Index to Slides April 2019 Seminar

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

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

Technology and Application

Condensing Technology, principles involved, heat recovery, how it works, and why it is the most efficient choice in mainstream heating systems. The FCX will be introduced and discussions on heat transfer theory and technology, hydronics unique to condensing boilers, handling the condensate, and comparisons with conventional boilers will be made. Examples will be shown on these systems, including uses in new construction and retrofits with baseboard.

Design and Installation

This part covers design, installation for low temperature hydronic systems and the FCX. Heat emitters of various types, best practices, controls, pumping, venting and specifics on condensate handling will be discussed with wiring and plumbing diagrams. Mixing and set point temperature control will also be covered. This is all about how we achieve and optimize the principles discussed in the previous section.

Startup, Trouble Shooting, & Maintenance

Boiler commissioning and setup consist of some things to do and some things to check that may save you a trip later. Control settings and burner adjustments for fuel pressure and air settings will be covered in depth.

Disassembly for servicing, cleaning the primary and condenser, nozzle replacement, soot levels, trap maintenance and general inspections are discussed. Trouble shooting burner faults, safeties, and other problems, are covered. Special requirements for retrofitting of older boilers with the Riello discussed. And a factory tutorial on assembly and disassembly of the RDB burner will be shown.

Science of Condensing

How Heat is Recovered?

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

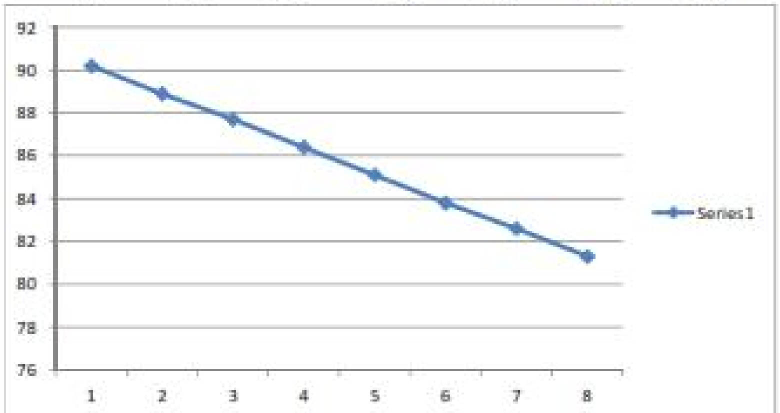
Reduction of the burn temperature (sensible heat). Oil burns at about 3500° F, the stack temperature normally is about 450° F. Further reduction leads to the 2nd Process.

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

%O2	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…

$$90.2 - 82.6 = 7.6\%$$

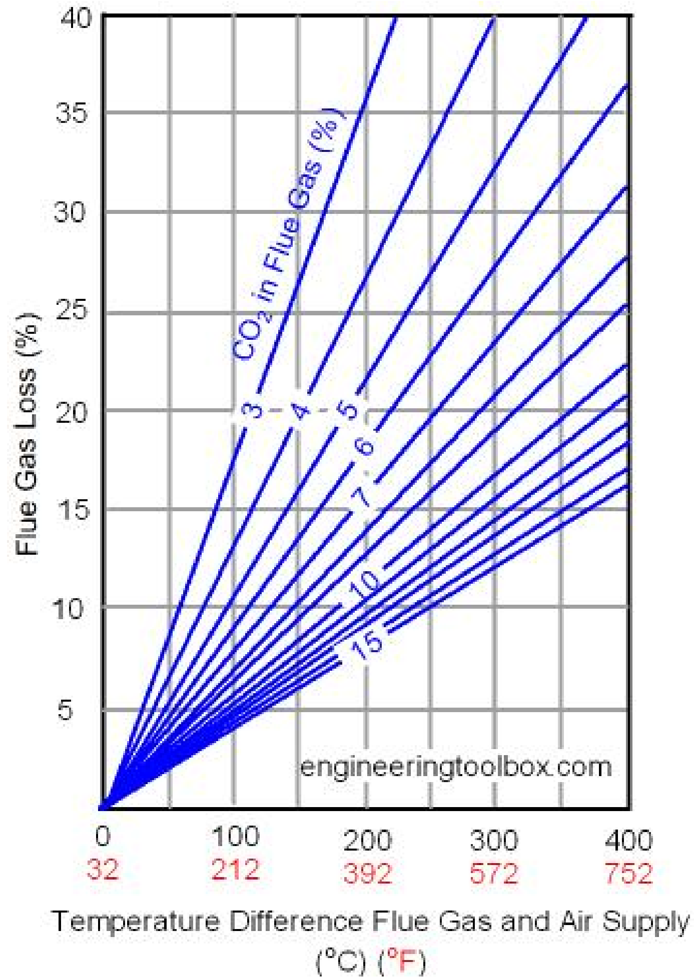
Relationship – Combustion Air vs. Stack Temperature

Flue Gas Loss with Oil Combustion

The relation between temperature difference in flue gas and supply air, the CO_2 concentration in the flue gas, and the efficiency loss in the flue gas oil combustion, is expressed below:

Example - Oil Combustion and Heat Loss in the Flue Gas

If the temperature difference between the flue gas leaving a boiler and the ambient supply temperature is *450º F - 60º F = 390 ºF*, and the carbon dioxide measured in the flue gas is *10%* - then, from the diagram above the flue gas loss can be estimated to be approximately ***11%*.**



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

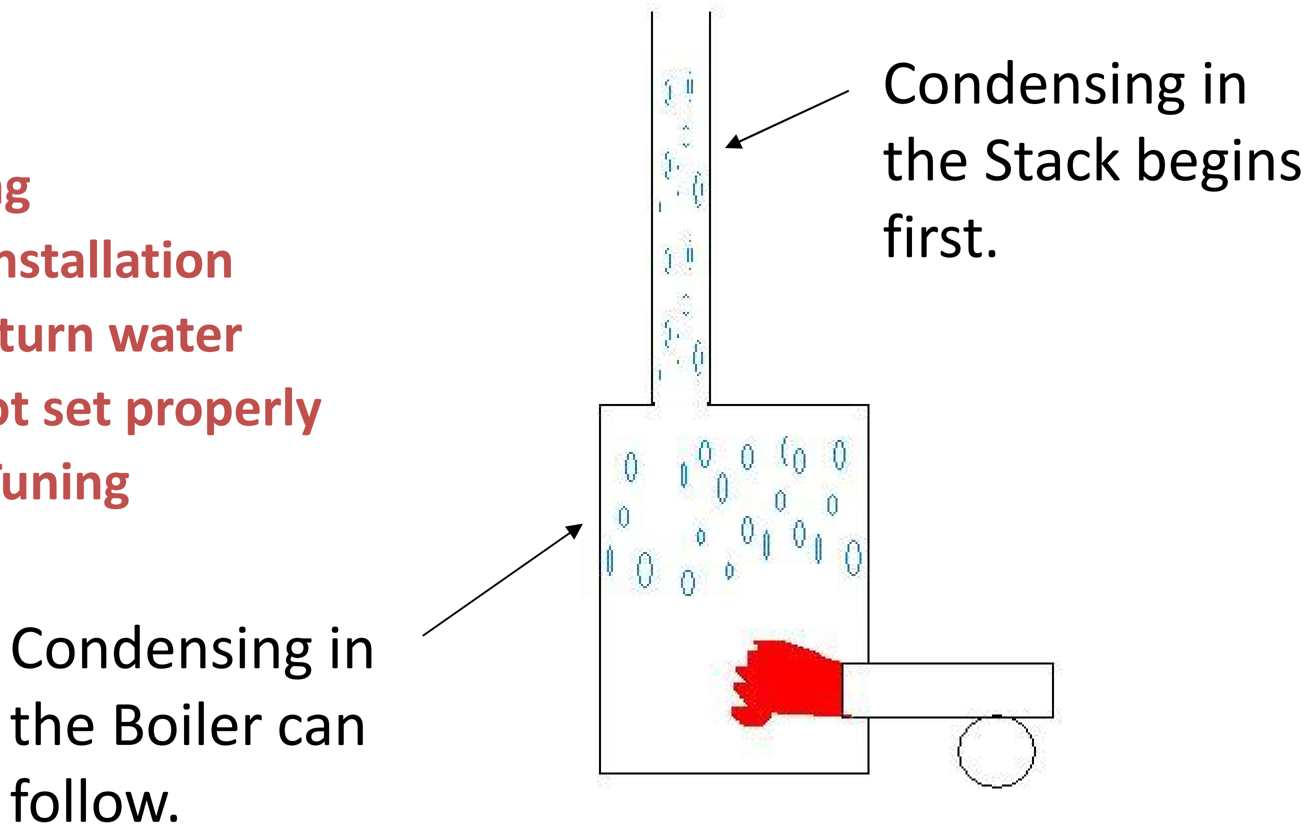
Condensing Technology

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.

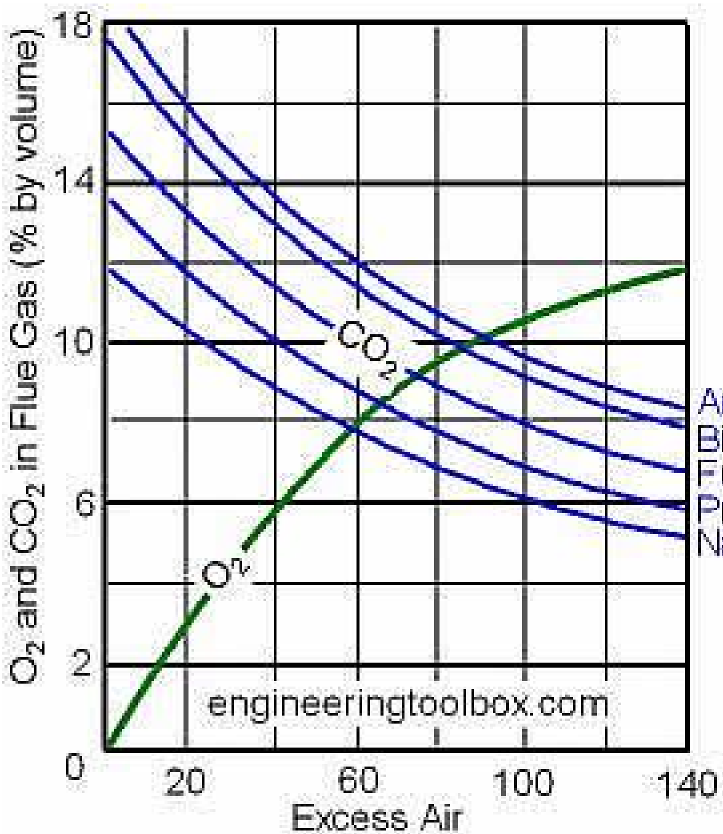
Causes for Condensing Conventional Boilers

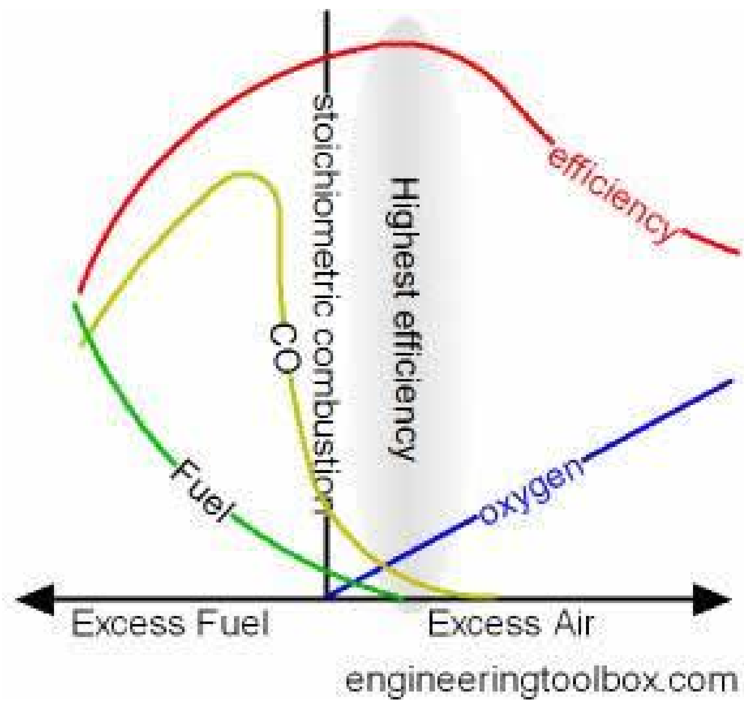
- Note that any boiler can be made to condense
- Causes
  - Under Firing
  - Improper installation
  - Too cool return water
  - Controls not set properly
  - Improper Tuning



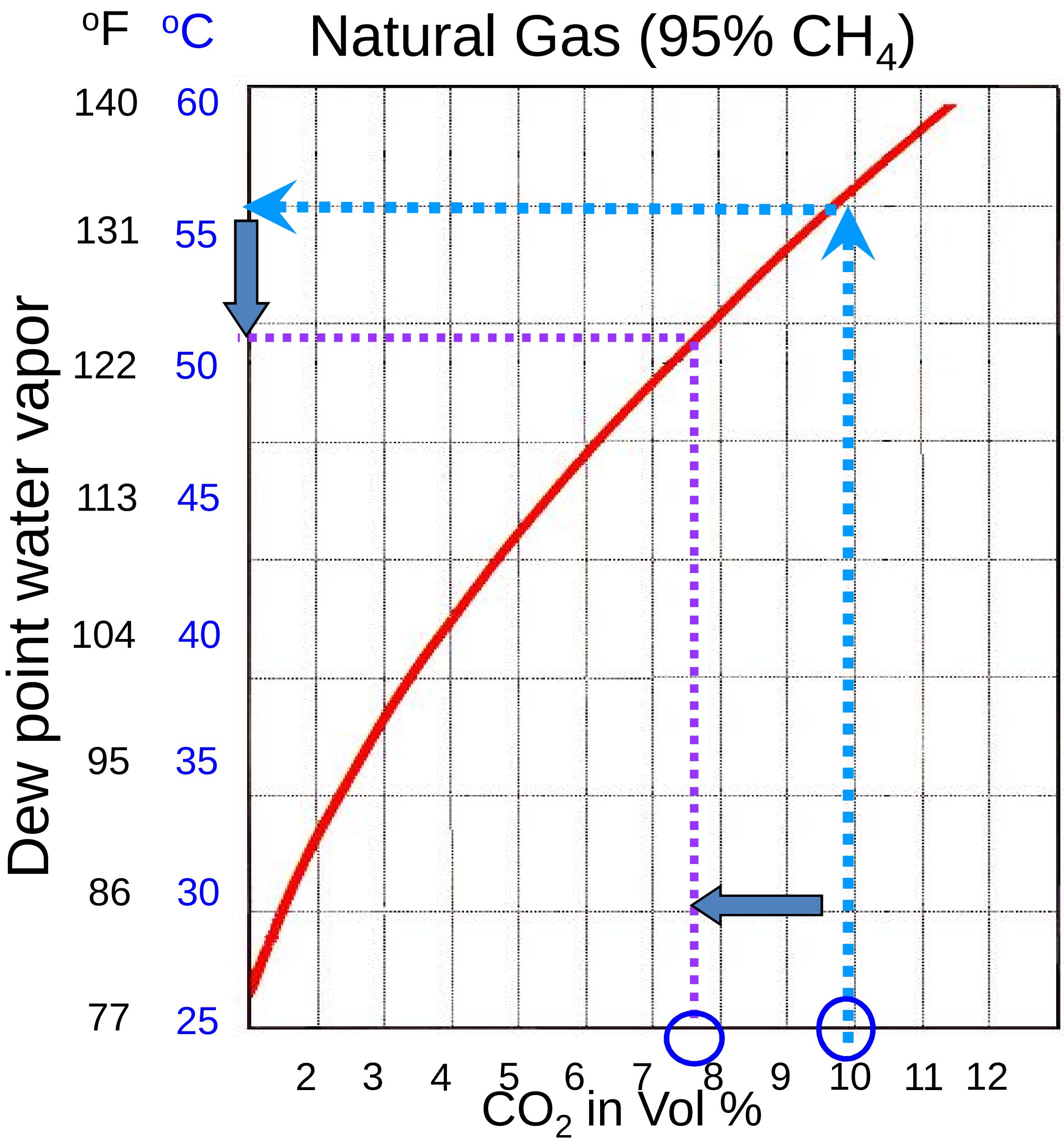
Condensing in a Boiler

CO2 vs. Excess Air





WATER VAPOR DEW POINT



CO_2% of flue gas influences dew point temperature

Higher CO_2
=Higher Dew point
=More Condensation

Lower CO_2
=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 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

CALEFFI
Hydronic Solutions

John Siegenthaler, P.E.

