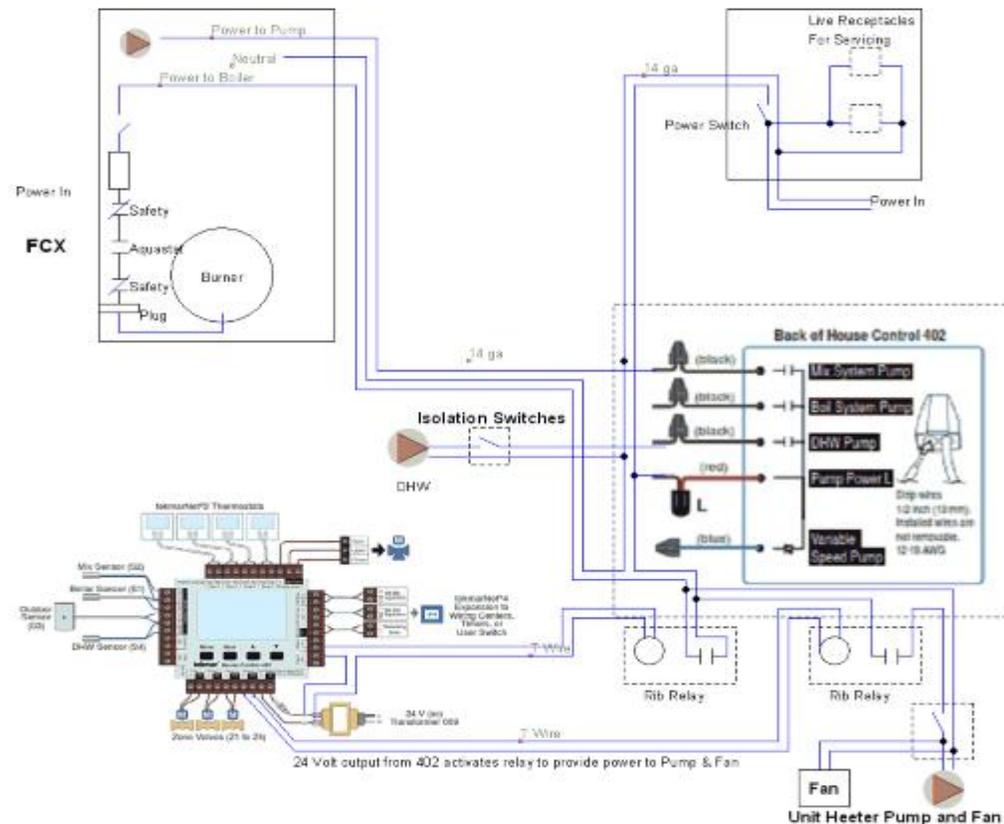
**FCX Wiring for the Taco SR503-4
Three Pump Relay
Riello Burners
End Switches in Parallel for Multiple Zones**



FCX Wiring with Taco SR502



**FCX with Tekmar 402, 3 Heating Zones
DHW and a Unit Heater
Controlling 3 pumps**



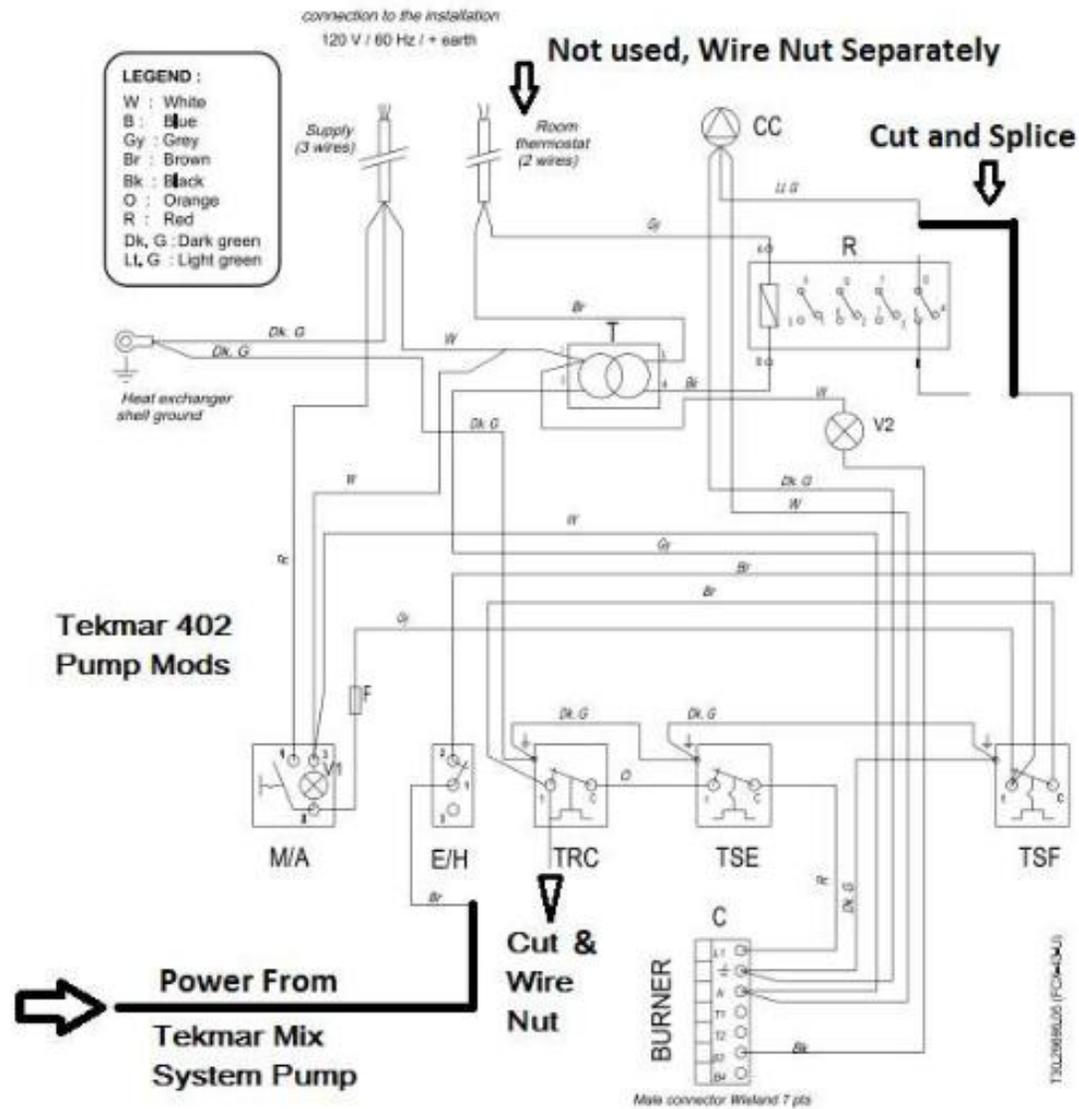
Notes:

The FCX has no TT on its controller, it is turned off and on by interrupting power to the boiler using a RIBUIC relay. These changes are necessary because the pump is powered separately from the boiler with the Tekmar 402.

It is adequate to use 14 gage, 3 conductor cable with ground as only one neutral is required.

The internal aquastat now functionally becomes a secondary high limit. It must be left in the circuit as the Tekmar is not rated as a primary controller.

Tekmar 402



- LEGEND :**
- L : Phase
 - N : Neutral
 - M/A: On/Off switch
 - E/H: Summer/Winter switch
 - TSE: Overheat safety cutout aquastat
 - TRC: Adjustable thermostat
 - TSF: Flue gas safety cutout thermostat

- V1: On light
- V2: Burner safety shutdown light
- C : Burner connector
- F : Fuse (6,3 A)
- R : Relay
- T : Main transformer 120/24 volts
- CC : Circulating pump

Pumping And Piping

Pumping

The Coup de Grâce to Inefficiency

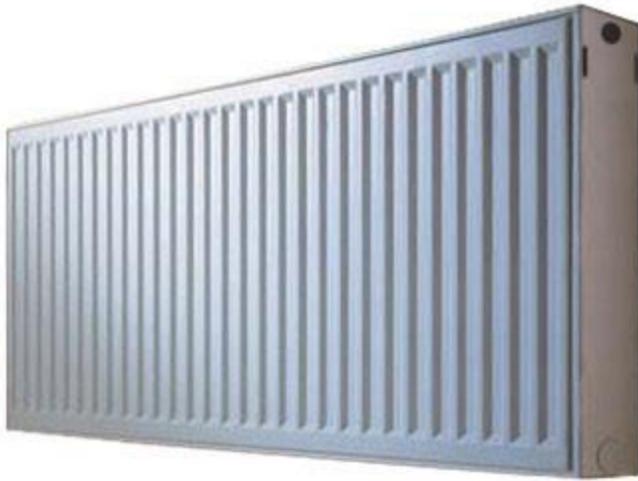
What We Want

- **Minimize the return water temperatures**
 - Slow, nearly continuous pumping at lower temperatures
 - ECM Variable Frequency Drive (VFD) with ΔT
 - ECM pumps use $\frac{1}{2}$ the electricity at full speed
 - ECM pumps at low speeds – 10 to 12 watts
- **Forget the Old School - The more the better???**
Reduce $\frac{1}{2}$ Vol = $\frac{1}{8}$ power Also Eliminates Need for By-Pass Valves