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.

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,

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John Siegenthaler, P.E.

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 Caleffi 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's 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* ¾-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

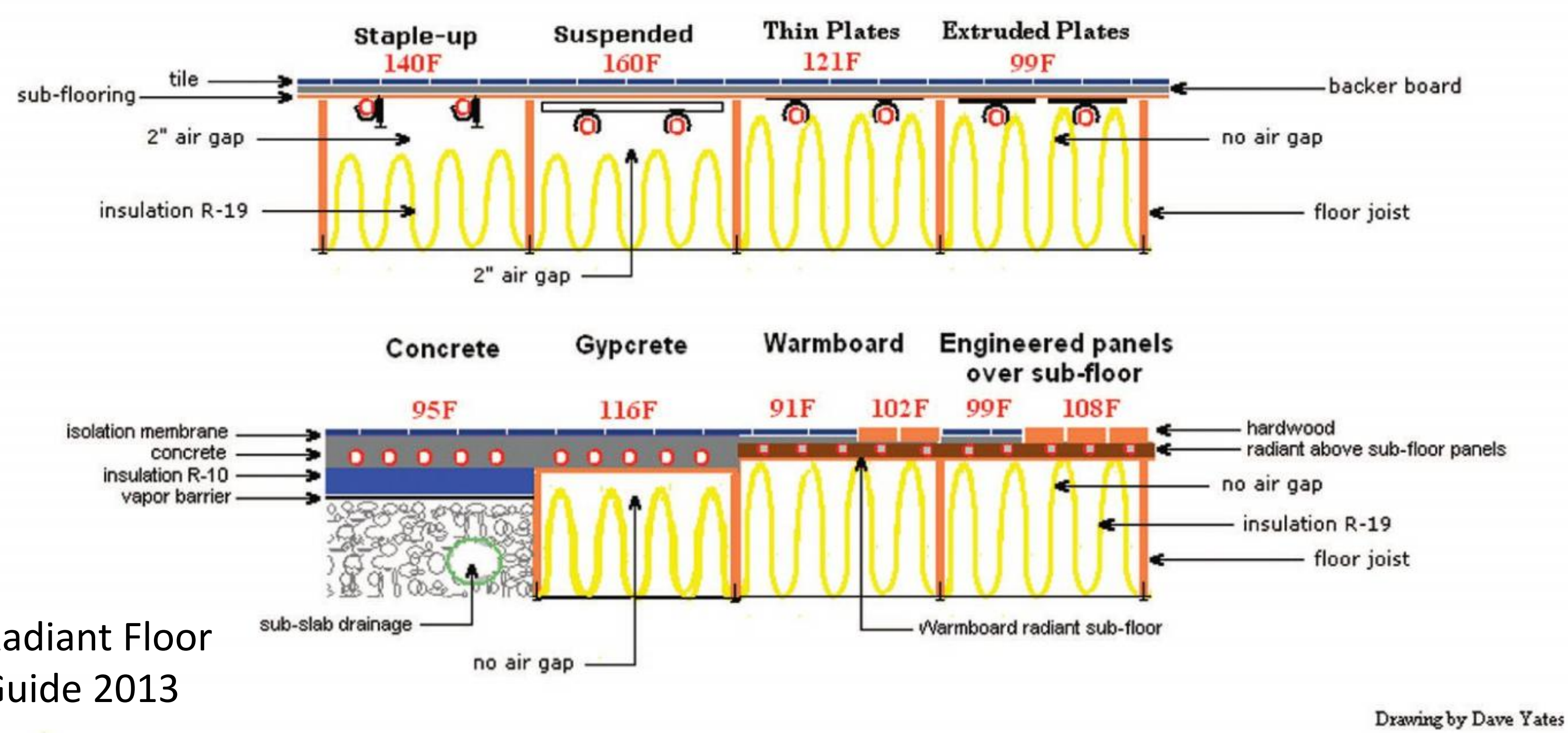
The key to achieving low water temperature operation is using heat emitters with large heated surface areas. The greater the heated surface area, the lower the required water temperature for a given rate of heat output.

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.



Radiant Floor Guide 2013

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.

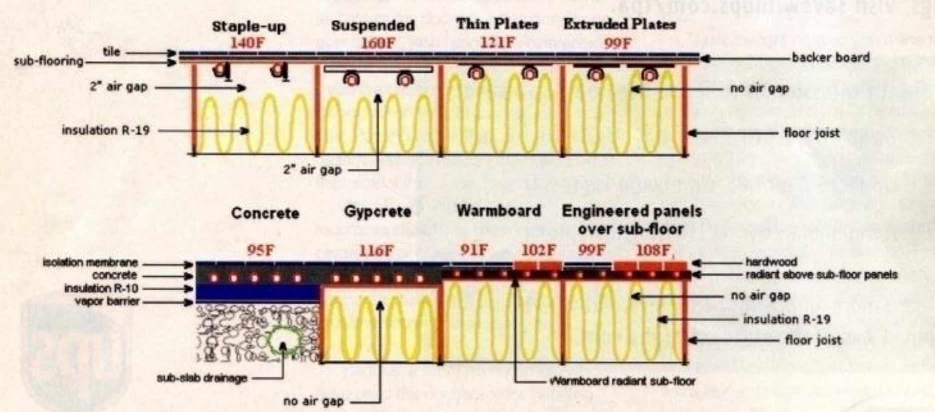
It is not unusual for room-by-room designs to require a wide variety of water delivery temperatures. Numerous reliable methods are available to precisely control multiple-temperature delivery from a single-temperature source or from blended systems where multiple- and varying-temperature energy sources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

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



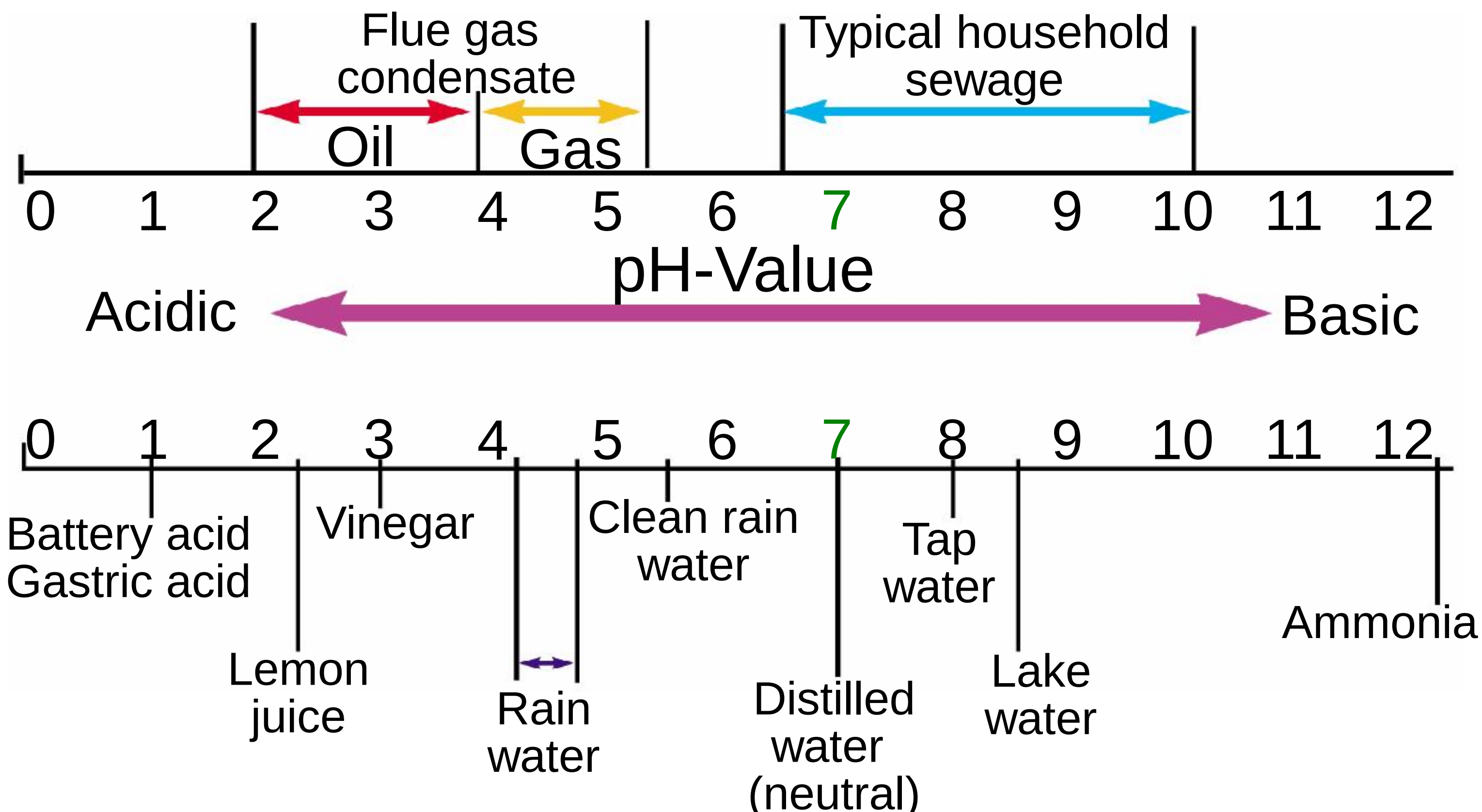
Drawing by Dave Yates

Handling
the
Condensate

Handling the Condensate

pH VALUES OF VARIOUS FLUIDS

Condensate – the NON-Issue



ASHRAY Presentation by Jim Cooke Mechanical Solutions NW, Nov 2005

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

FCX Oil-Fired Condensing Boiler

92-97% Efficient

The Most Efficient Oil-Fired Boiler

The State of Alaska and the City of Fairbanks Have Adopted the International Mechanical Code

IMC 1002 - 2018

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. 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. Solar thermal water heating systems shall comply with Chapter 14 and ICC 900/SRCC 300.

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*.

The FCX is defined by its Certification

The FCX is
UL 732 Certified as an
Oil-Fired Water Heater
And is Exempt from UL 726 Boiler Code

SECTION1003
PRESSURE VESSELS

1003.1 General.

All pressure vessels, **unless otherwise approved.** shall be constructed and certified in accordance with the ASME Boiler and Pressure Vessel Code. and shall be installed in accordance with the manufacturer's instructions and nationally recognized standards. Directly fired pressure vessels shall meet the requirements of Section 1004 [Boilers].

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

3800 F° Flow of Combustion Gas 150 F°

80 F° Parallel Flow of Water 150 F°

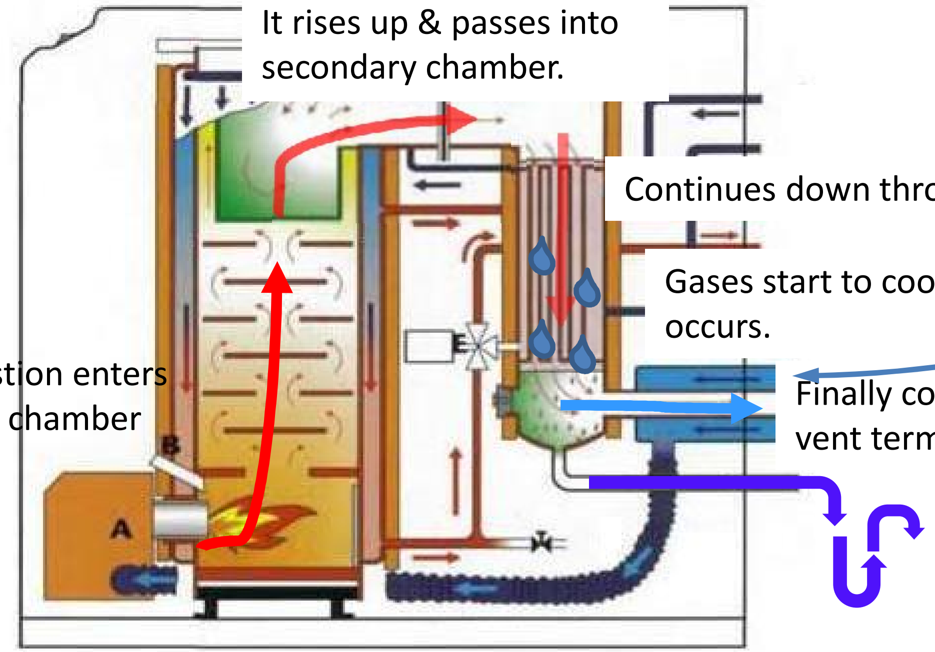
[In Parallel Flow] "…the temperature of the cold fluid exiting the heat exchanger never exceeds the lowest temperature of the hot fluid [gases]. This relationship is a distinct disadvantage if the design purpose is to raise the temperature of the cold fluid."

3800 F° Counter Flow of Water 80 F°

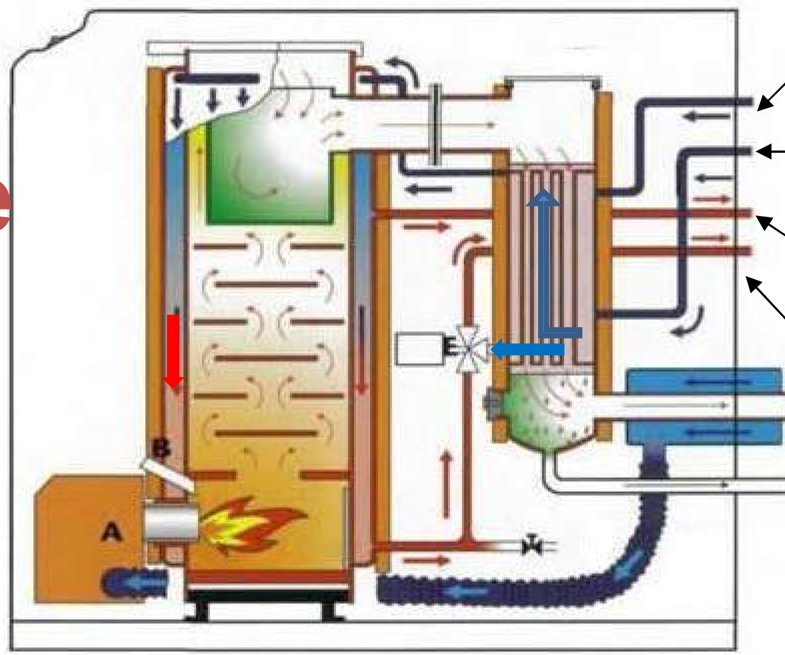
http://www.engineersedge.com/heat_transfer/parallel_counter_flow_designs.htm

Counter Flow Heat Exchange

Combustion Gas Flow →



Water Flow →

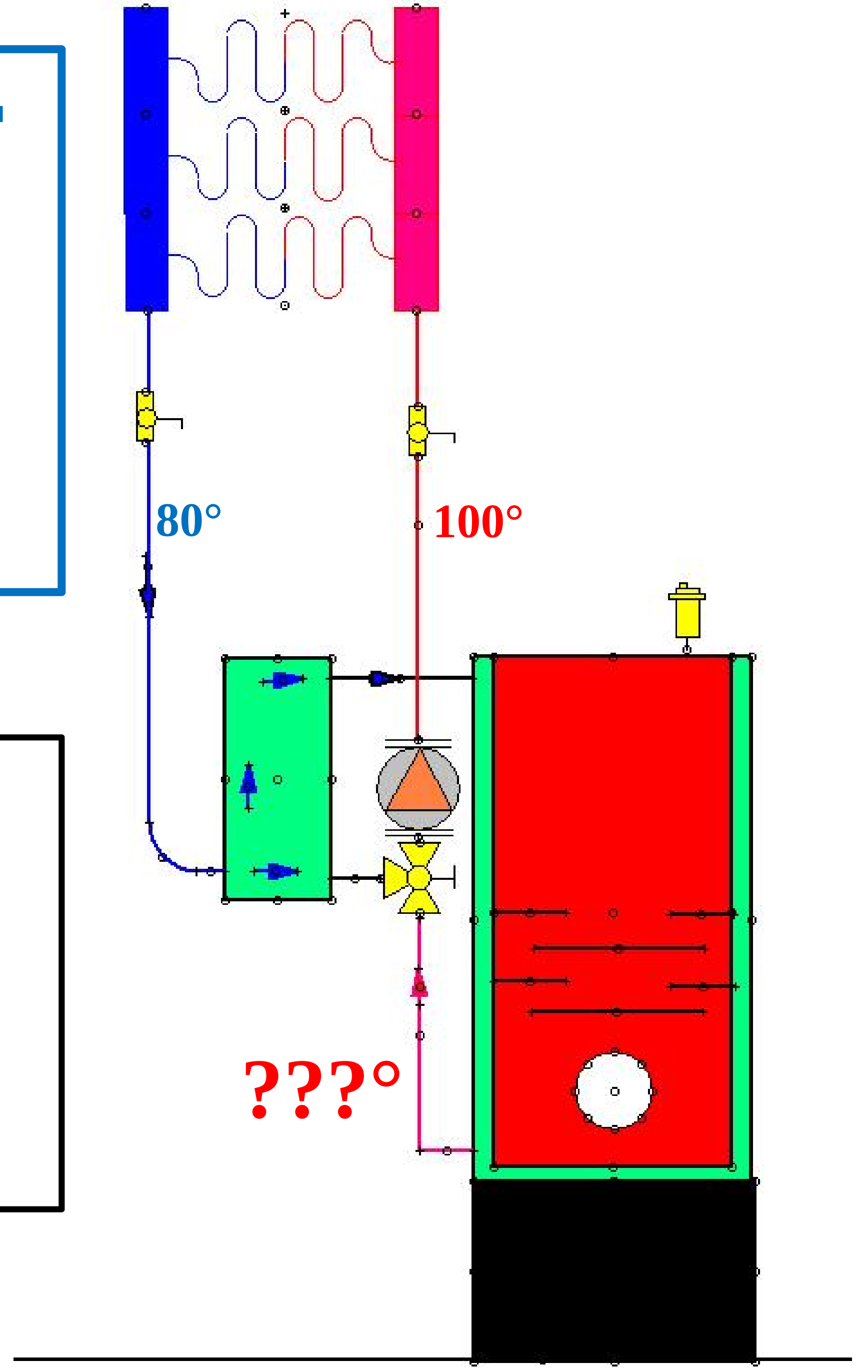


The Effects of Boiler Temperature on Mixing Efficiencies

Supply Target 100°

Return Temp 80°

Boiler Supply 160° vs. 120°



Compare

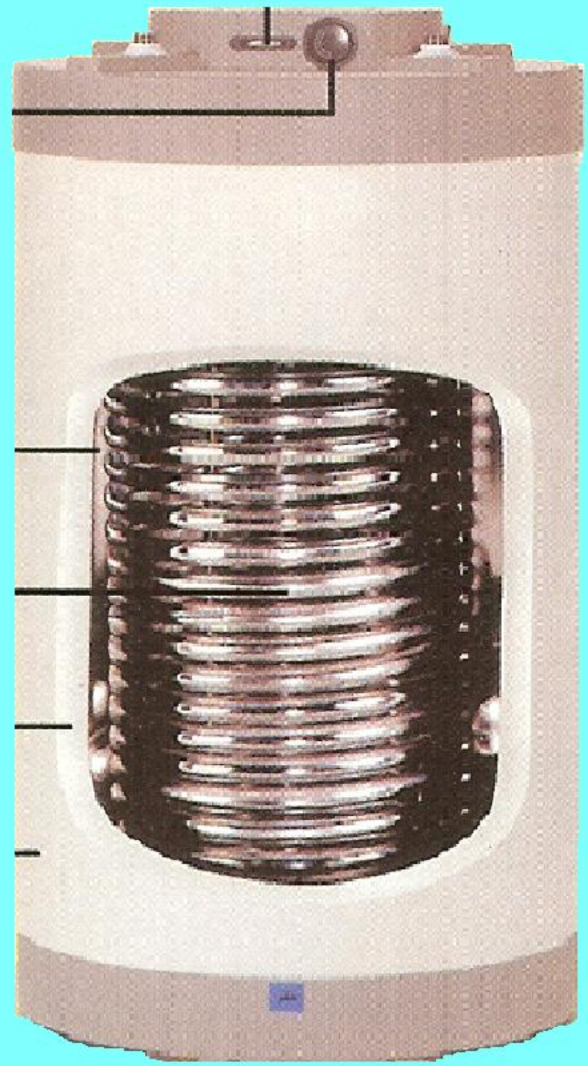
[120 – 100] / (120-80) = 20 / 40 = 50%

[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



First Hour Ratings Comparisons

Geminox BS50 — First Hr Rating **430**

	Power exchanged at ΔT 38°K	Continuous flow rate at 104°F	Specific flow rate	Heating time at 140°F (*1)	Lead time	Drawable volume at 140°F in 10 min	Drawable volume at 140°F in 1 hour	Drawable volume at 140°F in 10 min	Drawable volume at 140°F in 1 hour
						Storage at 176°F		Storage at 140°F	
	Btu/h	gal/min	gal/min	min	min	gallons	gallons	gallons	gallons
BS 25	119425.5	4.4	8.3	7	13	73	285	60	282
BS 40	119425.5	4.4	8.5	11	20	98	310	69	290
BS 50	204729.5	7.8	10.8	9	16	135	512	108	487
BS 80	211553.5	7.8	12.7	13	22	186	587	137	519

Cold water temperature = 10°C / 50°F
Primary temperature = 80°C / 176°F

Performances obtained with a power generator at least equal to that of the exchanger.

(*1): after 10 mins' drawing.

Models		BS25	BS40	BS50	BS80
Nominal Storage	GAL	25	40	50	80
Height	IN.	27.3	44.6	46.3	63
Diameter	IN.	23.6	23.6	23.6	23.6
All Pipe Connections	MPT	3/4"	3/4"	3/4"	3/4"
Max. DHW Pressure	PSI	150	150	150	150
Aquastat Range	°F	68-176	68-176	68-176	68-176
Aquastat Differential	°F	10.8	10.8	10.8	10.8
Inspection Port Opening	IN.	3.5	3.5	3.5	3.5
Nominal Exchanger Power at 176°F Av. Boiler Water Temperature	MBH	113	113	200	210
Nominal Preheat Time from 50°F to 140°F stored	MIN.	10	15	11	17
Continuous Output at 110°F	GPM	3.8	3.8	6.5	6.7
Nominal First Hour Draw at 70°F Rise	GAL.	230	340	430	465
Dry Weights	LBS.	71	88	121	139

Triangle tube Smart 50 — #1 **220** — #2 **370**

Model	Boiler Heating Capacity MBH	Peak Flow Gal./10 min.	1st Hour Flow Gal./Hour	Continuous Flow Gal./Hour	Circulator Min. GPM
SMART 20	79	35	120	105	5
SMART 30	87	40	140	115	5
SMART 40	112	50	180	150	7
SMART 50	140	65	220	185	8
SMART 60	270	100	410	360	16
SMART 80	300	125	460	400	18
SMART 100	337	150	525	450	25
SMART 120	420	190	650	560	28
Conditions:	50° F Domestic Cold Water Inlet Temperature 140°F Domestic Hot water Outlet Temperature 200°F Boiler Water Supply Temperature				

Model	Boiler Heating Capacity MBH	Peak Flow Gal./10 min.	1st Hour Flow Gal./Hour	Continuous Flow Gal./Hour	Circulator Min. GPM
SMART 20	95	50	195	175	6
SMART 30	115	60	235	210	8
SMART 40	130	70	270	240	9
SMART 50	180	95	370	330	12
SMART 60	320	145	635	590	21
SMART 80	340	165	690	630	24
SMART 100	380	185	775	700	26
SMART 120	445	235	915	820	30
Conditions:	50° F Domestic Cold Water Inlet Temperature 115°F Domestic Hot water Outlet Temperature 200°F Boiler Water Supply Temperature				

Buderus LT Series LT200 — **176**

2.6 Technical Data

	Unit	LT160/1	LT200/1	LT300/1
Tank capacity				
Tank capacity (total)	gal (l)	42.6 (160)	52.5 (200)	76 (300)
Maximum flow rate	gpm (l/min)	4.2 (16)	5.3 (20)	7.8 (30)
Maximum hot temperature (on the domestic hot water side)	°F (°C)	203 (95)	203 (95)	203 (95)
Maximum operating pressure DHW	psi (bar)	150 (10.3)	150 (10.3)	150 (10.3)
Stand-by heat loss (at 145 °F (65 °C) hot water temperature and 68 °F (20 °C) room temperature)	°F/h (K/h)	0.63 (0.27)	0.63 (0.25)	0.39 (0.20)
DHW tank performance at:				
Domestic cold water inlet temperature	°F (°C)	50 (10)	50 (10)	50 (10)
Domestic hot water outlet temperature	°F (°C)	140 (60)	140 (60)	140 (60)
DHW temperature rise	°F (°C)	90 (50)	90 (50)	90 (50)
Heat exchanger supply temperature (heating water)	°F (°C)	176 (80)	176 (80)	176 (80)
Flow rate (heating water)	gpm (l/h)	14 (3180)	14 (3180)	14 (3180)
Pressure drop (heating water)	fdh (mbar)	2.4 (71)	2.8 (84)	3.2 (98)
Continuous rating	gph (l/h) gpm (l/min)	122 (461) 2.03 (7.7)	128 (486) 2.13 (8.1)	208 (787) 3.50 (13.1)
Amount that can be drawn off in the first hour	gph (l/h)	160 (614)	176 (667)	276 (1046)
Maximum heat input	btu/hr (kW)	76,086 (22.3)	82,985 (24.3)	126,323 (37.0)
Heat exchanger				
Content	gal (l)	1.7 (6.4)	1.9 (7.2)	3.2 (12.1)
Surface area	ft² (m²)	8.72 (0.81)	10.01 (0.93)	16.15 (1.50)
Maximum heating water temperature	°F (°C)	230 (110)	230 (110)	230 (110)
Max. operating pressure, heat exchanger	psi (bar)	232 (16)	232 (16)	232 (16)

Table 1 Technical Data

Burnham A — **225**

Ratings

Model Number	Maximum First Hour Rating at 135°F (gal./hr.)	Continuous Draw Rating at 135°F (gal./hr.)	Standby Loss (°F/hr.)	Minimum Boiler Output (MBtu/hr.)	Boiler Water Flow Rate (gal./min.)	Pressure Drop through Coil (ft. w.c.)
AL27SL	192	162	0.97	99	6	9.0
AL35SL	200	162	0.72	99	6	9.0
AL50SL	225	171	0.56	110	6	9.5
AL70SL	294	217	0.45	120	6	10.0
AL119SL*	339	235	0.39	149	14	17.0

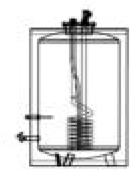
1. First flow ratings are based on 58°F inlet water, 135°F hot water and 180°F boiler supply water.
2. The above ratings were obtained at the boiler outputs (in MBtu/hr.) shown in column (4) at the boiler water flow rates (in GPM) shown in column (5). Other results will be obtained under different conditions.

* Note: The AL119SL utilizes a side mounted coil that is shipped separately.

Weil Mclai **293 interpolated**

Model AQUA PLUS	First Hour Rating (GPH)	Continuous Draw Rating (GPH)	Minimum Heat Output Rate (Btu/hr)	Minimum Heat Source Flow Rate (GPM)	Heat Source Friction Loss (Feet w.c.)	First Draw Rating (GPH)	Standby Loss (Degrees F per hour)	The ratings in this table are certified by AHRI. The conditions under which these ratings were obtained are listed below.
35	230.0	203.9	134,477	14.0	5.4	26.1	0.9	These ratings were obtained with a heat source output rate of 134,477 Btu/hr at a heat source flow rate of 14 gpm. Other results will be obtained under different conditions.
45	263.7	228.2	150,488	14.0	8.8	35.6	0.8	These ratings were obtained with a heat source output rate of 150,488 Btu/hr at a heat source flow rate of 14 gpm. Other results will be obtained under different conditions.
55	322.9	265.8	175,320	13.9	4.2	57.1	0.5	These ratings were obtained with a heat source output rate of 175,320 Btu/hr at a heat source flow rate of 13.9 gpm. Other results will be obtained under different conditions.
85	341.4	270.3	178,279	14.0	5.4	71.0	0.5	These ratings were obtained with a heat source output rate of 178,279 Btu/hr at a heat source flow rate of 14 gpm. Other results will be obtained under different conditions.
105	453.7	373.0	245,926	14.0	7.1	80.8	0.4	These ratings were obtained with a heat source output rate of 245,926 Btu/hr at a heat source flow rate of 14 gpm. Other results will be obtained under different conditions.