The pumping can have a great effect on efficiency

Consider

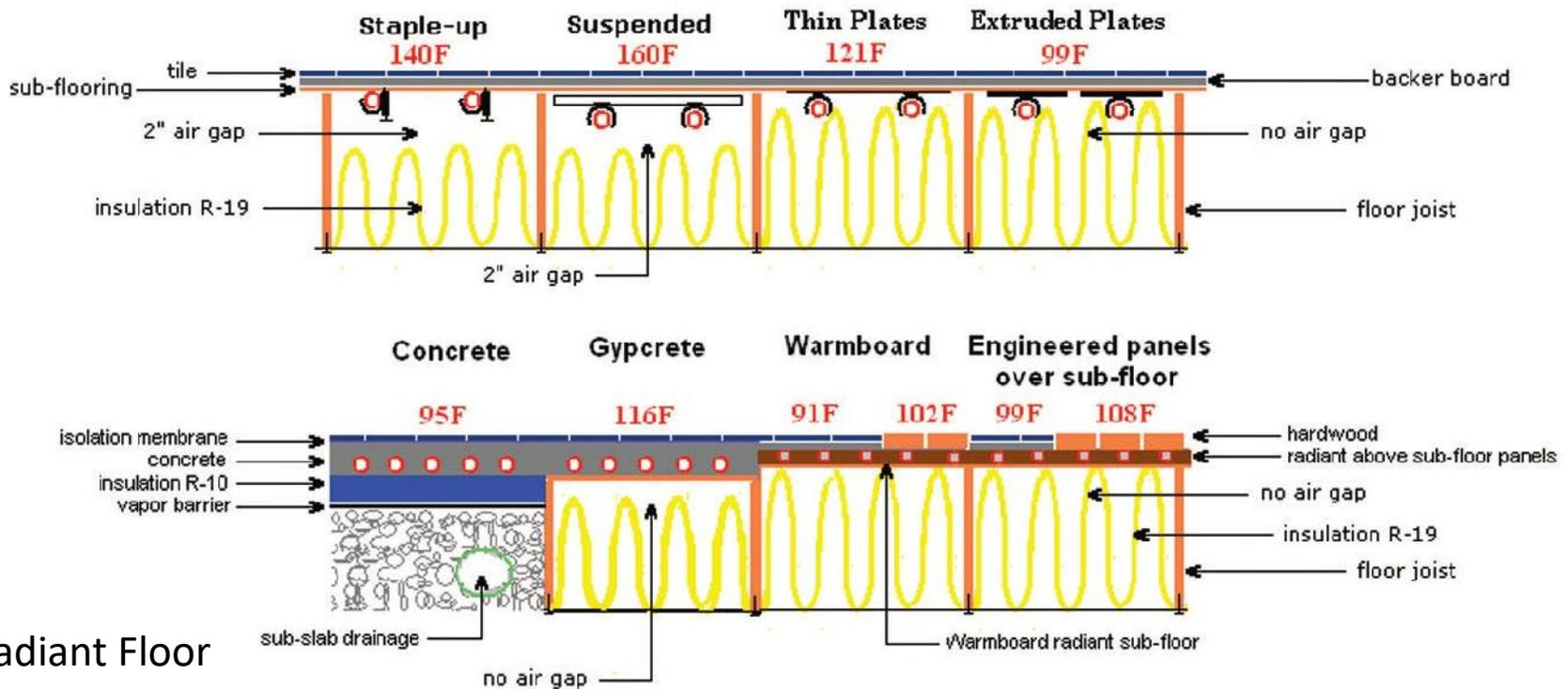
10 gpm at $10^\circ \Delta T$ or 5 gpm at $20^\circ \Delta T$

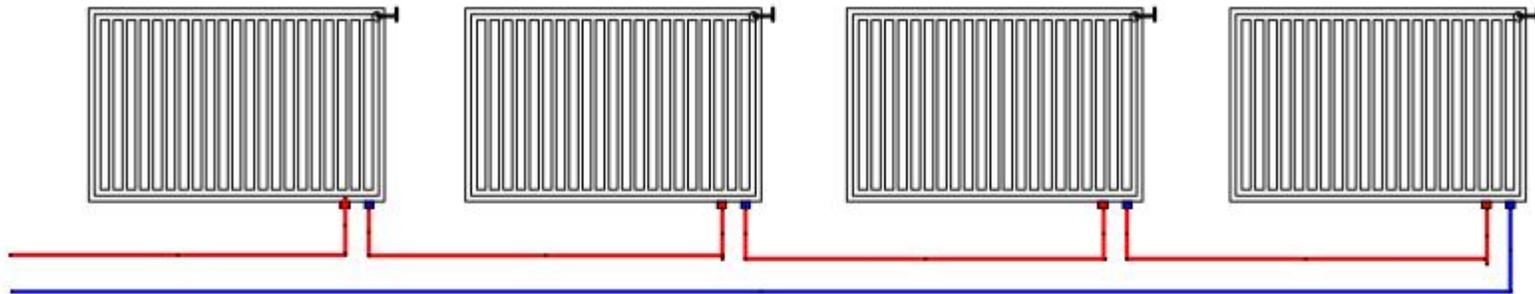


Typical Floor Types

The Major Factor: "The lower the systems temperature requirements, the better the overall system-wide efficiency, which will ensure the lowest possible operating costs for fuel and power." [and the Most Condensing and Lowest Stack Temperatures]

Water temperatures required to meet the required 80F floor surface temperature.

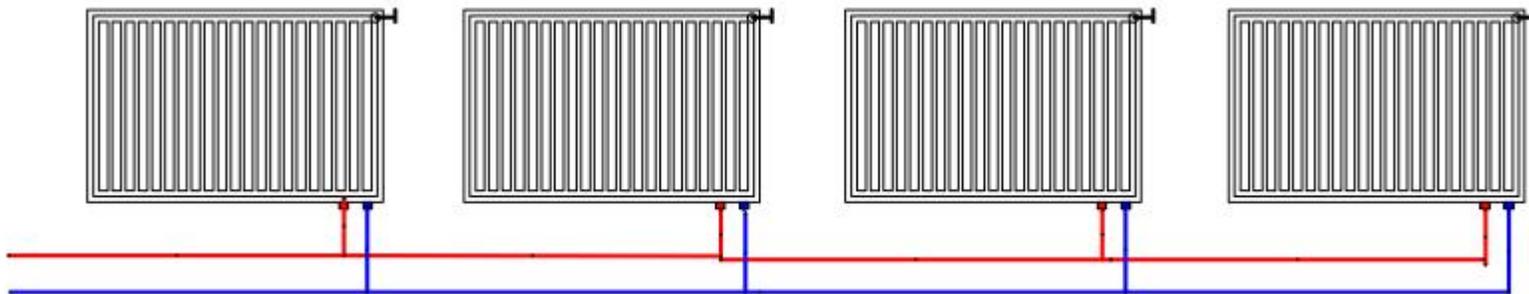




Parallel Vs Series

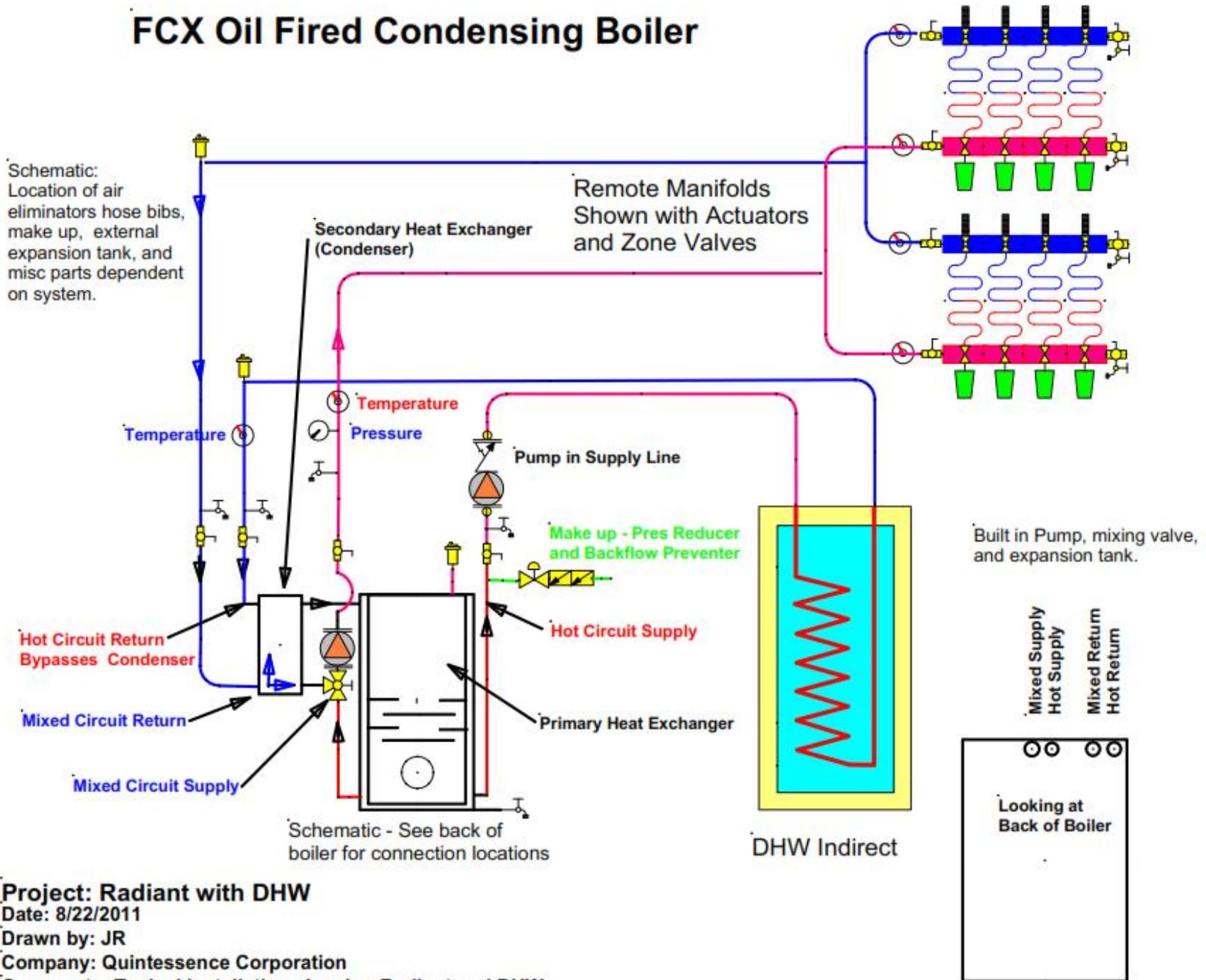
Parallel:

- More Even Heat Distribution
- Better Pumping Characteristics



FCX Oil Fired Condensing Boiler

Schematic:
Location of air
eliminators hose bibs,
make up, external
expansion tank, and
misc parts dependent
on system.



Project: Radiant with DHW

Date: 8/22/2011

Drawn by: JR

Company: Quintessence Corporation

Comments: Typical installation showing Radiant and DHW

circuits, with FCX boiler schematic. Component placement will vary.

Project: Baseboard Alone

Date: 10/23/2012

Drawn by: JR

Company: Quintessence Corporation www.FCXalaska.com

Comments: Why to use the mixed circuit when baseboard is the only heat emitter.

Notes:

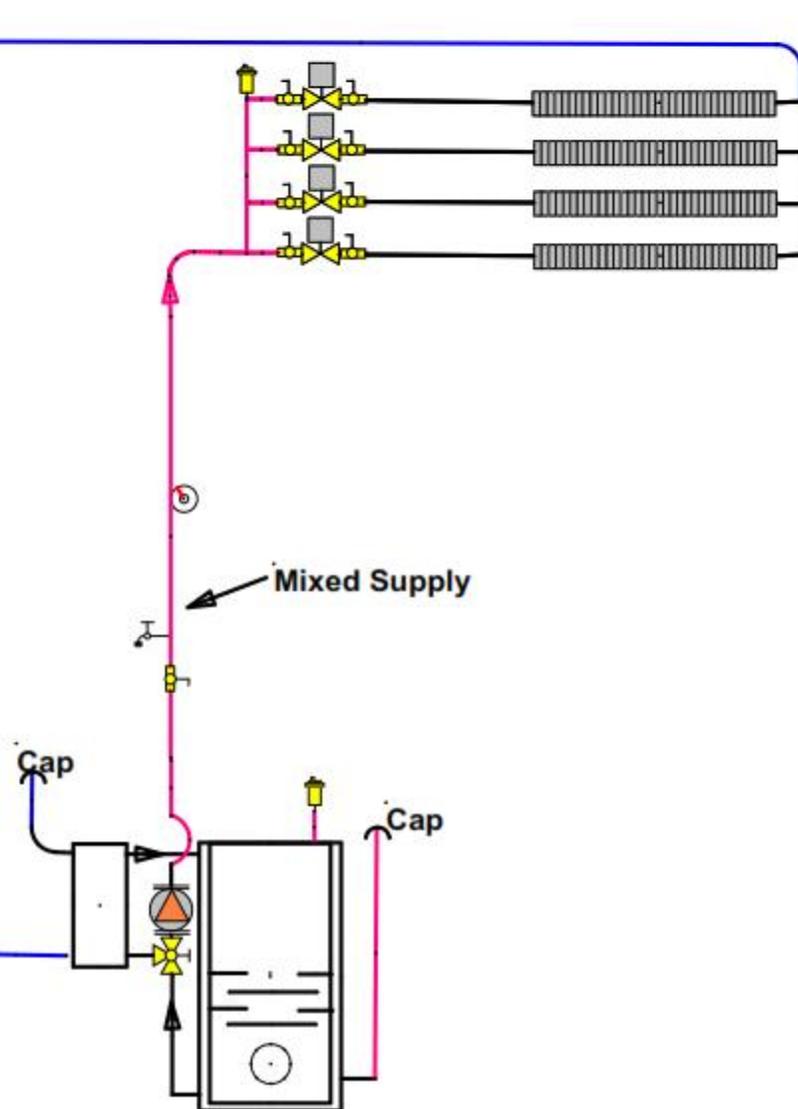
Whenever a system has baseboard without radiant always plumb to the mixed circuit because at times the baseboard will run in condensing mode.

Even in noncondensing mode the condenser serves as a secondary heat exchanger reducing stack temperatures. If the hot return is used it will negate this

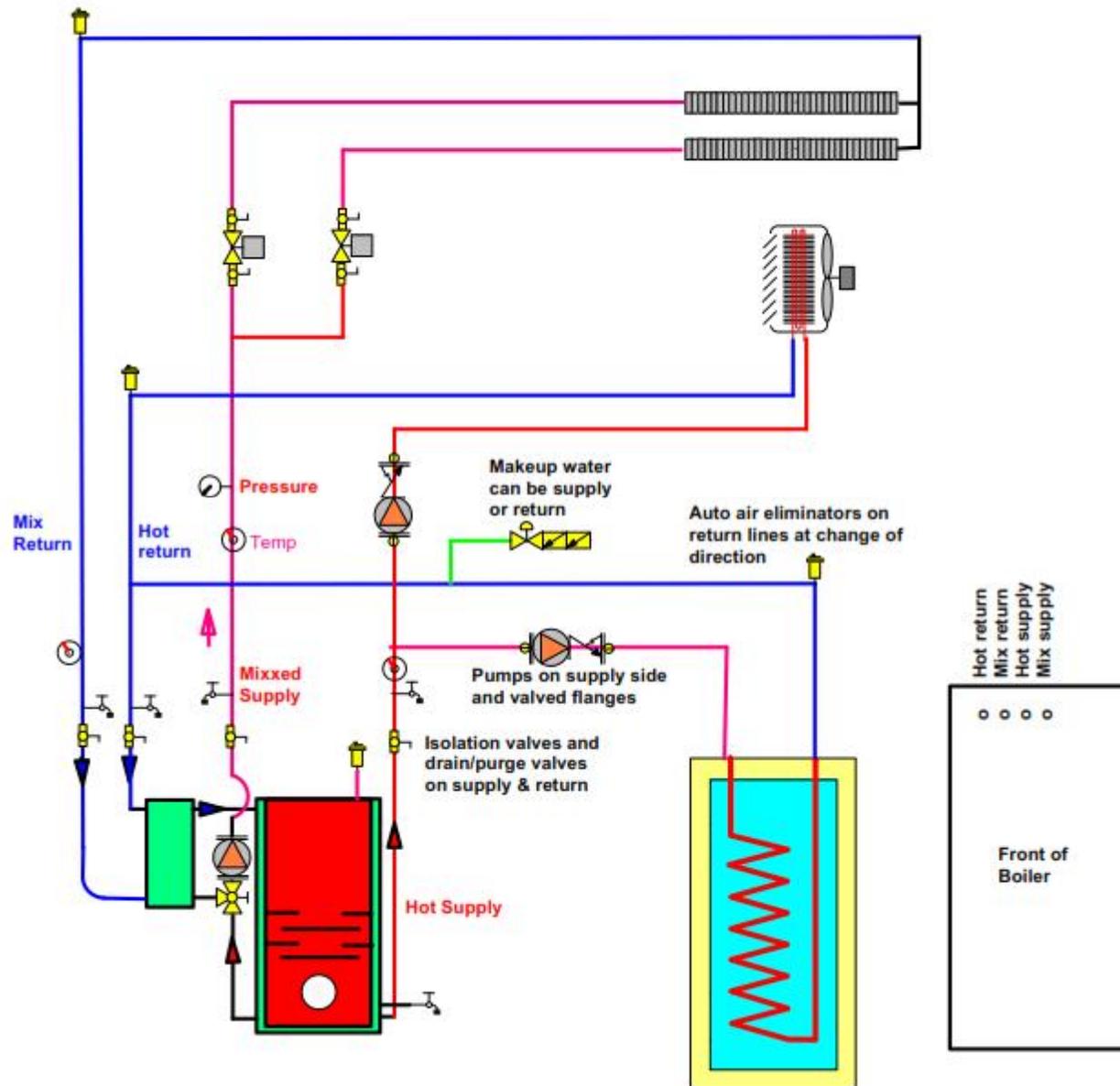
The DHW heater is always plumbed to the hot circuit in every case unless other devices are added post to decrease return water temperature. See white paper on enhancing and optimising.

Make up water can be plumbed anywhere.

Mixed Return



Baseboard - Unit Heater - DHW



FCX Optimized System for 3 types of heat emitters

Radiant_BB_DHW_OPT

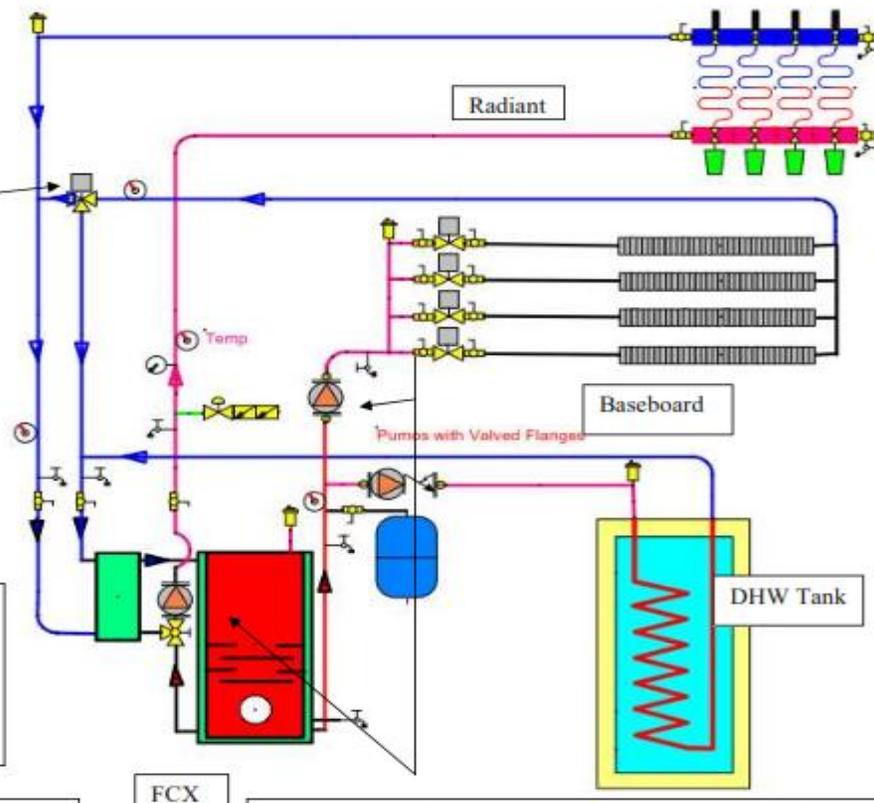
Three-way zone valve redirects return flow of baseboard to bottom of condenser when there is no flow in the radiant portion.

See Note below.

Temperature gages on all supply and returns allow for optimum tuning of the system for maximum ΔT .

Recommended control is the TACO SR503. See TACO switching relays on the Diagrams page of the website.