AHRI certified ratings: 180°F boiler water entering | 58°F to 135°F domestic 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

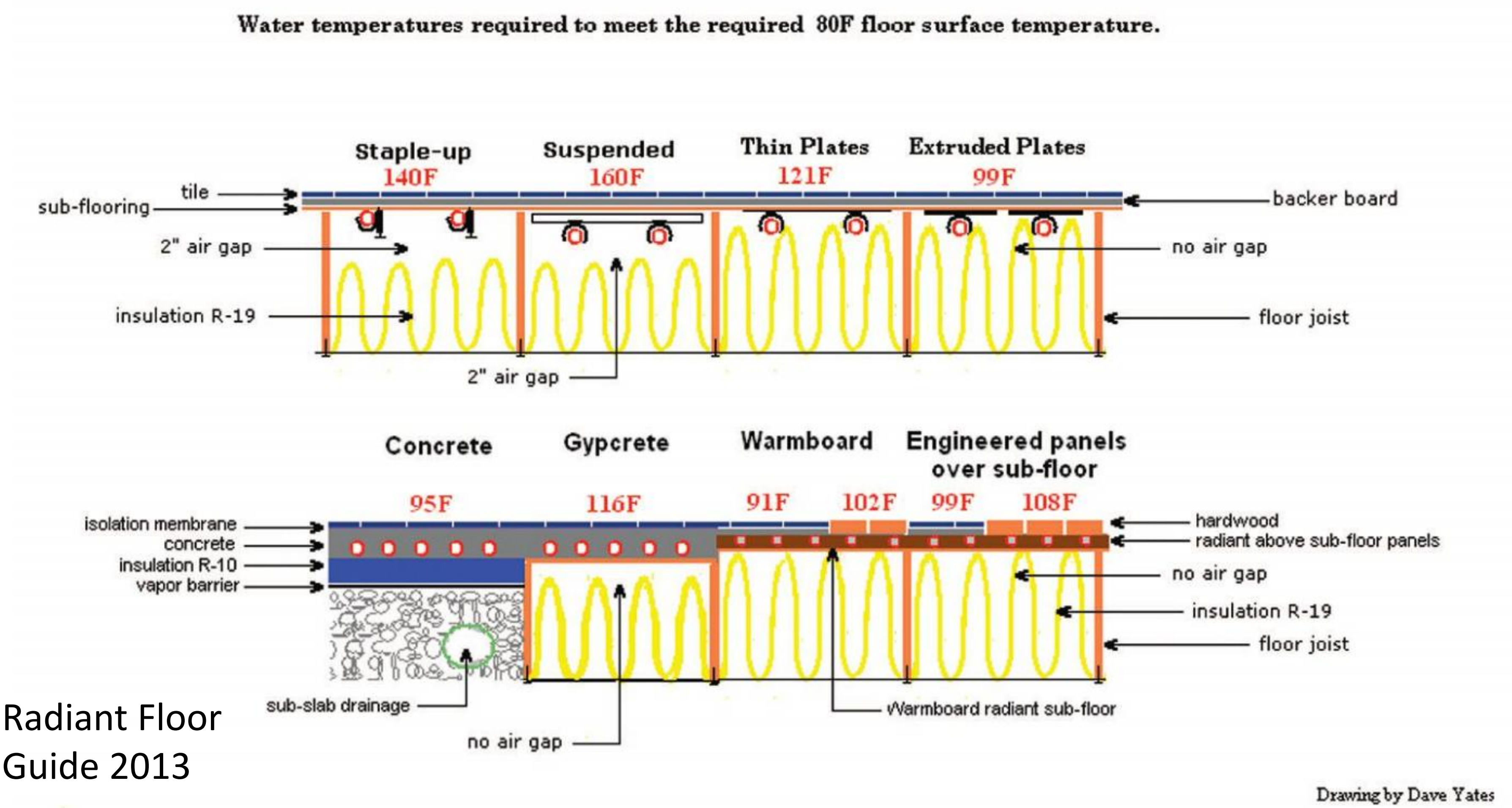
Application

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]



Radiant Floor Guide 2013

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, [Control boiler and mix supply temperatures based on need].**
- **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 Losses
- Over Sizing

Operating

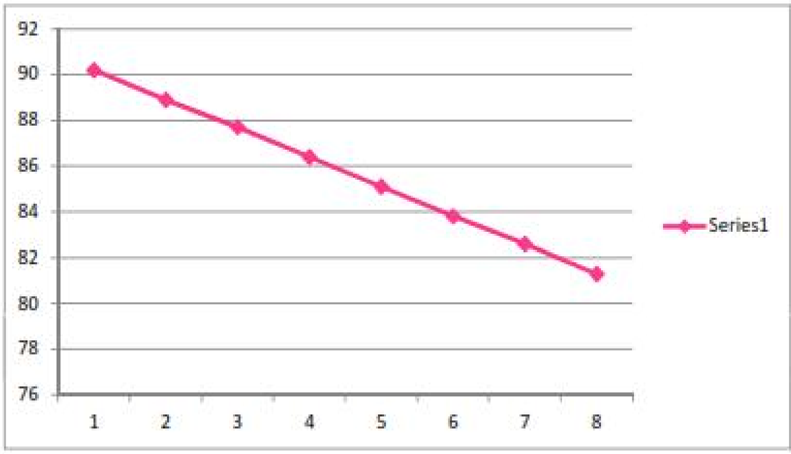
- Short Cycling
- High Stack Temperatures – 1.3% per every 50 degree drop
- Tuning - AFUE vs. Actual – under/over Performing, CO2, Excess Air, Stack Temps
- Boiler Temperatures - 1% loss per 10 degree
- Return Water Temperatures
- Condensing Effect
- Cold Starting
- Side Arms

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 effencies 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

%O2	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% CO_2 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, <u>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</u>.

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

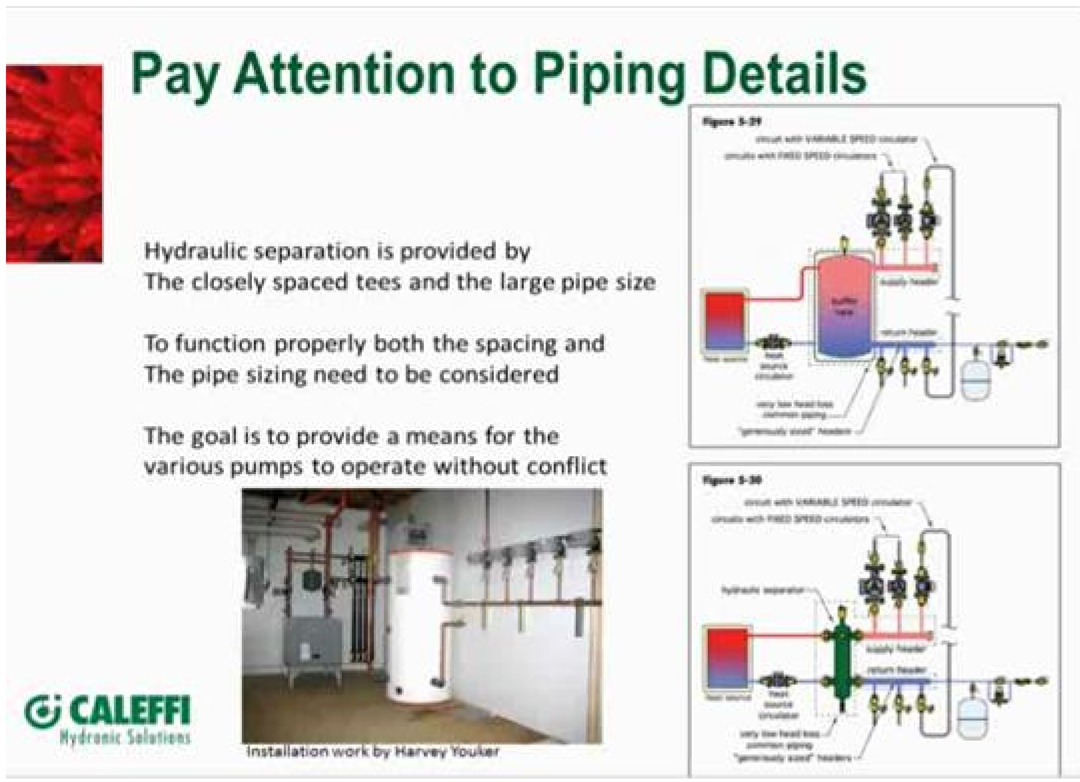
Design

&

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!!



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

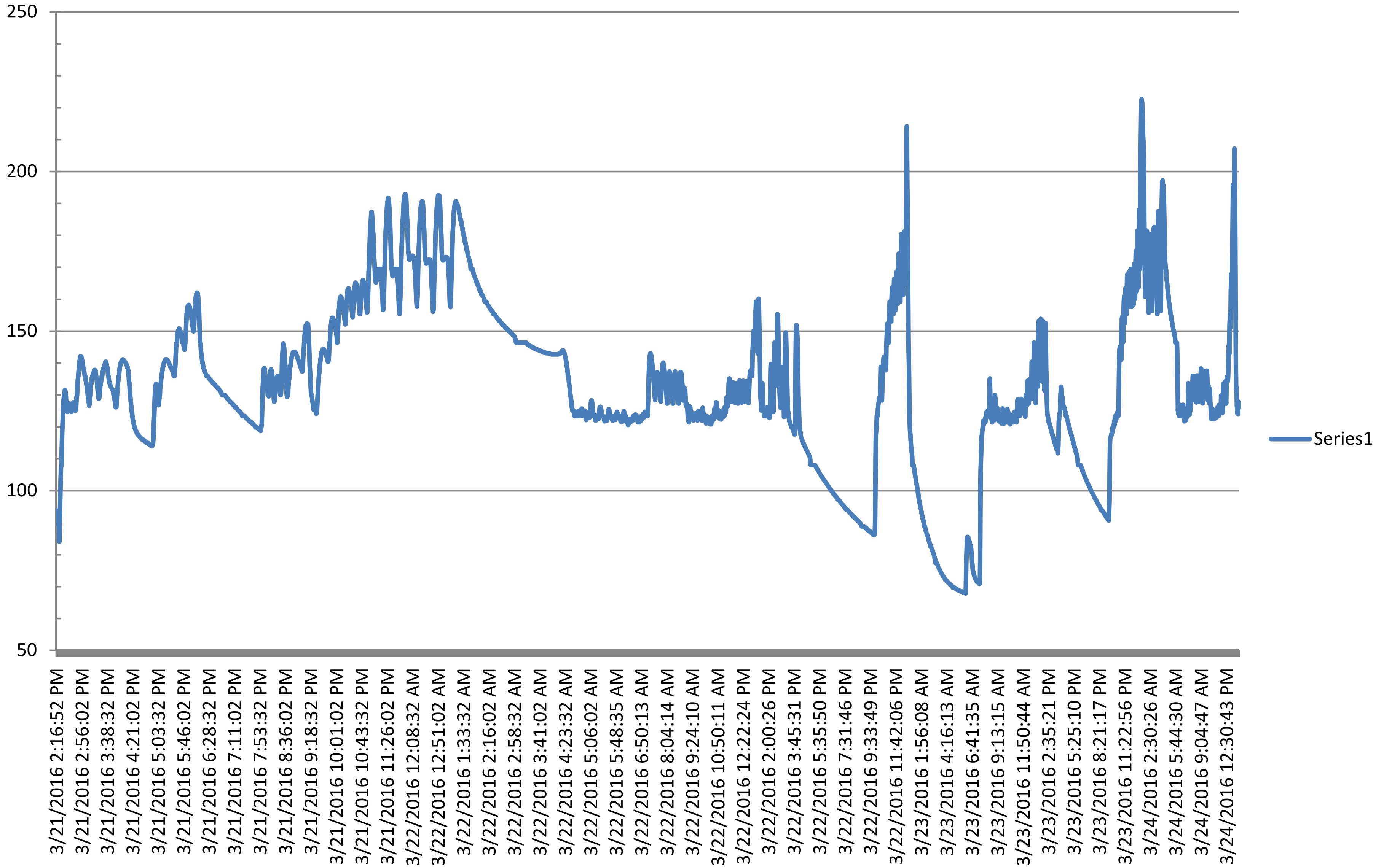
Control Options

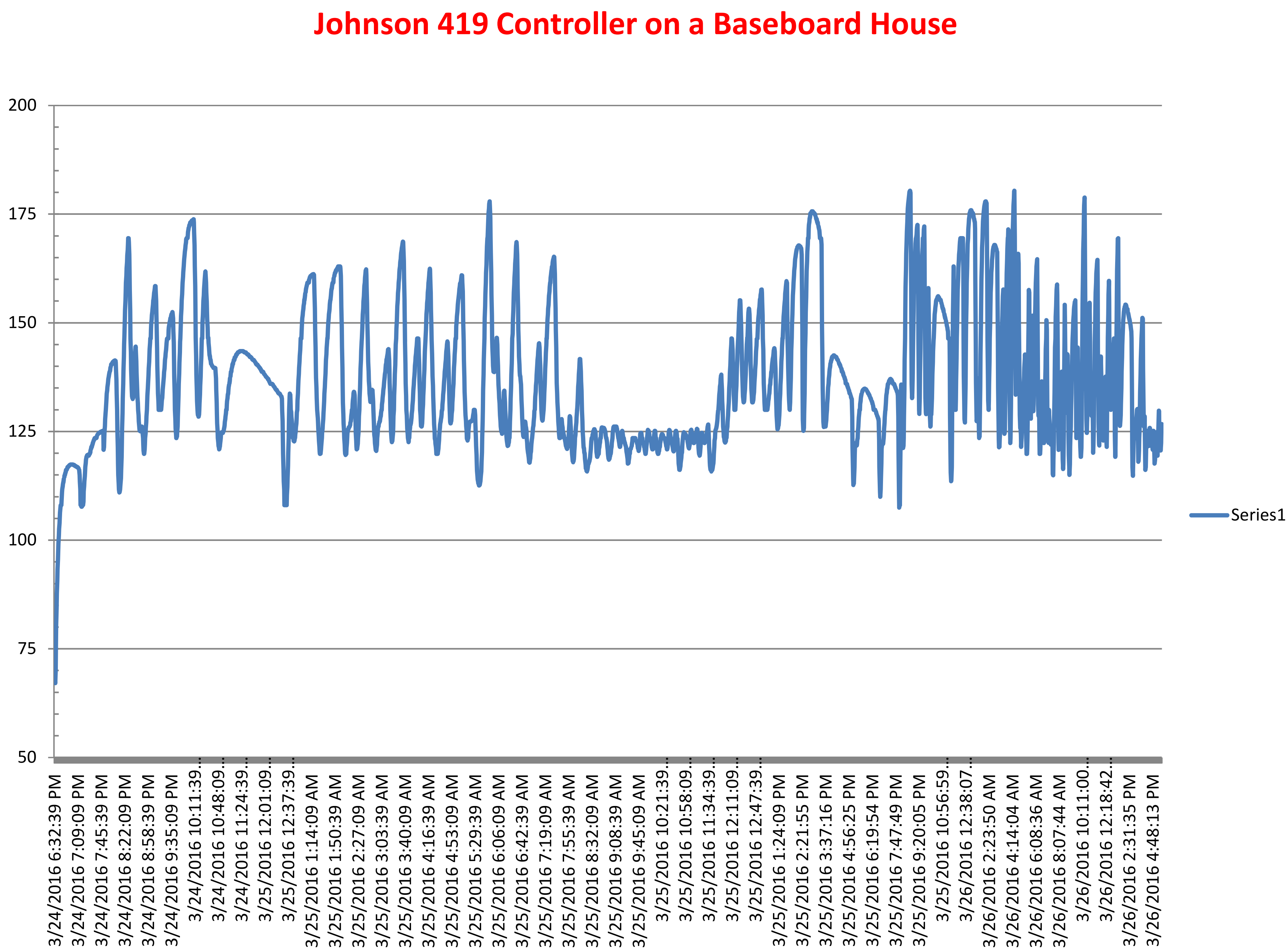
The FCX is a plug and play Boiler....but

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
200
175
150
125
100
75
50
Series1
3/24/2016 6:32:39 PM
3/24/2016 7:09:09 PM
3/24/2016 7:45:39 PM
3/24/2016 8:22:09 PM
3/24/2016 8:58:39 PM
3/24/2016 9:35:09 PM
3/24/2016 10:11:39…
3/24/2016 10:48:09…
3/24/2016 11:24:39…
3/25/2016 12:01:09…
3/25/2016 12:37:39…
3/25/2016 1:14:09 AM
3/25/2016 1:50:39 AM
3/25/2016 2:27:09 AM
3/25/2016 3:03:39 AM
3/25/2016 3:40:09 AM
3/25/2016 4:16:39 AM
3/25/2016 4:53:09 AM
3/25/2016 5:29:39 AM
3/25/2016 6:06:09 AM
3/25/2016 6:42:39 AM
3/25/2016 7:19:09 AM
3/25/2016 7:55:39 AM
3/25/2016 8:32:09 AM
3/25/2016 9:08:39 AM
3/25/2016 9:45:09 AM
3/25/2016 10:21:39…
3/25/2016 10:58:09…
3/25/2016 11:34:39…
3/25/2016 12:11:09…
3/25/2016 12:47:39…
3/25/2016 1:24:09 PM
3/25/2016 2:21:55 PM
3/25/2016 3:37:16 PM
3/25/2016 4:56:25 PM
3/25/2016 6:19:54 PM
3/25/2016 7:47:49 PM
3/25/2016 9:20:05 PM
3/25/2016 10:56:59…
3/26/2016 12:38:07…
3/26/2016 2:23:50 AM
3/26/2016 4:14:04 AM
3/26/2016 6:08:36 AM
3/26/2016 8:07:44 AM
3/26/2016 10:11:00…
3/26/2016 12:18:42…
3/26/2016 2:31:35 PM
3/26/2016 4:48:13 PM

Why Use Third Party Controls

- **FCX can just be plugged in so….why?**
- **Better temperature control**
  - **Core boiler temperature**
  - **Mixing temperature**
  - **Delta T functionallity**
  - **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

Taco SR502-4 Series

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

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

Manual Mix Control

The Best Solution

Tekmar 400 Series Digital House Controllers
Boiler / Mixing Valve / Temperature

Outside Reset
with
Indoor Feedback

This control is essential when retrofitting a Baseboard house because of the need to vary boiler temperature with the season. With radiant it provides additional efficiency, comfort, and boiler protection.