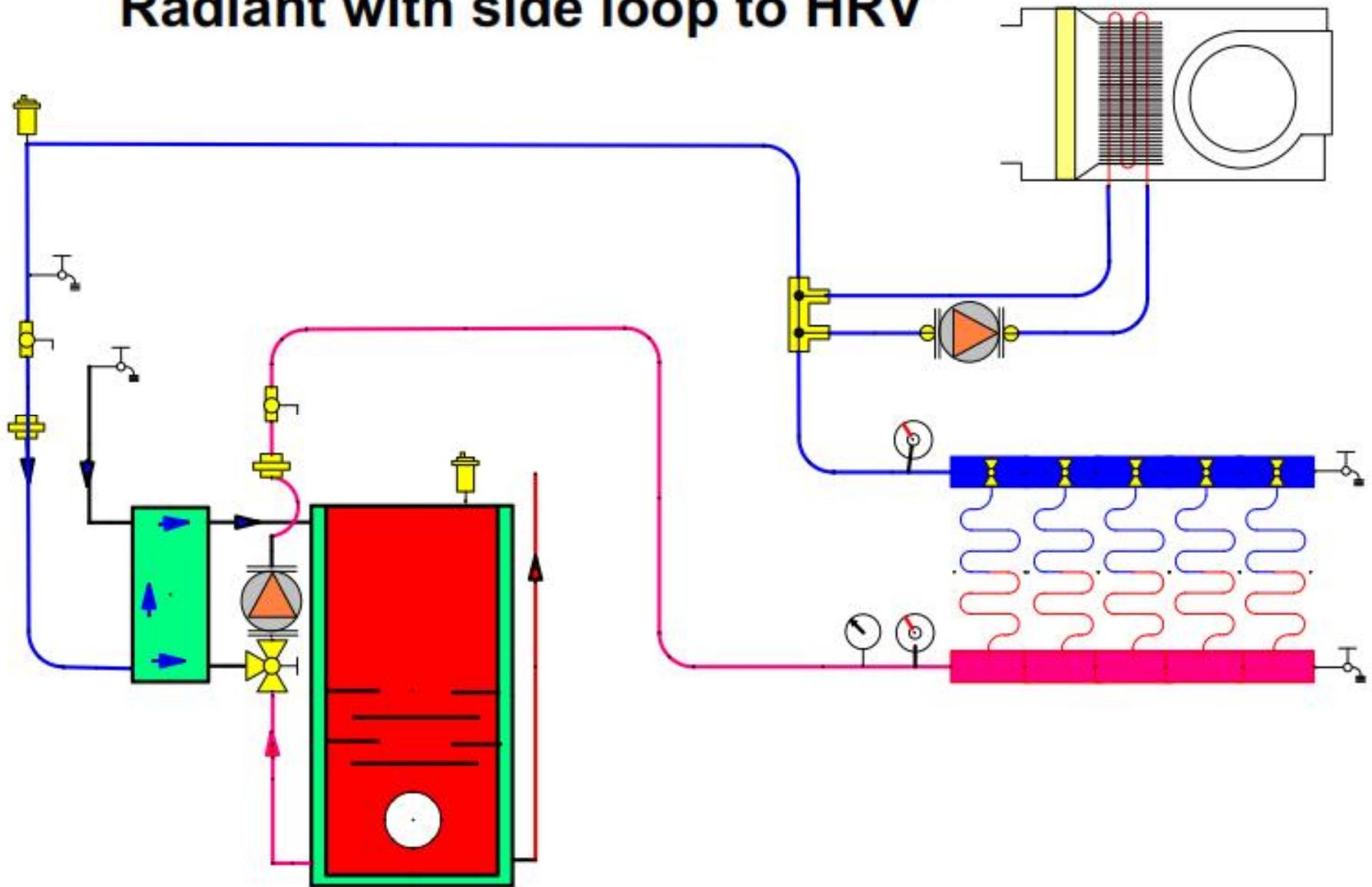
Zoned groups with single pumps per heating group



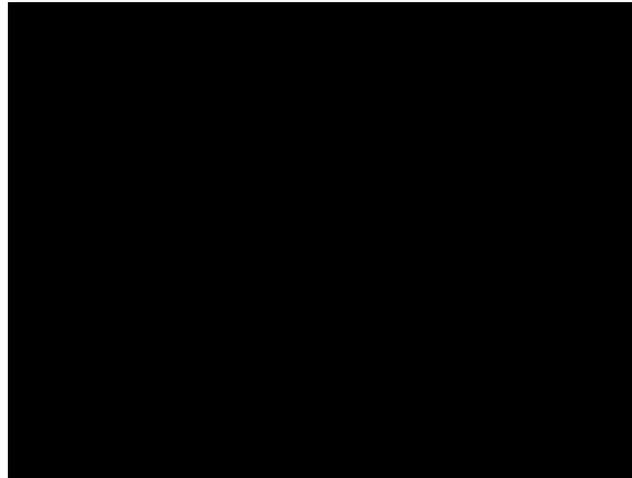
Taco Bumble Bee ΔT VFD pumps insure optimum flow in all circuits regardless of number zones open. This also reduces pumping costs. Rather than two pumps on the hot circuit, a zone valve could be used on the DHW side also.

General schematic for 3 heat emitter types (Radiant, Baseboard, & DHW) requiring both high and lower temperatures, and expected ΔT 's. The three-way zone valve on the return will promote some condensing on the Baseboard circuit when the radiant circuit is not active, but will not contaminate the cooler return of the Radiant when active. This enhancement is not necessary if the radiant is the primary heat emitter in the system, but would be desirable if the baseboard is on a significant portion of the time and the radiant is not. In any event it will not detract from the system.

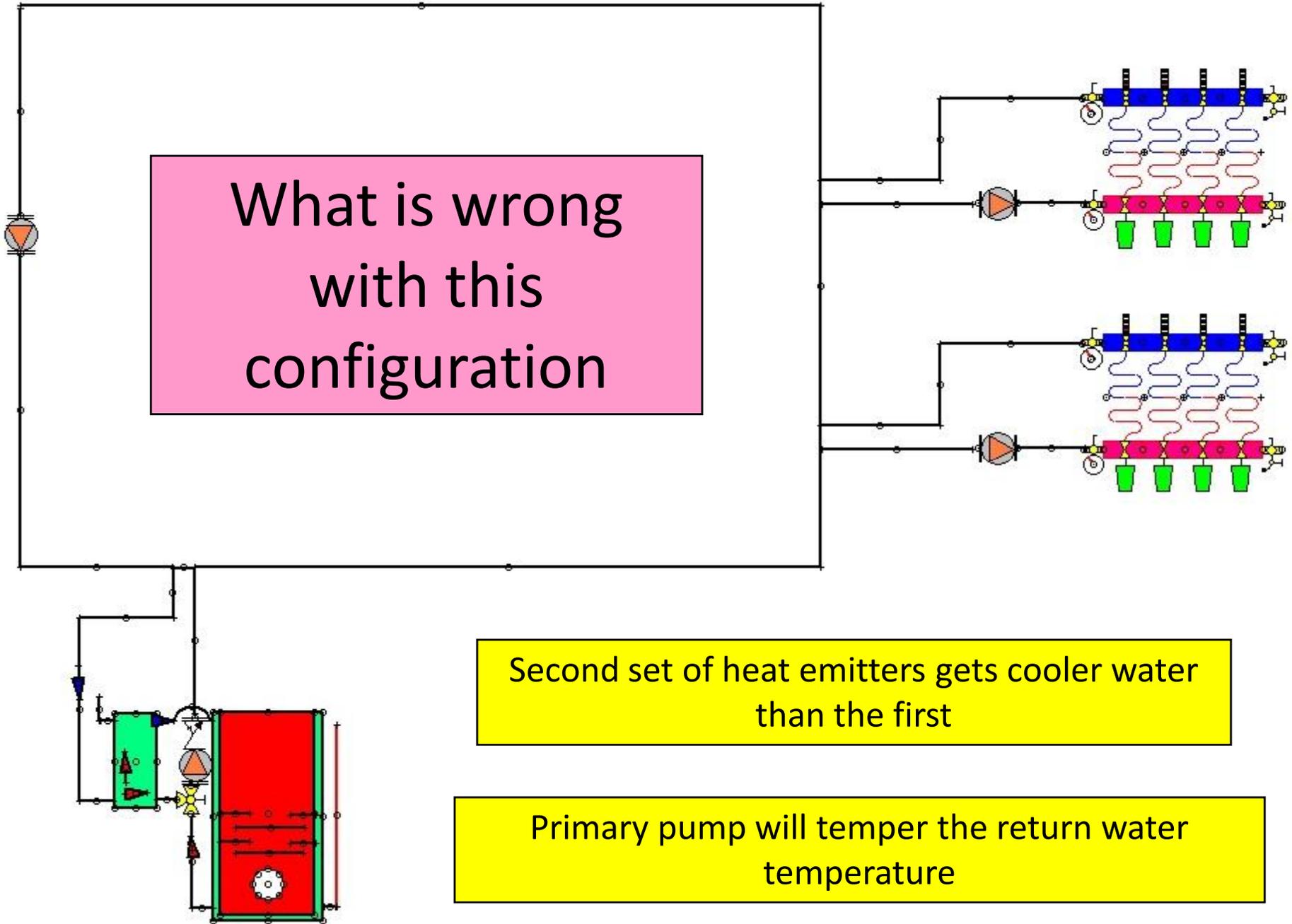
Radiant with side loop to HRV



What we want if using Base Board



Common Mistakes

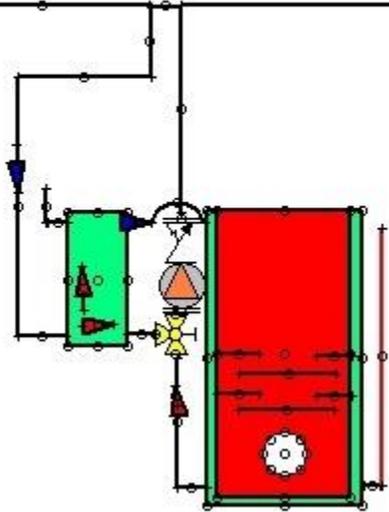
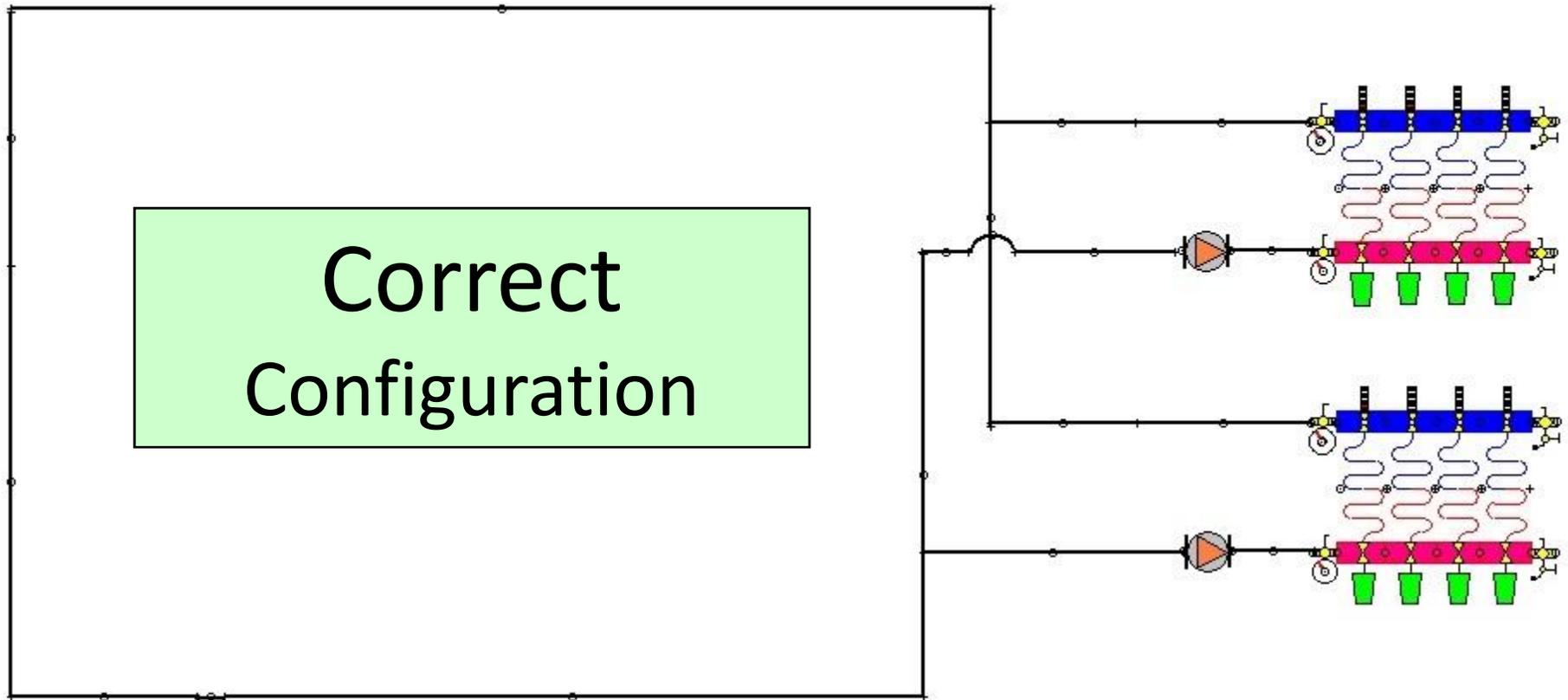


What is wrong with this configuration

Second set of heat emitters gets cooler water than the first

Primary pump will temper the return water temperature

Correct Configuration

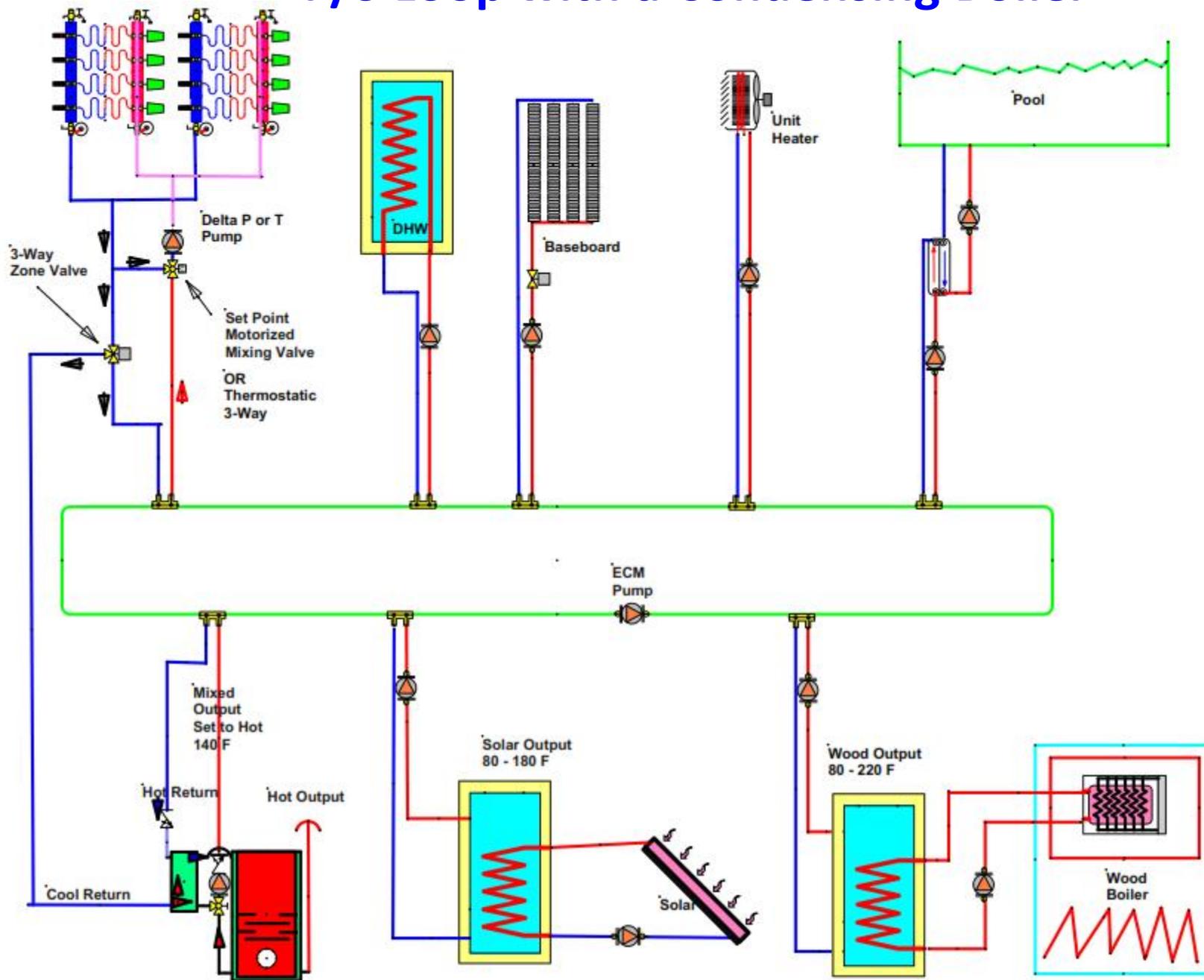


Second set of heat emitters are now in parallel – both receiving the same temperature water.

Caution – the supply pump can still over pump the delivery pumps causing tempering of the return water.

Solution is to use an injection pump.

P/S Loop with a Condensing Boiler



You Also Need Tiger Loop and 36" Flex Lines

**Tigerloop Ultra
Recommended**



Stacks
Venting
Condensate

3 Types of Venting are Available

Singlewall – Inside Combustion Air



Combo



Concentric – Sealed combustion



Applicability

Single Wall (SW)

- Only where house is isolated from the location of the boiler. Never use a sidewall exit. SW on long vertical stacks extending above the highest point in the house have been used successfully with cold air intakes.

Concentric

- This type can be used anywhere but can be very expensive with long lengths. We have gone over 40 feet.
- Always use this type with side exit with a boiler room on a bottom floor.

Combo

- Use this technique when sealed combustion is essential but long lengths are needed.

FCX 22 - Long vent testing

Quote from test:

"For the venting configuration I used 7 3ft strait lengths, 2 1.5ft strait lengths, 2 90° elbows and a terminal."

Counting 90s at 3.28 ft this equates to 33.56 effective Length



Habit for Humanity - Baseboard



Condensate Traps, Drains, Vacuum Breaks, Pumps

<http://www.fcxalaska.com/PDFs/HandlingCondensate.pdf>

**Enhancing and Optimization
Of
Condensing Boilers
By
James Romersberger
7/16/12**

Dropping the Stack and Return Water Temperatures

Very Important Note:

Not all the return water needs to be reduced in temperature, ONLY the part that goes through the condenser

- Preheating domestic water with the return
- Preheating HRV air
- Unit heaters in series
- Series plumbing - Baseboard feeding slab or baseboard feeding a cold baseboard area such as a garage
- Reduced mixed output temperatures result in reduced returns
- Reduced pumping speeds (increases ΔT)
- Add an after-condenser to a single heat exchanger system
- Add another after-condenser for DHW well water
- Add a stack robber (condensing in the stack is as effective as condensing in a condenser if the heat is recovered). Open stacks (not walled in) or vented chases allow for heat recovery.



BNL-73314-2004-IR

Hydronic Baseboard Thermal Distribution System with Outdoor
Reset Control to Enable the Use of a Condensing Boiler