Tekmar 400 Series

Compare HVAC System Controls

System Requirements	256	260	261	279	356	360	361	362	374	400	401	402	403	422	423
Number of Water Temperatures Flexibility for custom applications	1	1	1	-	1	1	1	1	3	1	1	2	2	1&1*	4*
Number of Boilers Outdoor Temperature Reset control	1	1	2	1	1	1	1	1	2	1+	1+	1+	1+	1	2
Boiler Type On/Off (O) Modulating (M) or Steam (S)	O	O	O	S	O	O	O	O	O	O / M	O / M	O / M	O / M	O / M	O / M
Multi-Stage Boiler Expansion via EMS Control of additional boilers	-	-	-	-	-	-	-	-	-	•	•	•	•	•	•
DHW Through Valves (V) or Pumps (P) Domestic hot water operation	-	V/P	-	-	-	-	-	-	V/P	P	P	P	P	P	V/P
Setpoint Operation Hot water for hot-tubs, pools & snowmelt	-	-	•	-	-	-	-	-	•	•	•	•	•	•	•
Mixing Protects boiler	-	-	-	-	•	•	•	•	•	-	-	•	•	•	•*
Zone Control with Valves (V) or Pumps (P) Up to four onboard zones	-	-	-	-	-	-	-	-	-	V	P	V	P	-	-
Zone Expansion using Wiring Centers Offers quick installations & simple troubleshooting	•	•	•	-	•	•	•	•	•	•	•	•	•	•	•

Features & Benefits	256	260	261	279	356	360	361	362	374	400	401	402	403	422	423
Outdoor Temperature Reset Adjust water temperature based on outdoor temperature for energy savings	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Warm Weather Shut Down Shut down heating systems in warmer weather	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Automatic Differential Manage boiler run times to reduce cycling	•	•	•	-	•	•	•	•	•	•	•	•	•	•	•
Boiler Return Protection Limits the amount of cool return water to boiler	-	-	-	-	•	•	•	•	•	-	-	•	•	•	•
DHW Priority DHW has priority over space heating	-	•	-	-	-	-	-	-	•	•	•	•	•	•	•
Pump Exercising Briefly run pump to prevent seizing	-	•	•	-	•	•	•	•	•	•	•	•	•	•	•
tekmarNet® Communication - 2 or 4 Wire Network communication provides greater functionality	-	-	-	-	-	-	-	-	-	2	2	2	2	2 or 4	2 or 4

1+ Single modulating boiler **or** 2-stage boiler

* Requires addition of mixing expansion module

continued on next page

HVAC Systems
Heating, Ventilating & Air Conditioning

Compare HVAC System Controls Continued

Features & Benefits	256	260	261	279	356	360	361	362	374	400	401	402	403	422	423
Indoor Temperature Feedback Indoor zones report exact heating needs to the system control	-	-	-	•	-	-	-	-	-	•	•	•	•	•	•
Zone Synchronization Coordinate heat demands, minimize equipment cycling	-	-	-	-	-	-	-	-	-	•	•	•	•	•	•
Remote Monitoring Access tekmarNet® systems via the internet with a Gateway 483	-	-	-	-	-	-	-	-	-	•	•	•	•	•	•
Integrate with Home Automation Systems Connect to home automation systems with a Gateway 482	-	-	-	-	-	-	-	-	-	•	•	•	•	•	•
System Wide Control Add a User Switch to quickly adjust all networked thermostat settings	-	-	-	-	-	-	-	-	-	•	•	•	•	•	•

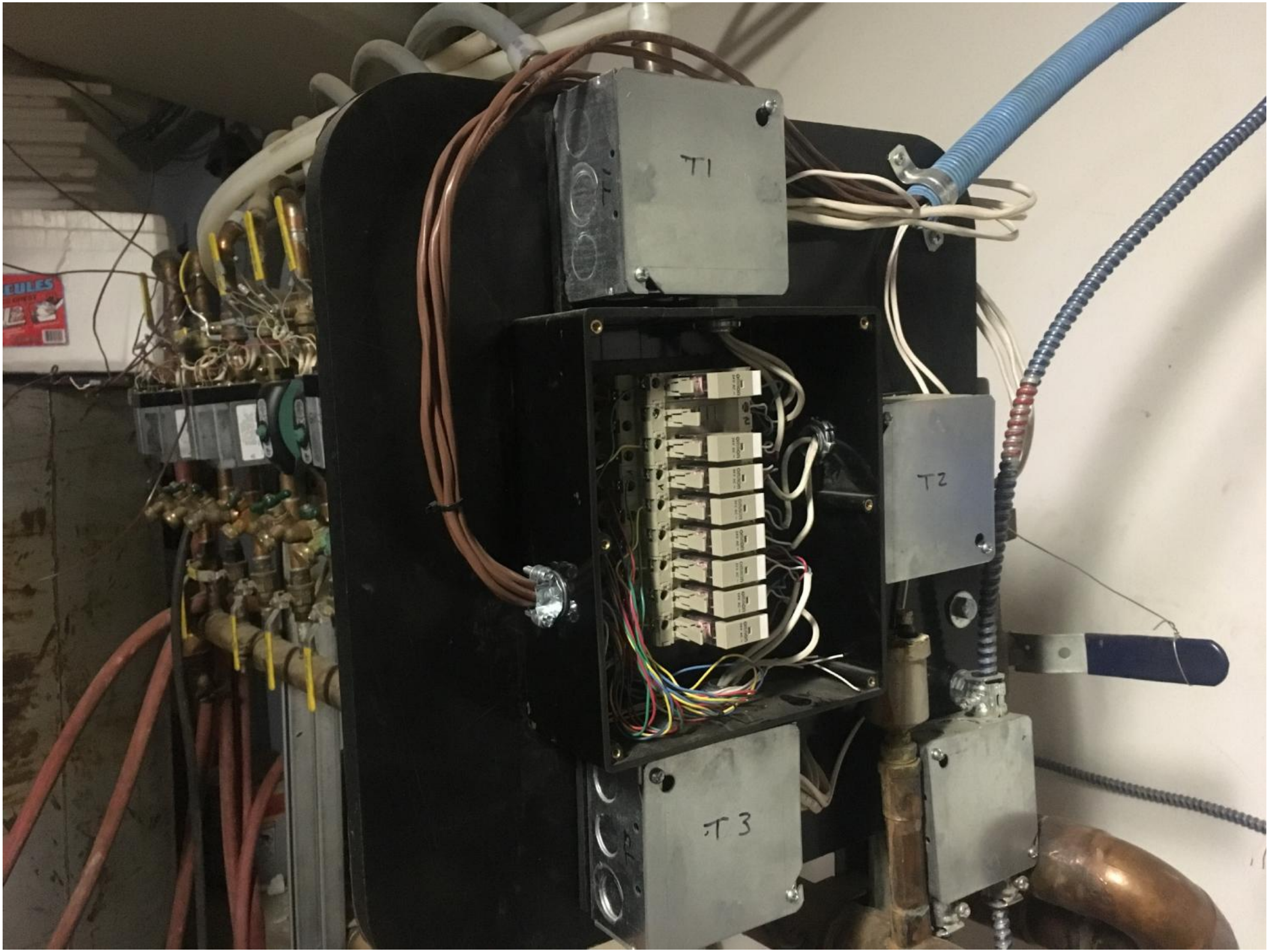
Compare Modulating Boiler Signals

	400	401	402	403	422	423
0-10 V (dc)	•	•	•	•	•	•
4-20 mA	•	•	•	•	-	-
EMS Stager	•	•	•	•	•	•
Temperature Target	•	•	•	•	-	-

Compare Designer Series Mixing Expansion Modules

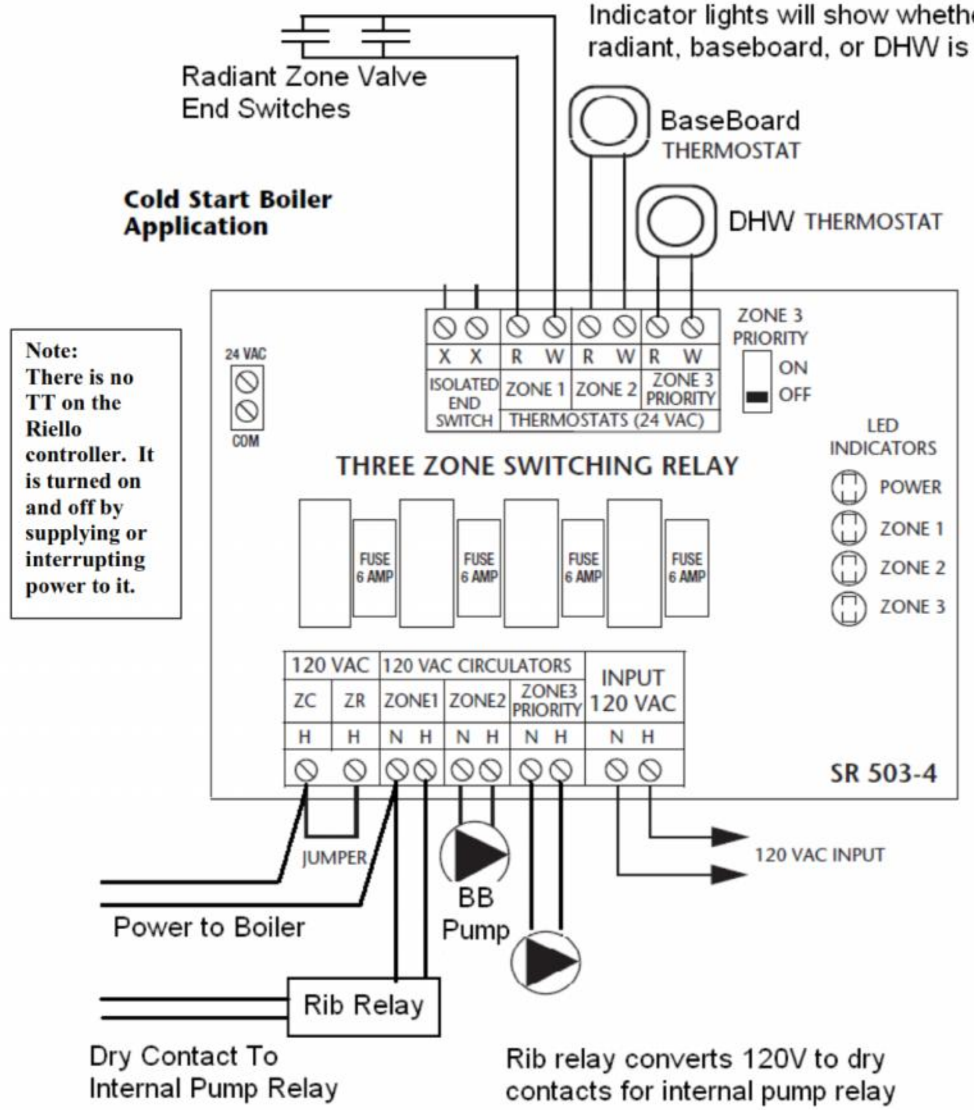
Pair mixing expansion modules with designer series reset modules to easily operate a mixing device within a tekmarNet® control system.

	440	441	444
Variable Speed	•	-	•
Floating Action	•	-	•
0-10 V (dc)	-	-	•
2-10 V (dc)	-	-	•
0-20 mA	-	-	•
4-20 mA	-	-	•
tekmarNet® valve actuator	-	•	-