Dr. Thomas A. Butcher

October, 2004

Startup

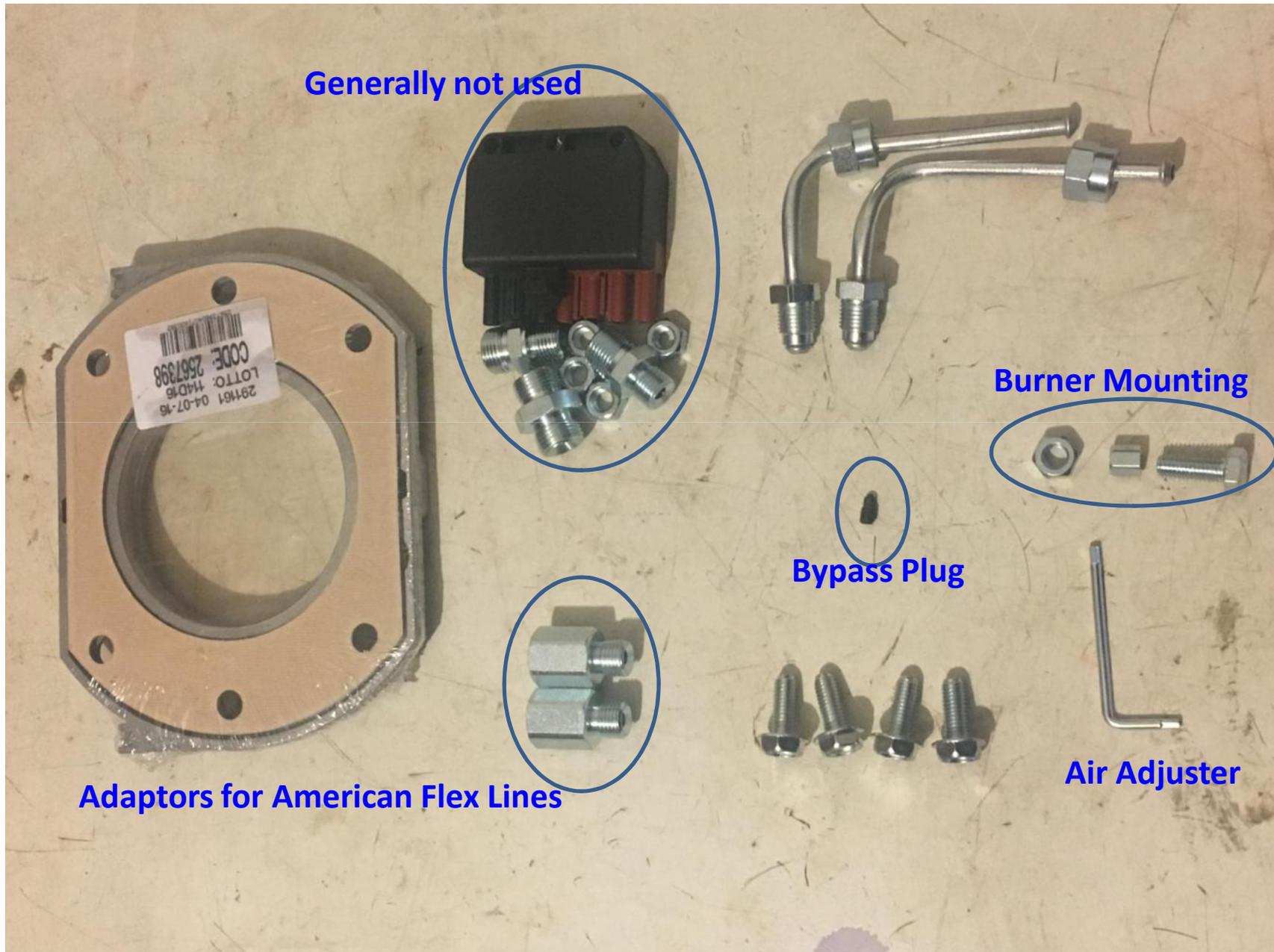
Commissioning the boiler

Riello Burner Setup

Riello RDB Burner



Riello Burner Parts



Generally not used

Burner Mounting

Bypass Plug

Adaptors for American Flex Lines

Air Adjuster

Mounting Instructions



Disassembly

- **4 Bolts on Primary**
- **1 Wingnut on Condenser**
- **1 Nut Holding Burner**
- **4 Screws on Control Panel**

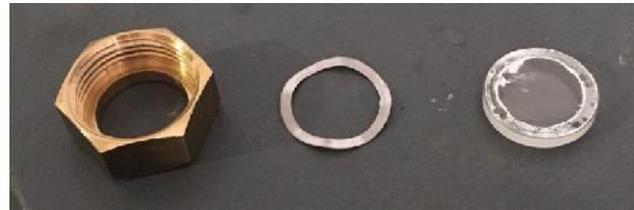
Disassembly and Assembly



Applying Anti-Sieze

Using a Teflon Paste as an anti-seize

- View port
- Condenser gasket or lid
- 4 – Fastening bolts on primary

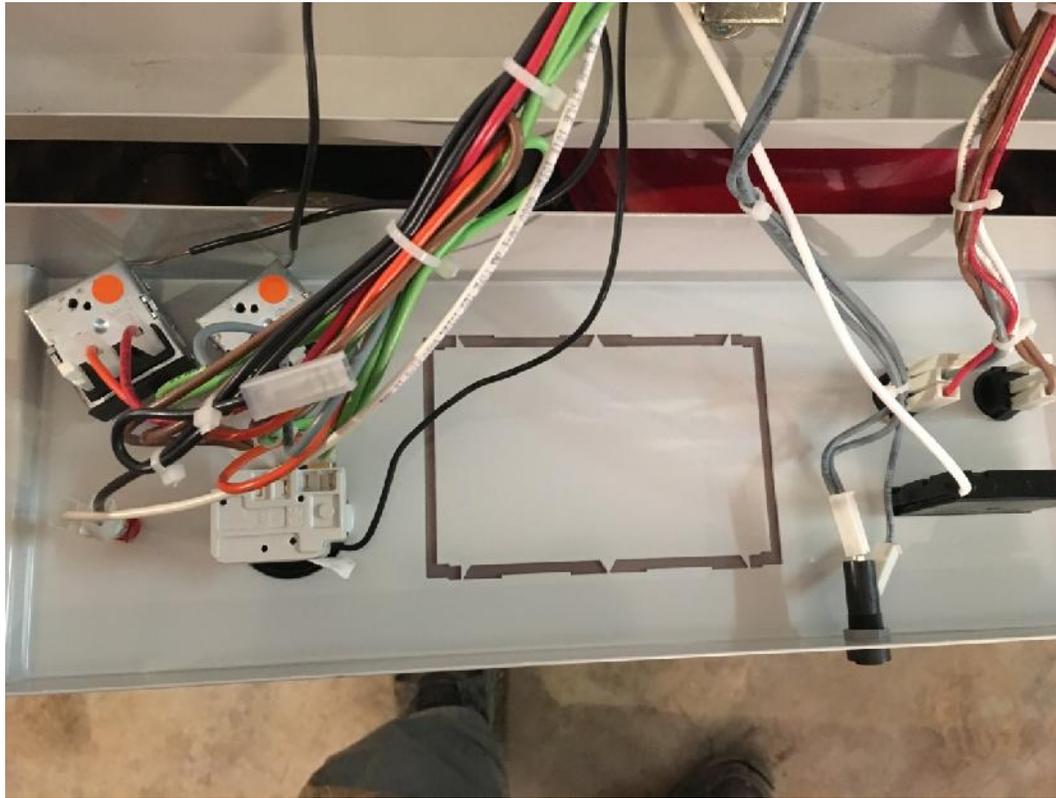


Don't lose spring



Inspecting Electrical Connections

Check all Spade Connectors



Check Gasketed Connections



Check Electrodes for blocking Light



Settings

Boiler and Pump Control

Minimum recommended for new construction w/radiant or low temp emitters.

Johnson a421 Digital
Temperature Controller



The Johnson provides more accurate temperature control of the boiler core and led read out.

Taco SR502-4 Series



The Taco allows for cold starting the boiler and the control of multiple pumps.

Manual Mix Control

Johnson 421

On = 120° F

Off = 130° F

ASd = 0 (anti-Short Cycle Delay)

SF = 0 (Sensor Failure – Relay De-Energized)

FCX Aquastat = 100%

FCX Mix = 50%

The Cadillac

Tekmar Digital Controller
Boiler / Mixing Valve / Pump / Temperature



This control is a must when retrofitting a Base Board House

Tekmar 402

Outdoor Design	-20°F
Mix Design	120°F
Boiler Design	130°F
Boiler Minimum	120°F
DHW Mode	1 (No Priority)
FCX Aquastat	100%

Maintenance

Cleaning

Maintenance

Cleaning and Inspection

- Once a year or every 1000 gallons
- Non-condensing mode and sooting
- Primary condensing – What to check for
- Secondary condensing (washing the tubes)
- Concentric air tee - need for inspection
- Plugged condensate drains
- Back drafting

Disassembly



Cleaning

- **Vacuum Primary**

- Alignment bolt
- Anti-seize on bolts



- **Flush Condenser**

- Plugged condensate trap
- Cleaning Turbulators
- Anti-seize on gasket



- **Clean Glass**

- How to remove stuck glass
- Anti-seize



Primary Heat Exchanger

- Debris
- Sooting in Primary
- Recycle of Exhaust gases









**Exhaust Gas Recirculation
and
Back Drafting
typified by
Yellowish Muck
Yellow Ash**



Yellowish Deposits



Secondary Heat Exchanger (Condenser)