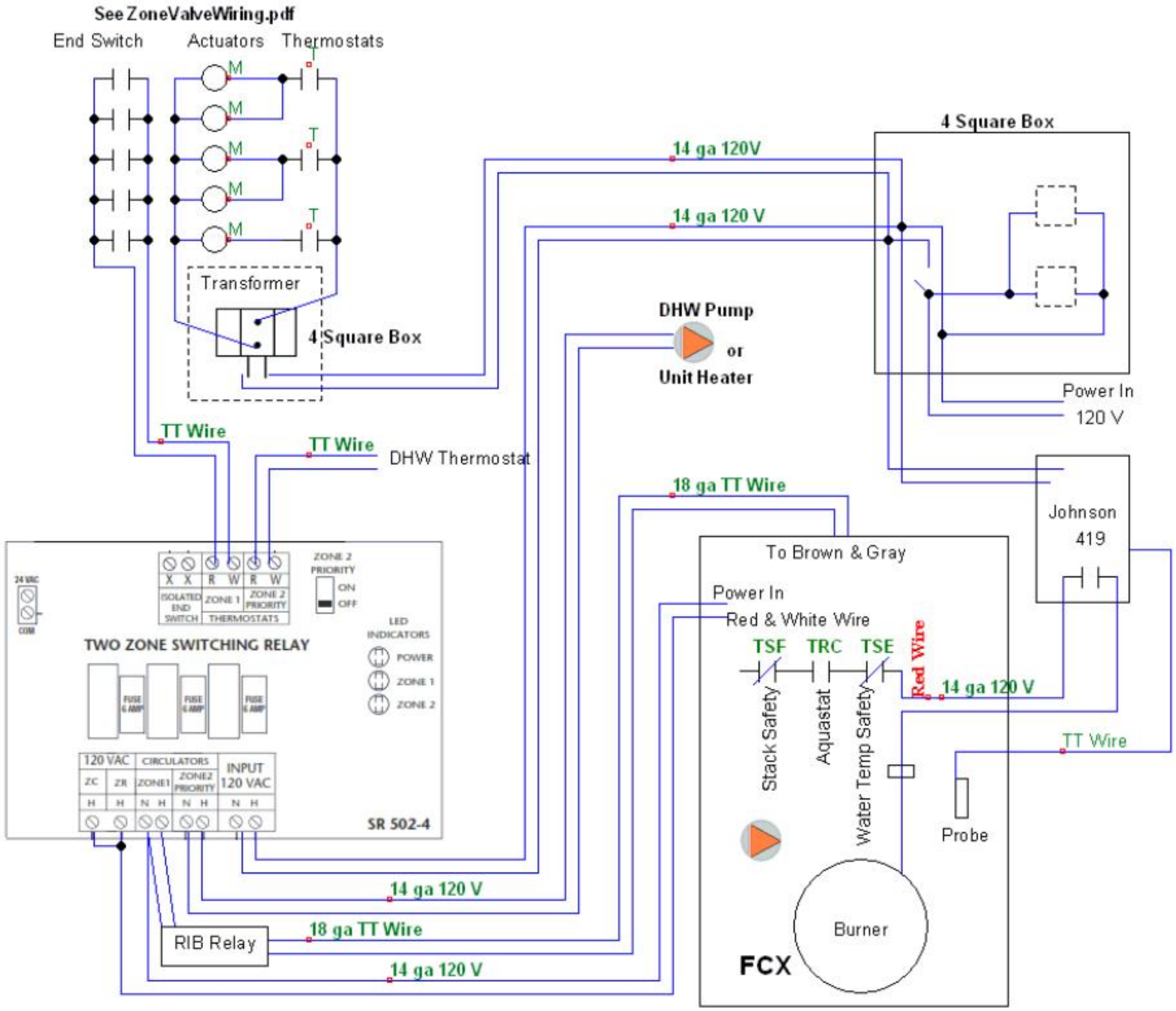

T1
T2
T3

How to Wire

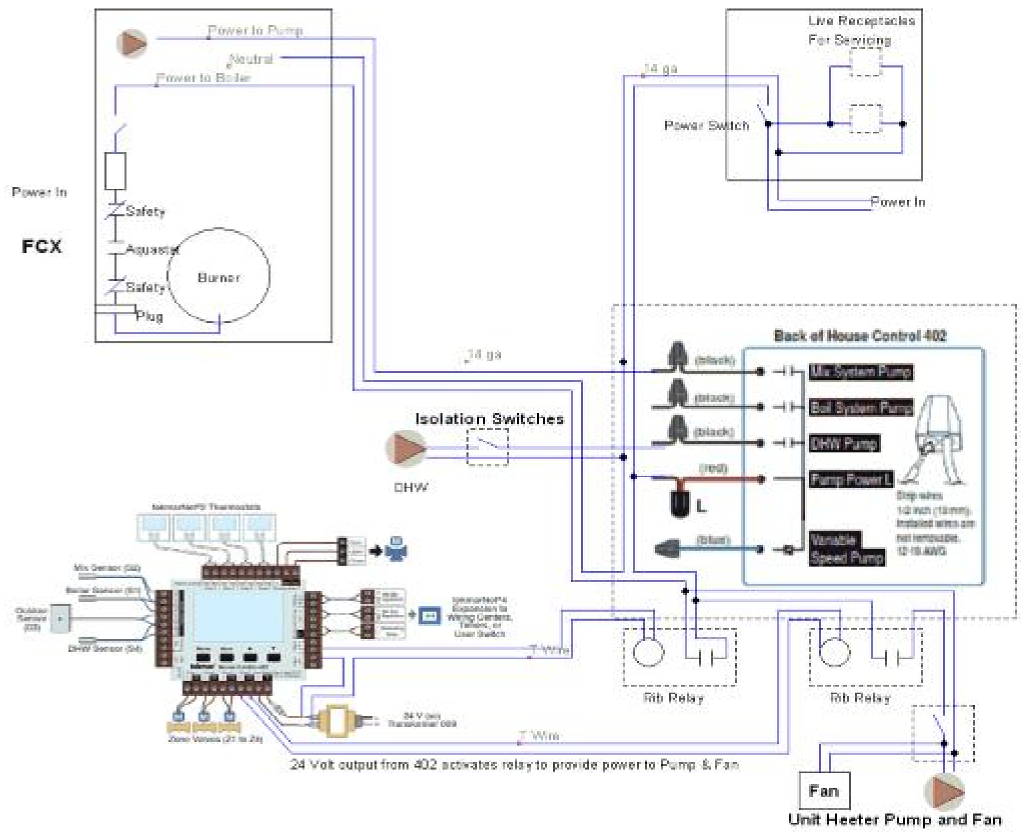
FCX Wiring for the Taco SR503-4
Three Pump Relay
Riello Burners
End Switches in Parallel for Multiple Zones



FCX Wiring with Taco SR502



FCX withTekmar 402, 3 Heating Zones
DHW and a Unit Heater
Controlling 3 pumps



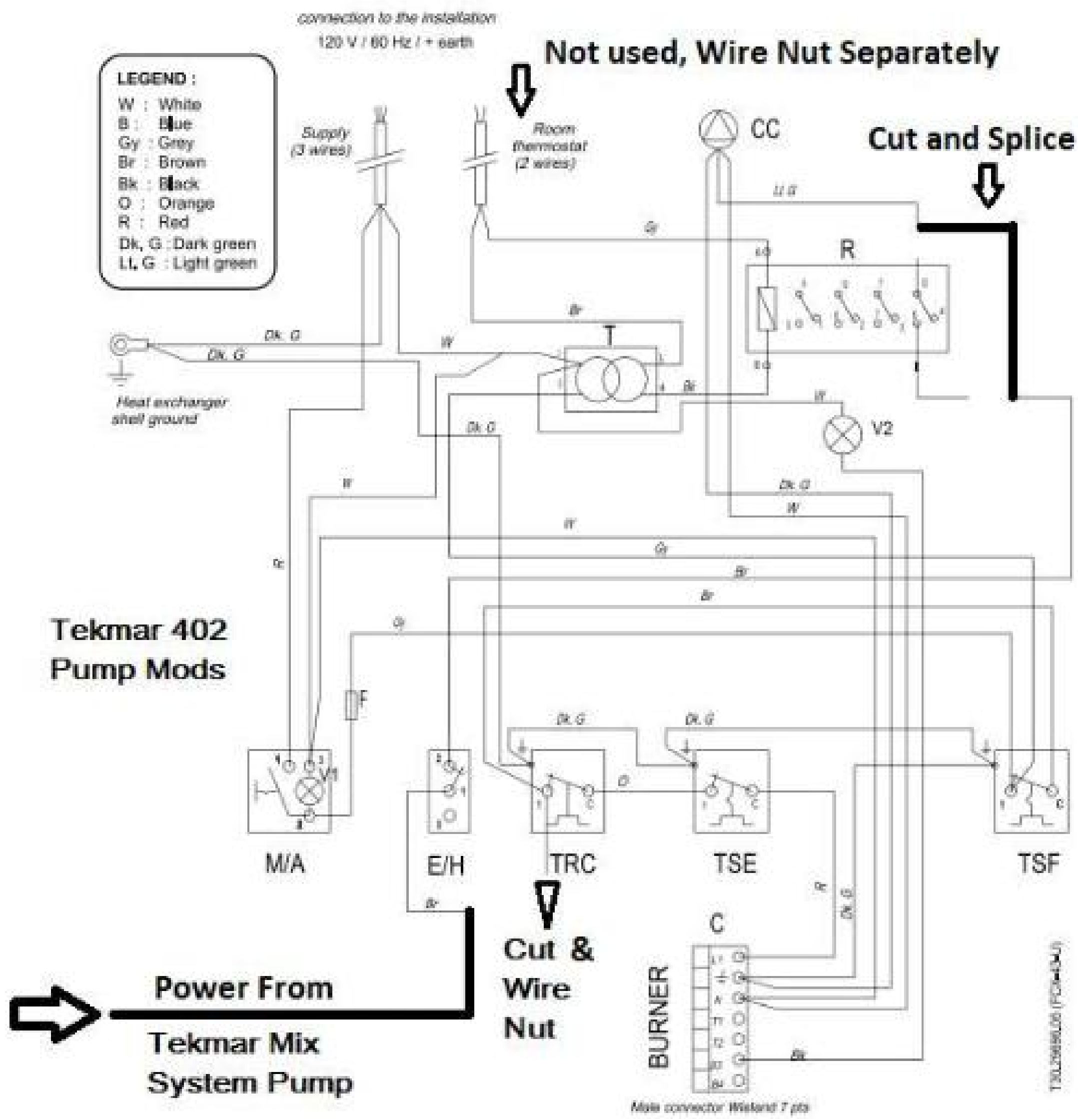
Notes:

The FCX has no TT on its controller, it is turned off and on by interrupting power to the boiler using a RIBU1C 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

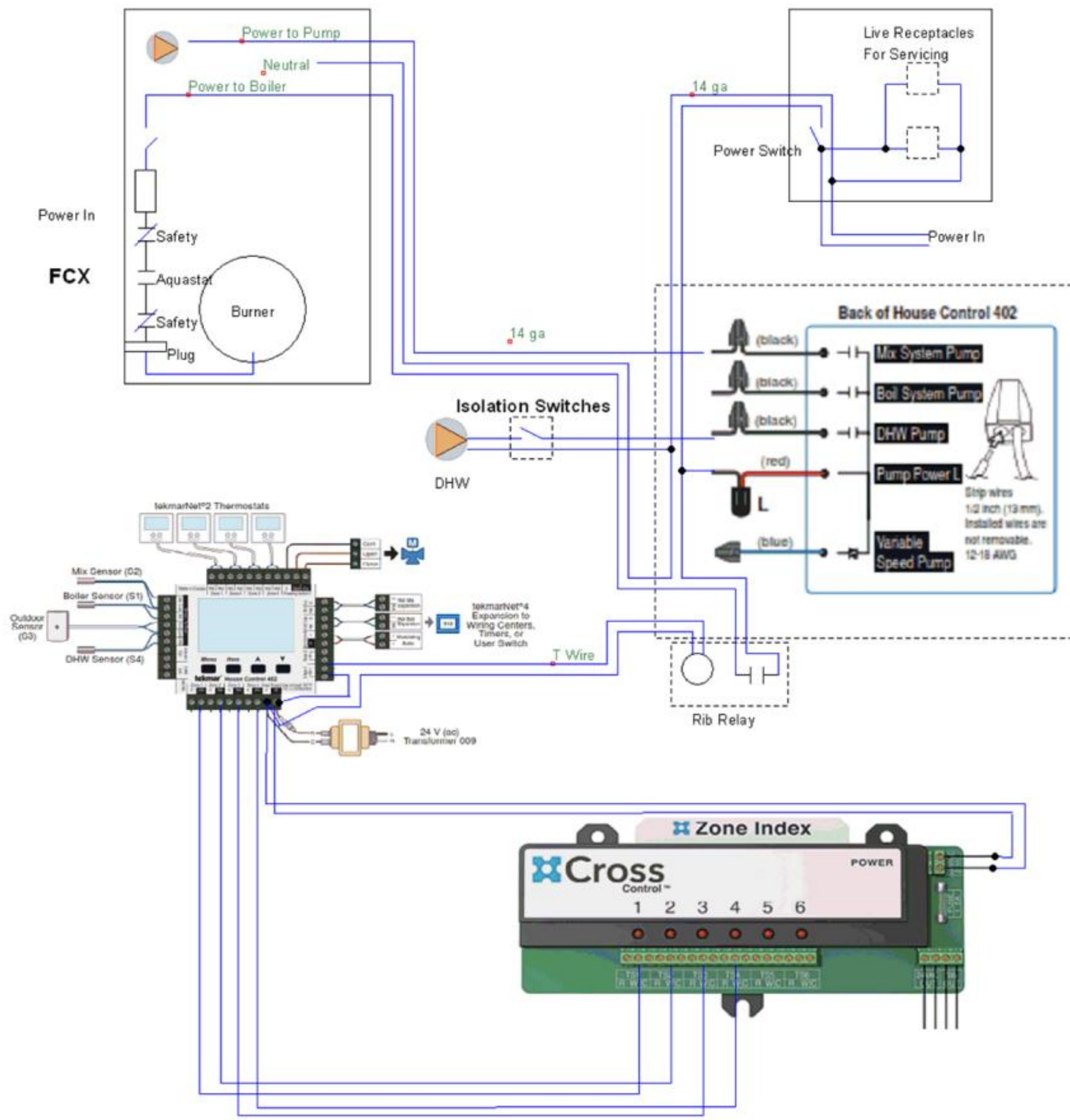
F : Fuse (6,3 A)

R : Relay

T : Main transformer 120/24 volts

CC : Circulating pump

Tekmar 402 with Cross Manifold



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 ½ the electricity at full speed
  - ECM pumps at low speeds – 10 to 12 watts
- Forget the Old School - The more the better???

Reduce ½ Vol = 1/8 power Also Eliminates Need for By-Pass Valves

The pumping can have a great effect on efficiency

Consider

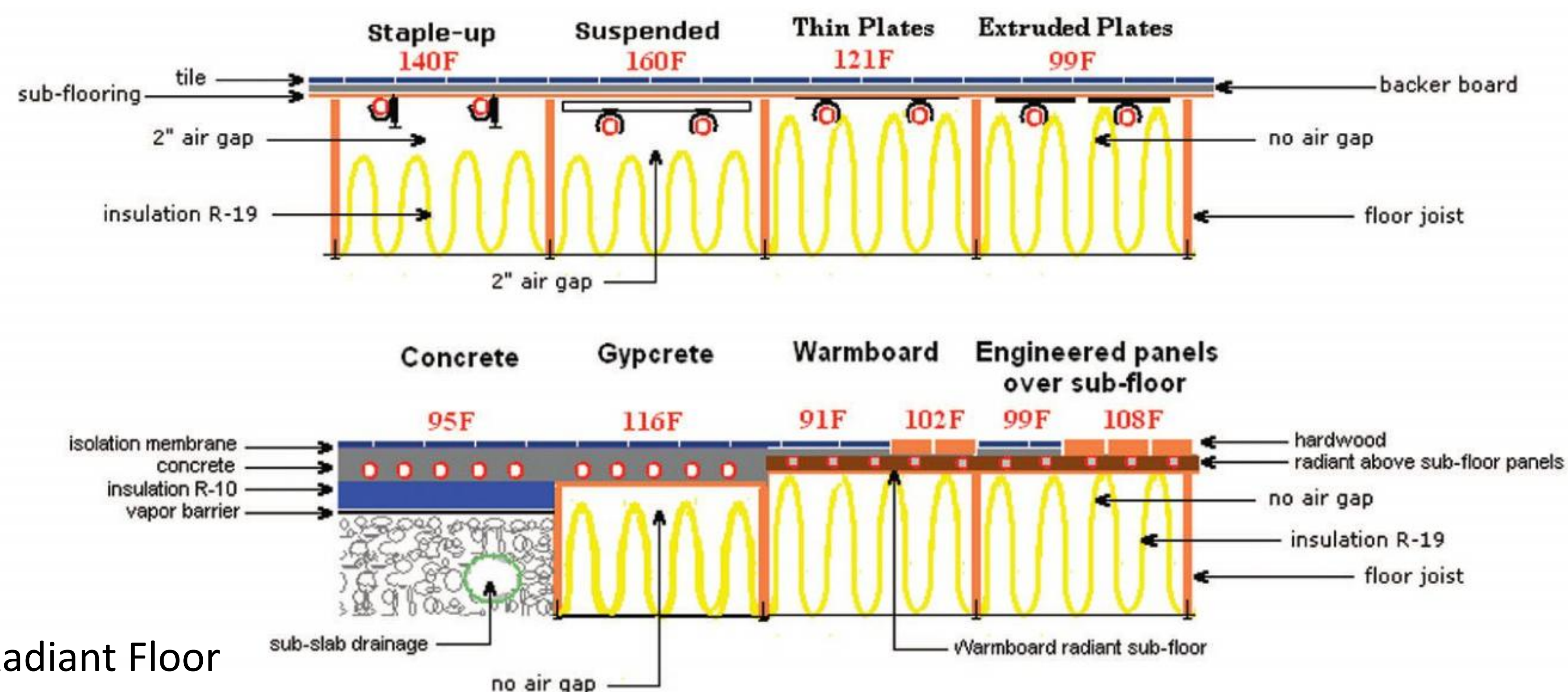
10 gpm at 10° ΔT or 5 gpm at 20° ΔT




Typical Floor Types

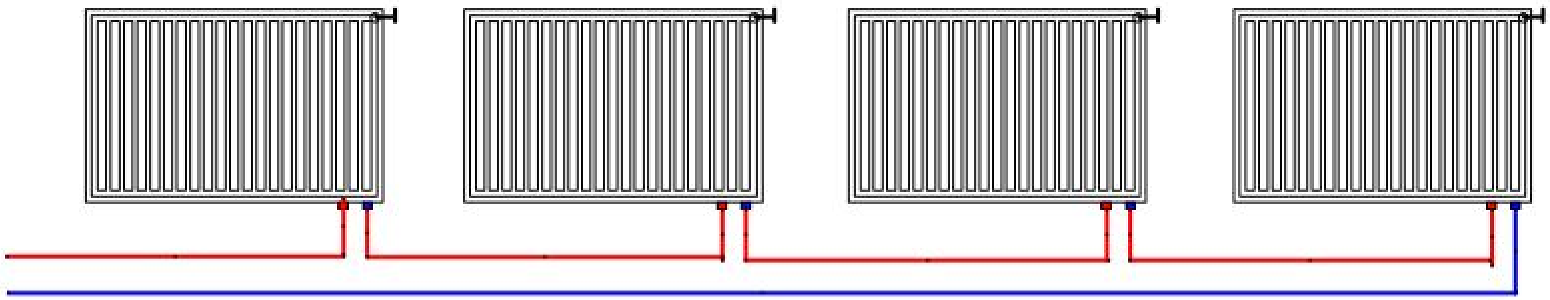
The Major Factor: "The lower the systems temperature requirements, the better the overall system-wide efficiency, which will ensure the lowest possible operating costs for fuel and power." [and the Most Condensing and Lowest Stack Temperatures]

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



Drawing by Dave Yates

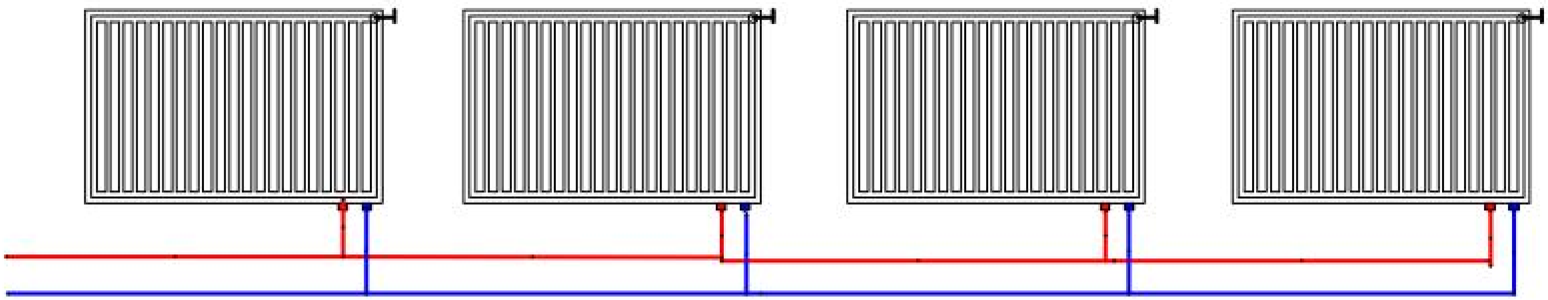
Radiant Floor Guide 2013



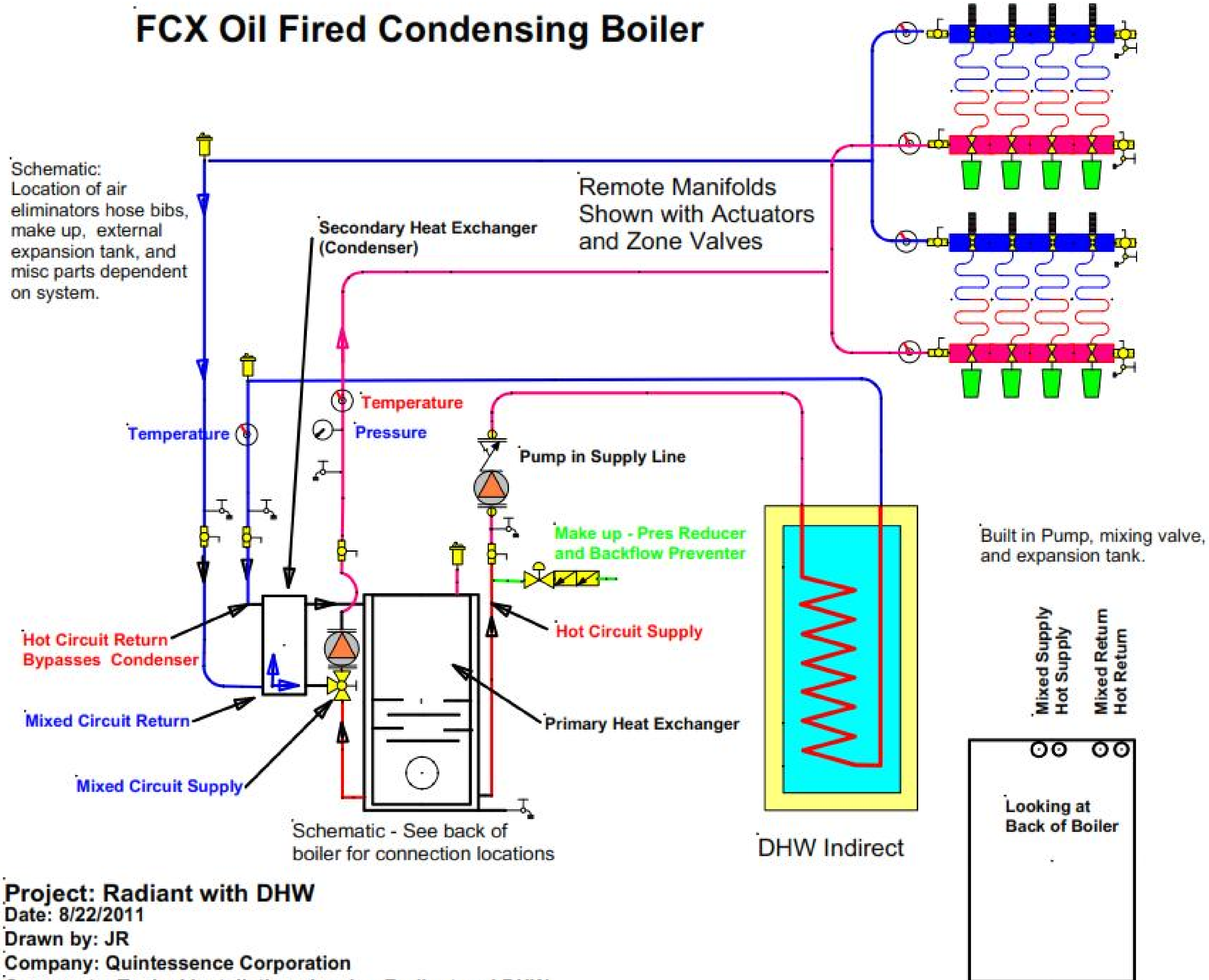
Parallel Vs Series

Parallel:

- **More Even Heat Distribution**
- **Better Pumping Characteristics**



FCX Oil Fired Condensing Boiler



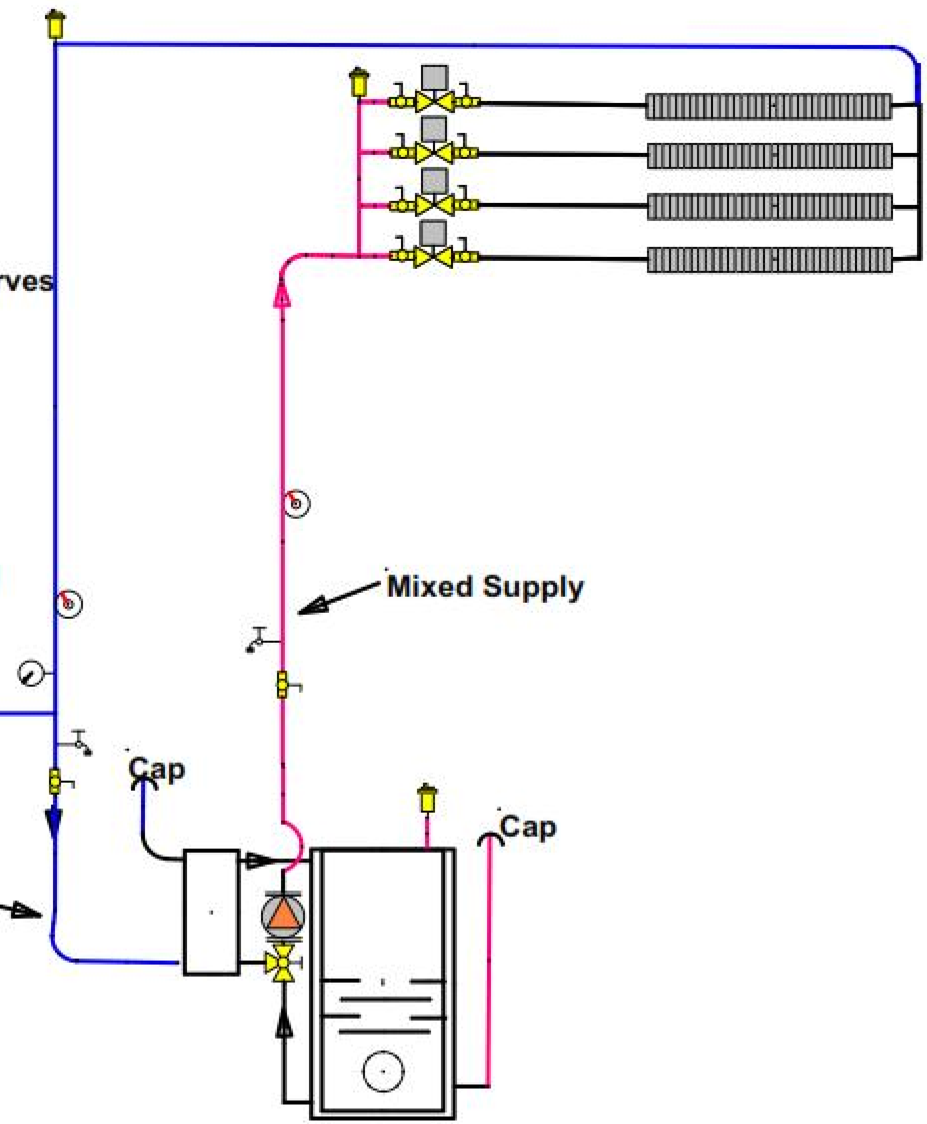
Project: Radiant with DHW
Date: 8/22/2011
Drawn by: JR
Company: Quintessence Corporation
Comments: Typical installation showing Radiant and DHW circuits, with FCX boiler schematic. Component placement will vary.

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.

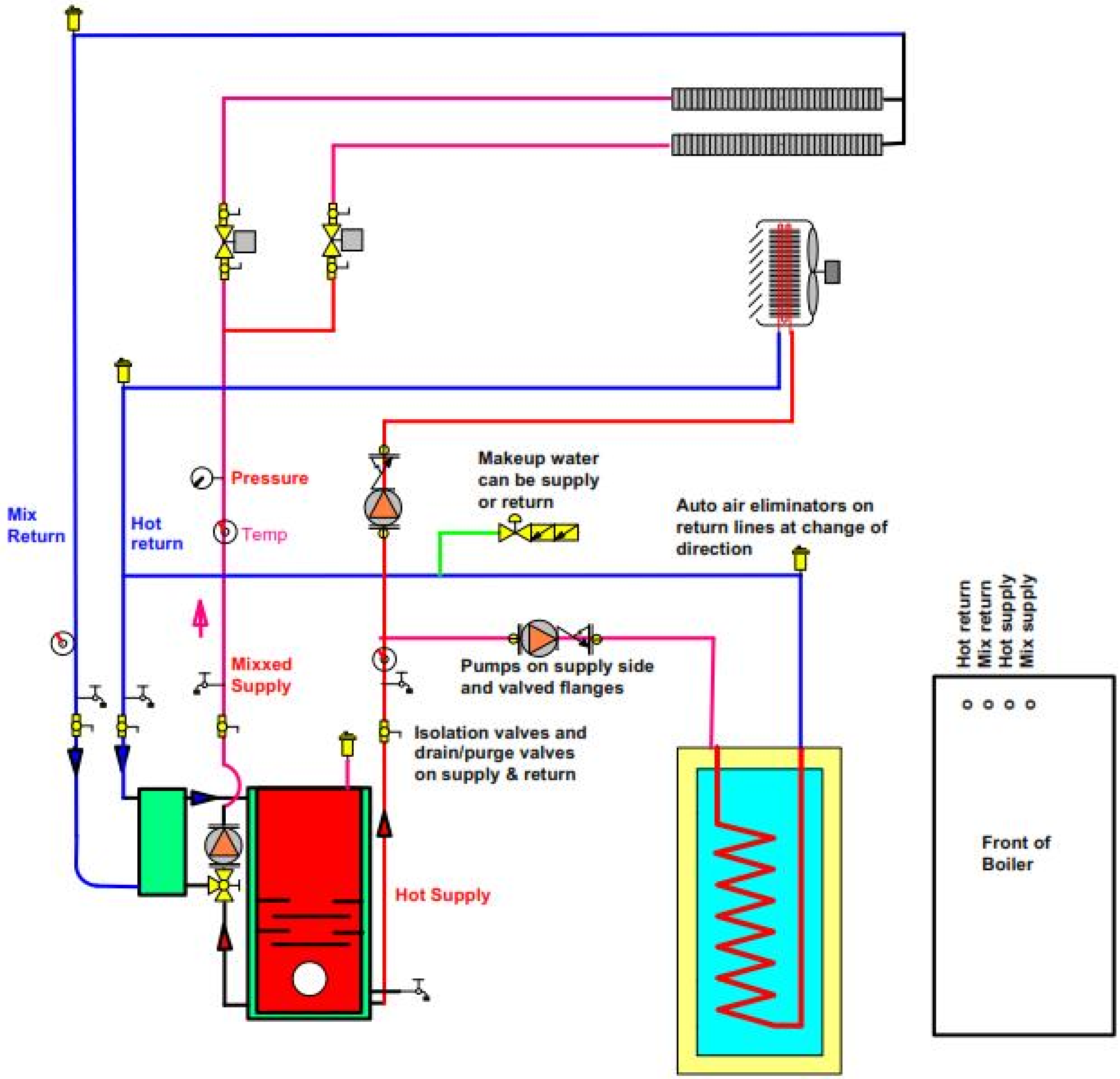
Notes:
Whenever a system has baseboard without radiant always plumb to the mixed circuit because at times the baseboard will run in condensing mode.

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.