- Debris
- Sooting in Condenser
- Recycle of Exhaust gases
- Backdrafting









Clean System 550 Gallons Baseboard House with Tekmar 402









The Danger of Continual Resetting



Blocked Stack

- **Partially / Full**
- **Endless Purge Cycle**
- **Fixes**



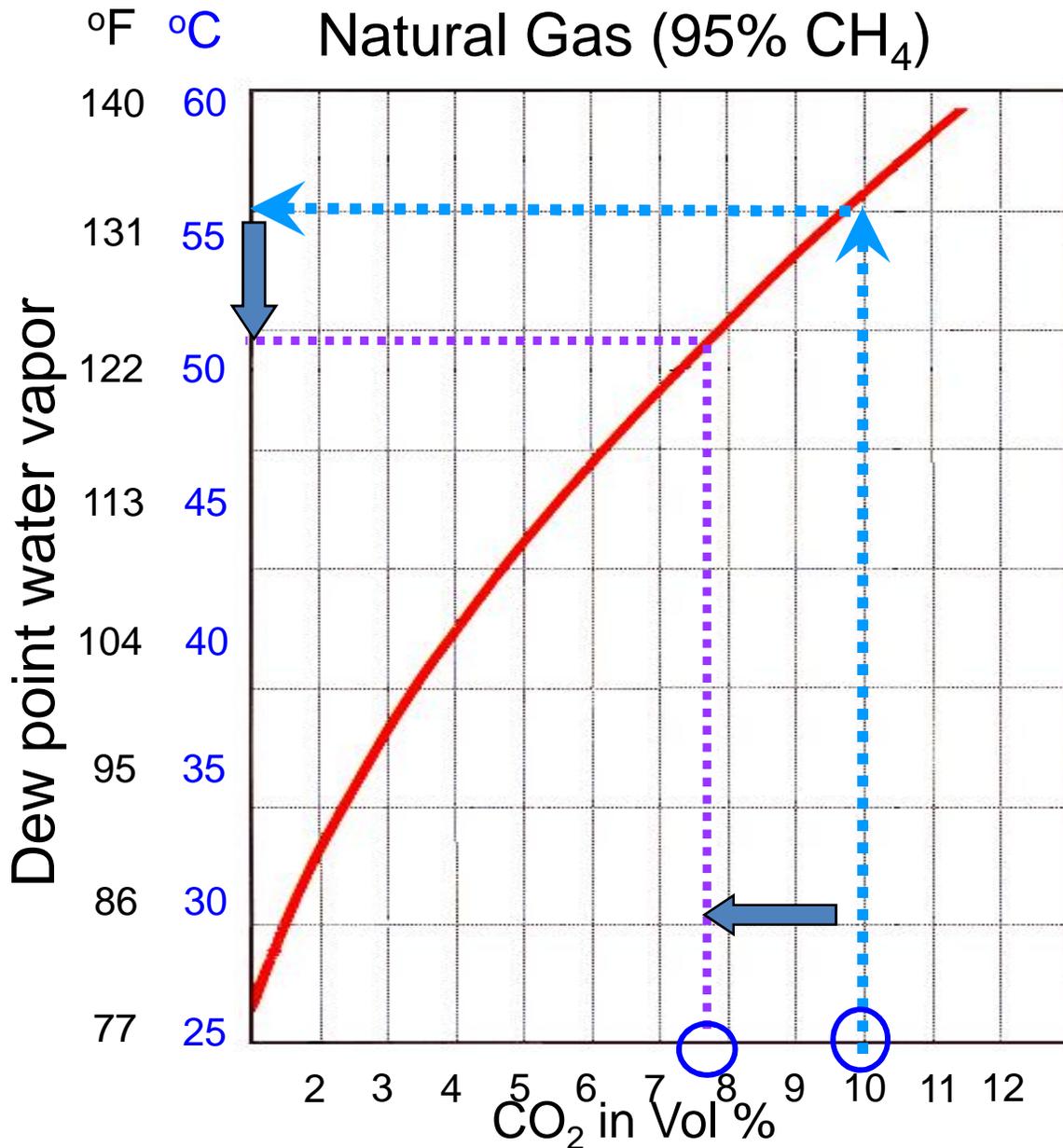


Disassembly

- **4 Bolts on Primary**
 - Alignment bolt
 - Anti-seize on gasket
- **1 Wingnut on condenser**
 - Anti-seize on gasket
- **1 Nut Holding Burner**
 - Serviced from Blast Tube

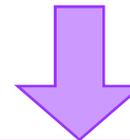
Tuning

WATER VAPOR DEW POINT



CO₂% of flue gas influences dew point temperature

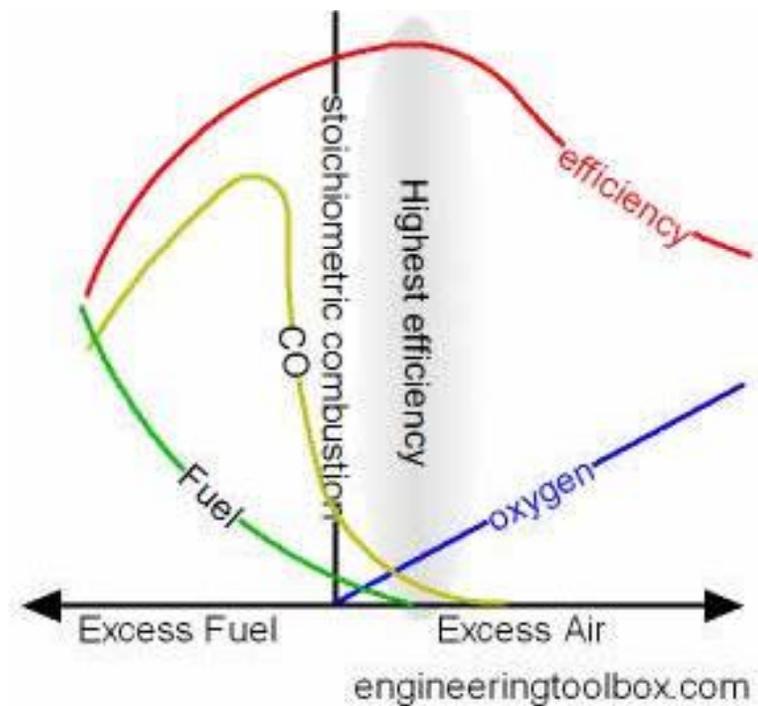
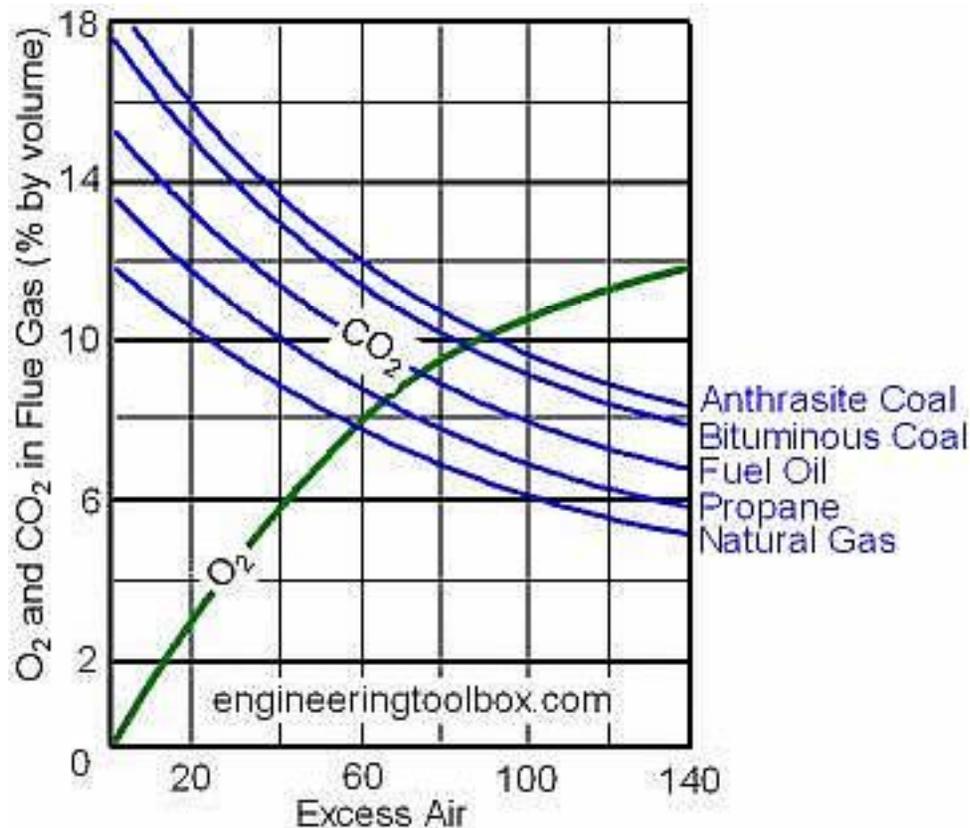
Higher CO₂
= Higher Dew point
= More Condensation



Lower CO₂
= Lower Dew point
= Less Condensation

Maintenance

Tuning a Condensing Boiler



Tuning

**** This boiler cannot be tuned by eye ****

- **CO / O2 / Temp / Pres - Measured**

- CO higher after cleaning – about 30 ppm
- O2 +/- 4.0
- Pressure 185 psi

- **CO2 / Excess Air - Calculated**

- CO2 – 12.5
- Excess air +/- 20

- **Efficiency / Stack Temperature**

- Also Calculated
- On system startup – 96-97% / Stack 80F
- Stabilized (Warm Return) – 92+% / 125-175F

CO2 / Excess Air / Pressure



Set: CO2 = 12.5 Pressure = 185
Corresponding O2 = $\pm 4\%$, CO < 30ppm

Last and Most Important Smoke Spot Check

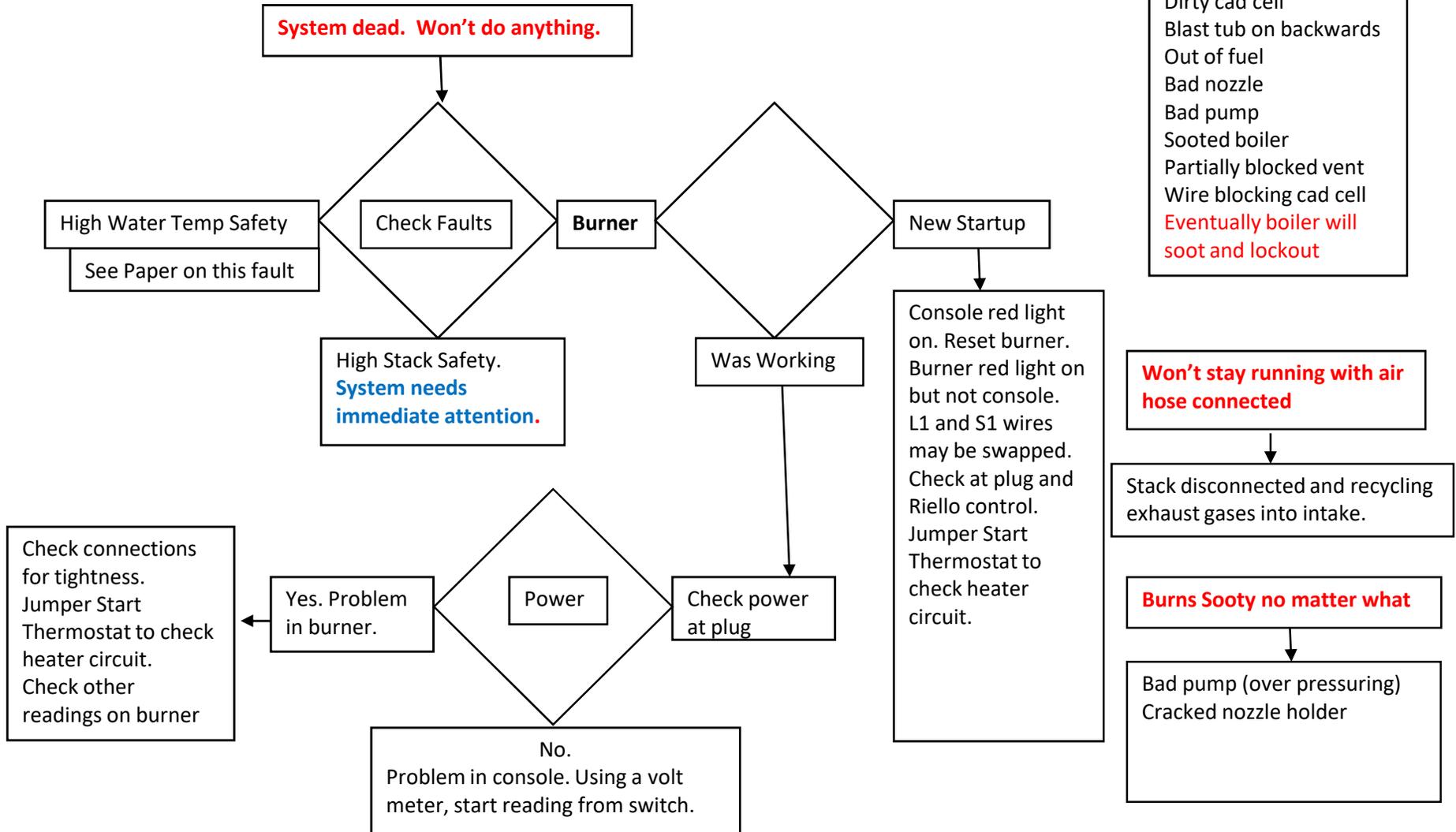


Troubleshooting

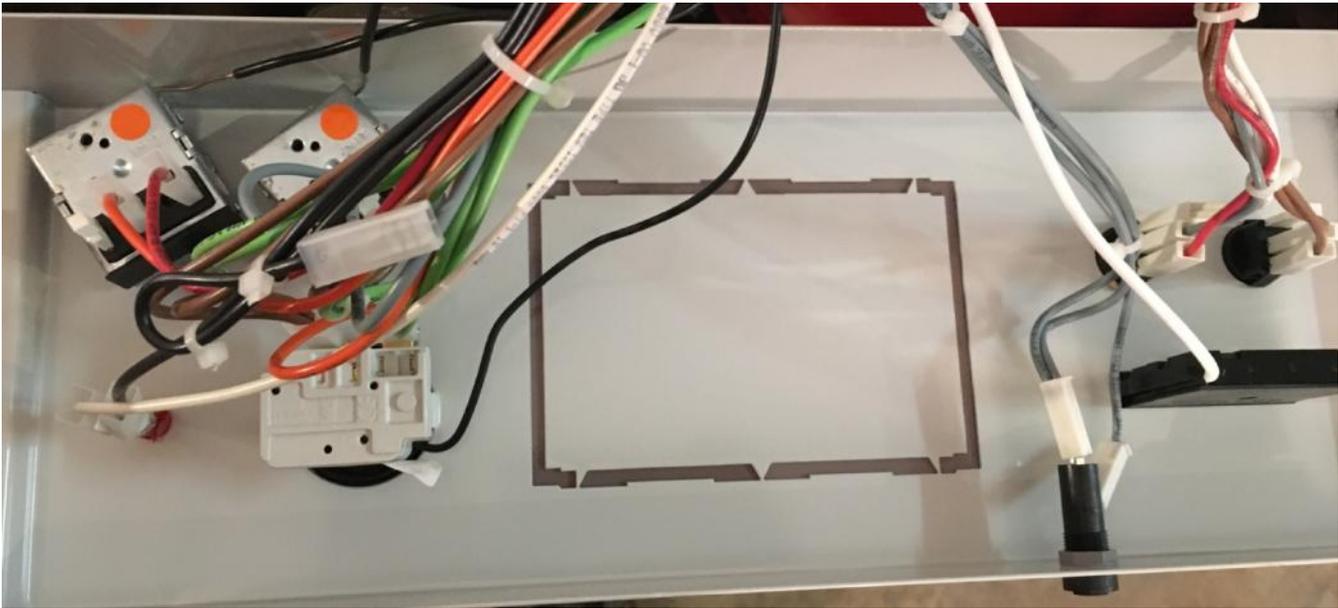
Sequence of operations:

Turn on.
1 to 2 minutes delay for heater to heat fuel in nozzle assembly.
Prepurge 10 to 15 seconds. Oil pressure 10 to 20 PSI
Burner fires. Oil pressure initially about 140 PSI Adjust to 185 and set CO2 12.5

Prepurge, fires, flame out, prepurge, fires, flameout



Console



Check safeties first

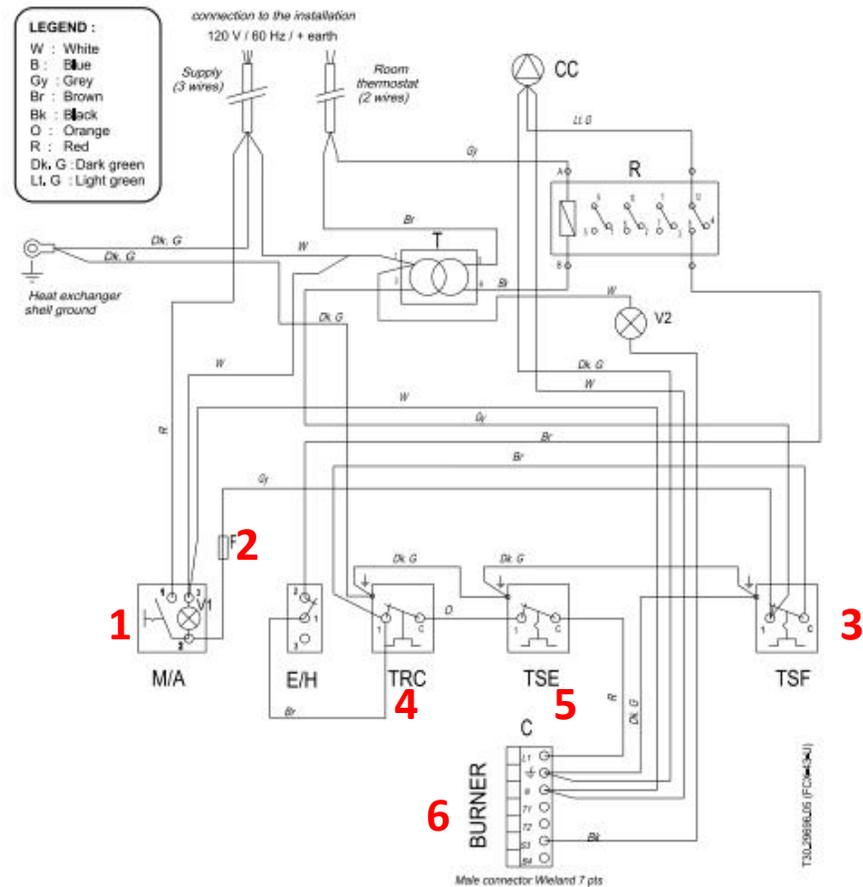
**Safeties do not stick out when tripped,
listen for click when reset.**

Check for loose spade connectors

Wiring Diagram

Power Route

- M/A - Switch (green light)
- Fuse
- TSF - Flue Gas Safety
- TRC - Aquastat
- TSE – Water Temperature Safety
- Boiler Plug to Riello Burner



LEGEND :
 L : Phase
 N : Neutral
 M/A: On/Off switch
 E/H: Summer/Winter switch
 TSE: Overheat safety cutout aquastat
 TRC: Adjustable thermostat
 TSF: Flue gas safety cutout thermostat

V1: On light
 V2: Burner safety shutdown light
 C : Burner connector
 F : Fuse (6,3 A)
 R : Relay
 T : Main transformer 120/24 volts
 CC : Circulating pump

Boiler Side Plug

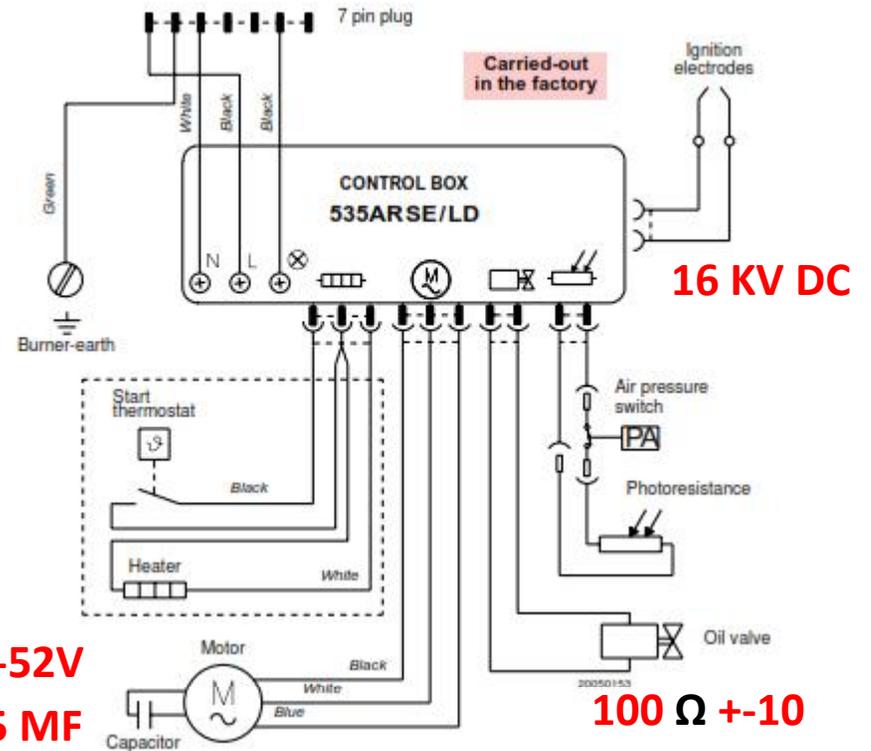
Power Ground Neutral



**Boiler dead
Power on
Wont fire**

Jumper the thermostat

**Motor White to Blue 42-52V
12.5 MF**



Riello 535ARSE/LD Readings - FCX 22/30

Motor

	Unplugged V	Running V
Bk - W	0	46
Bk - Bl	120	120
Bl - W	120	70

Cadcell

Disconnected -

Prepurge, fires, shutdown, lockout

Jumpered - Continuous prepurge, does not fire

Ohms - 4,000 w/Light, Infinity (open) no Light

Transformer 16 Kv

Inspection

- **Stack**

- Check for loose connections

- **Aquastat**

- Check on and off boiler core temperatures
- After firing and coming up to temperatures should be on at 122F, off at 130-135F

- **2363 Tee**

2363 (MPI Branded FCX's)

- **Failure**
- **Causes**
- **Replacement**







Riello Disassembly