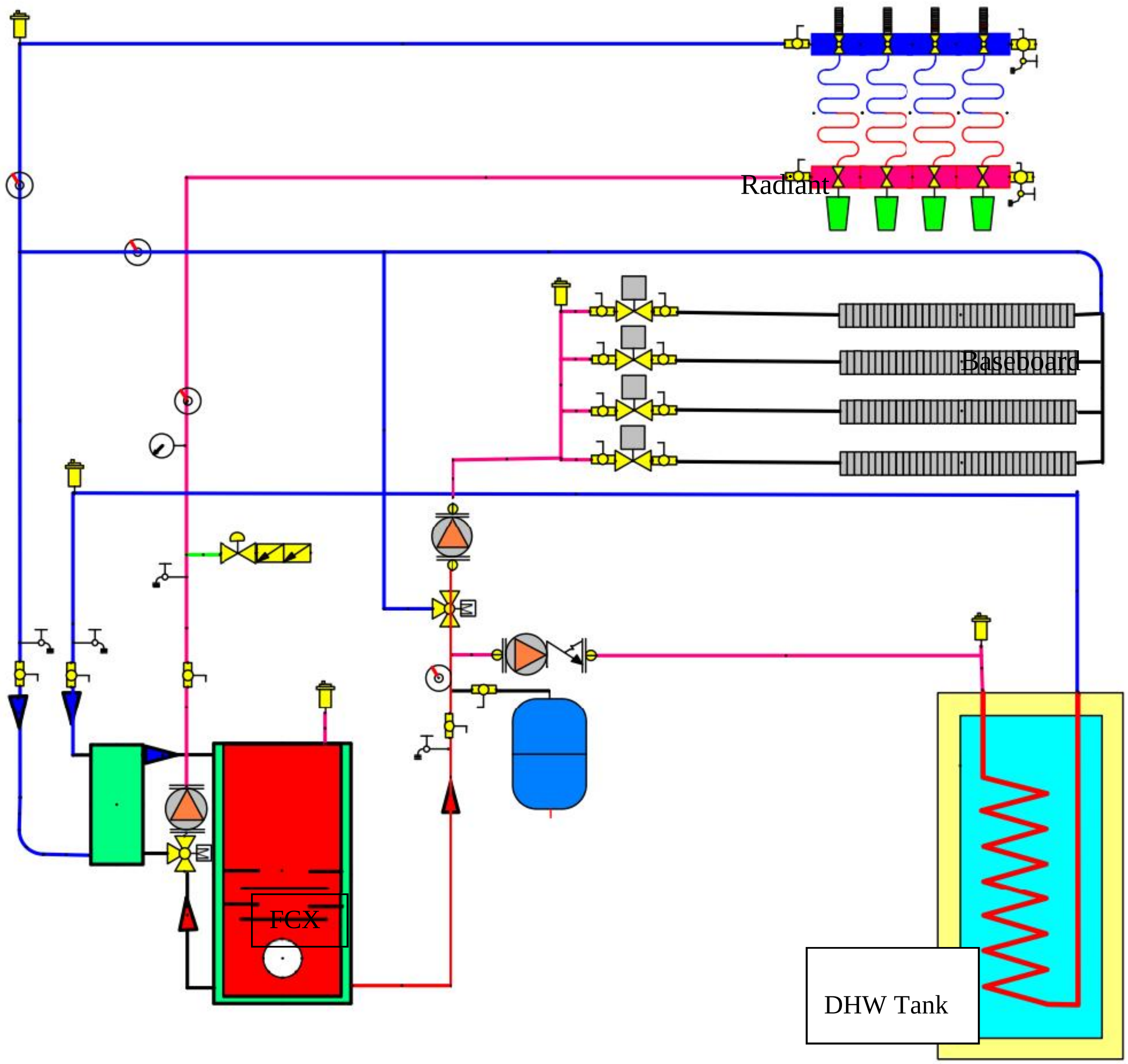


Baseboard - Unit Heater - DHW



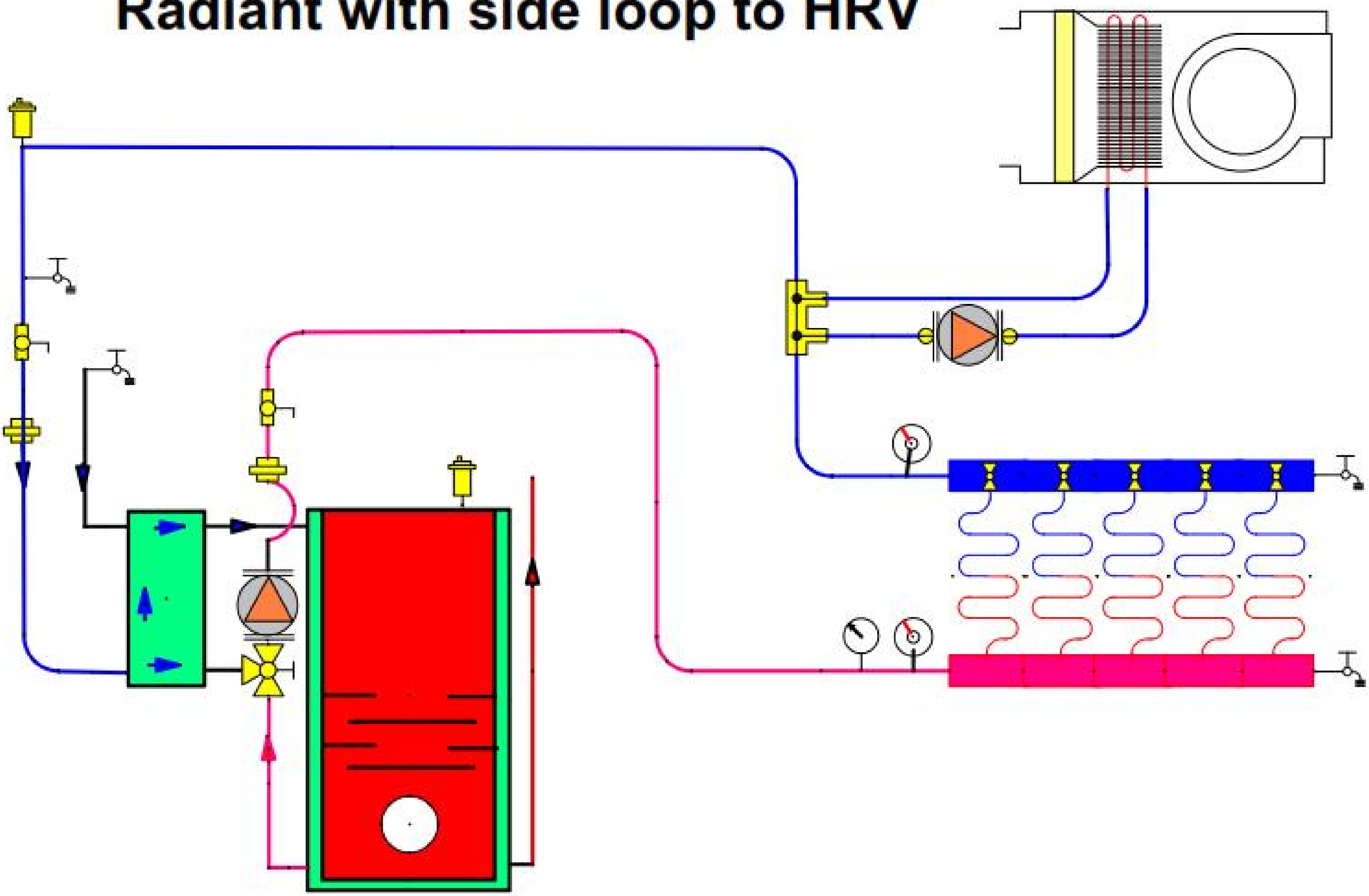
FCX Optimized System

for 3 Types of Heat Emitters using the Tekmar 423 House Control

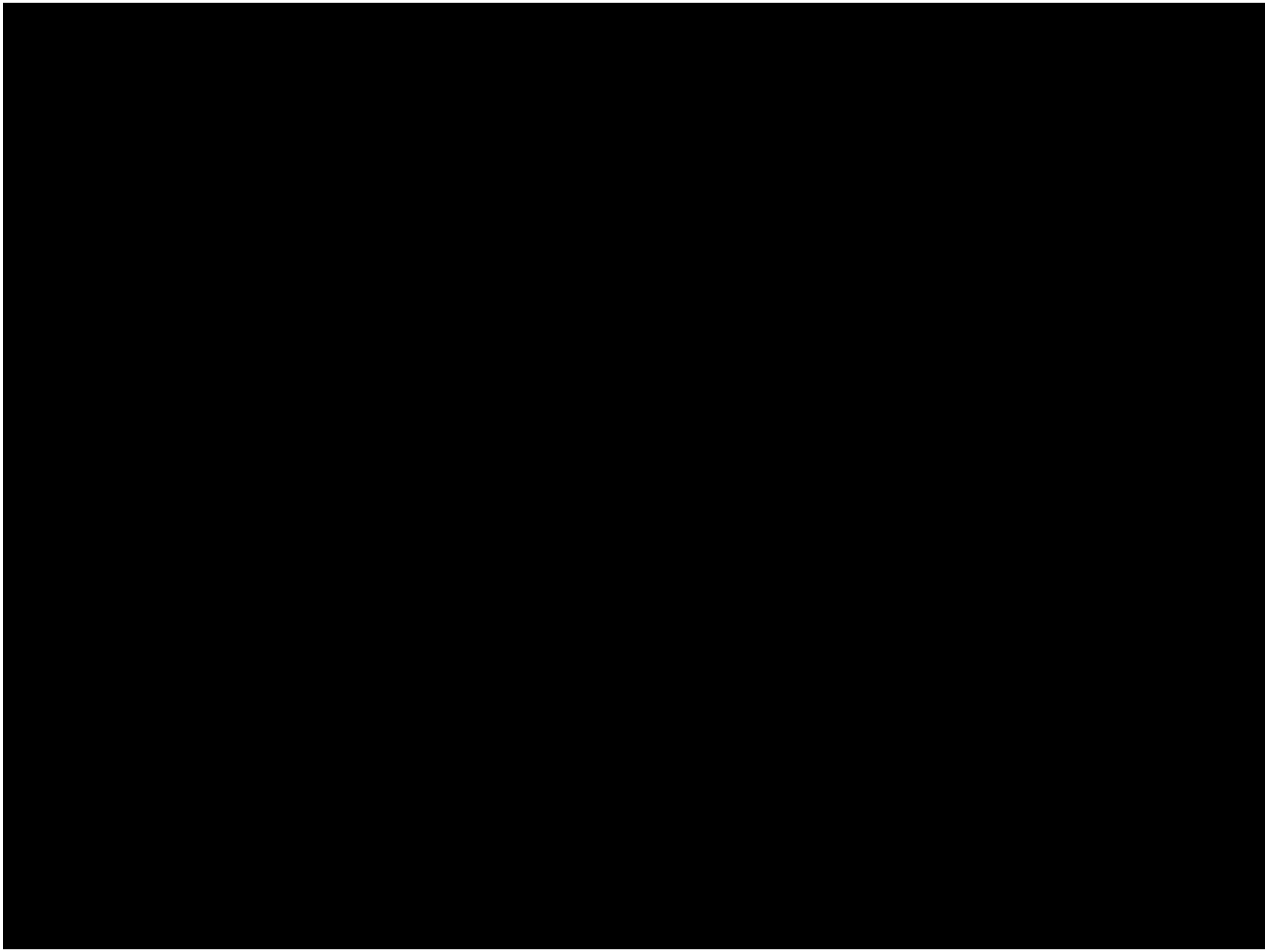


This schematic shows how to optimally plumb a home that contains both Radiant and Baseboard emitters, with DHW. Here the Tekmar 423 house control is modulating 2 motorized mixing valves to produce 2 water temperatures and is simultaneously setting the DHW temperature by controlling the boiler temperature
This controller has the capability of controlling 4 water temperatures and 2 boilers

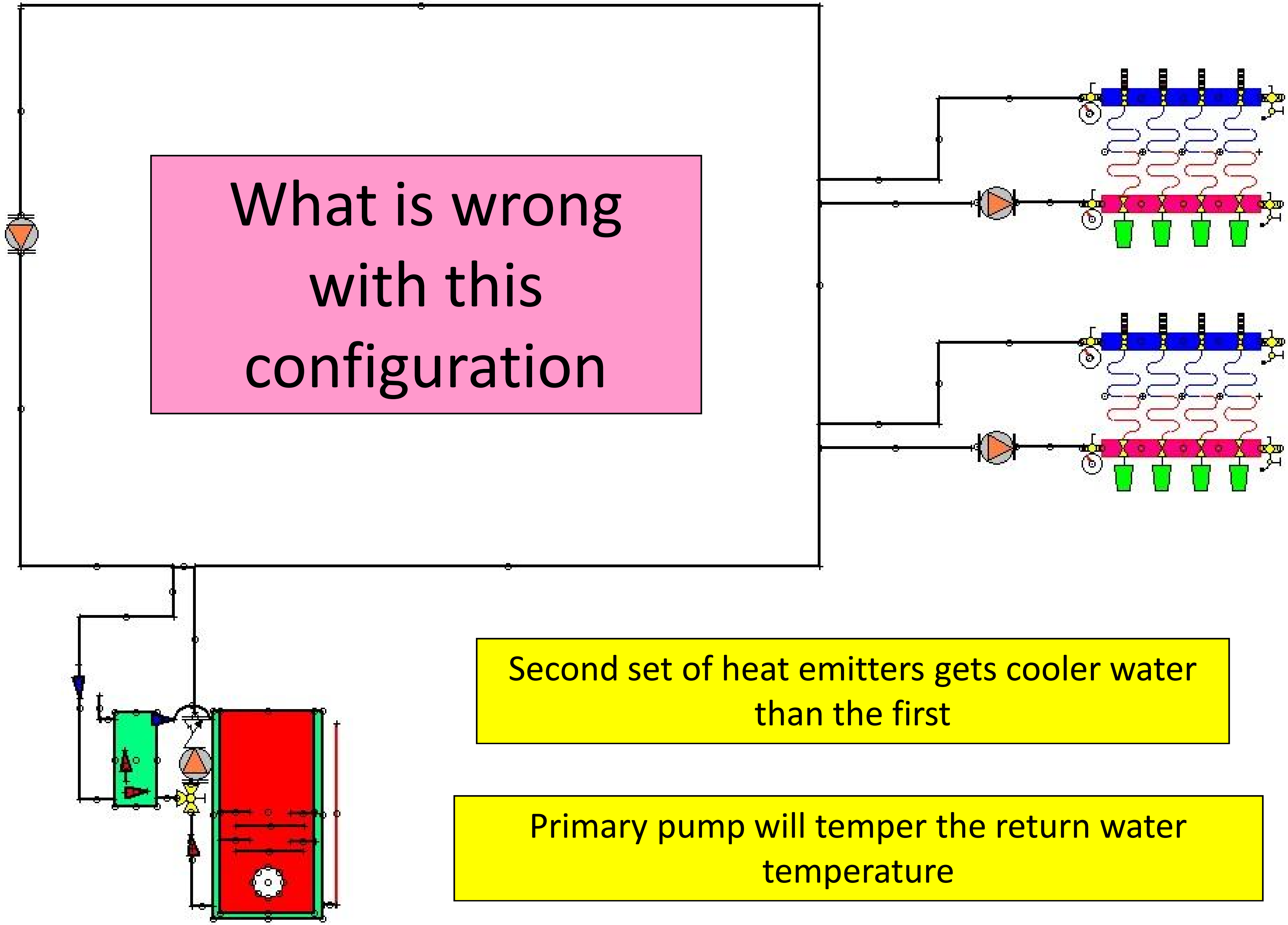
Radiant with side loop to HRV



What we want if using Base Board



Common Mistakes

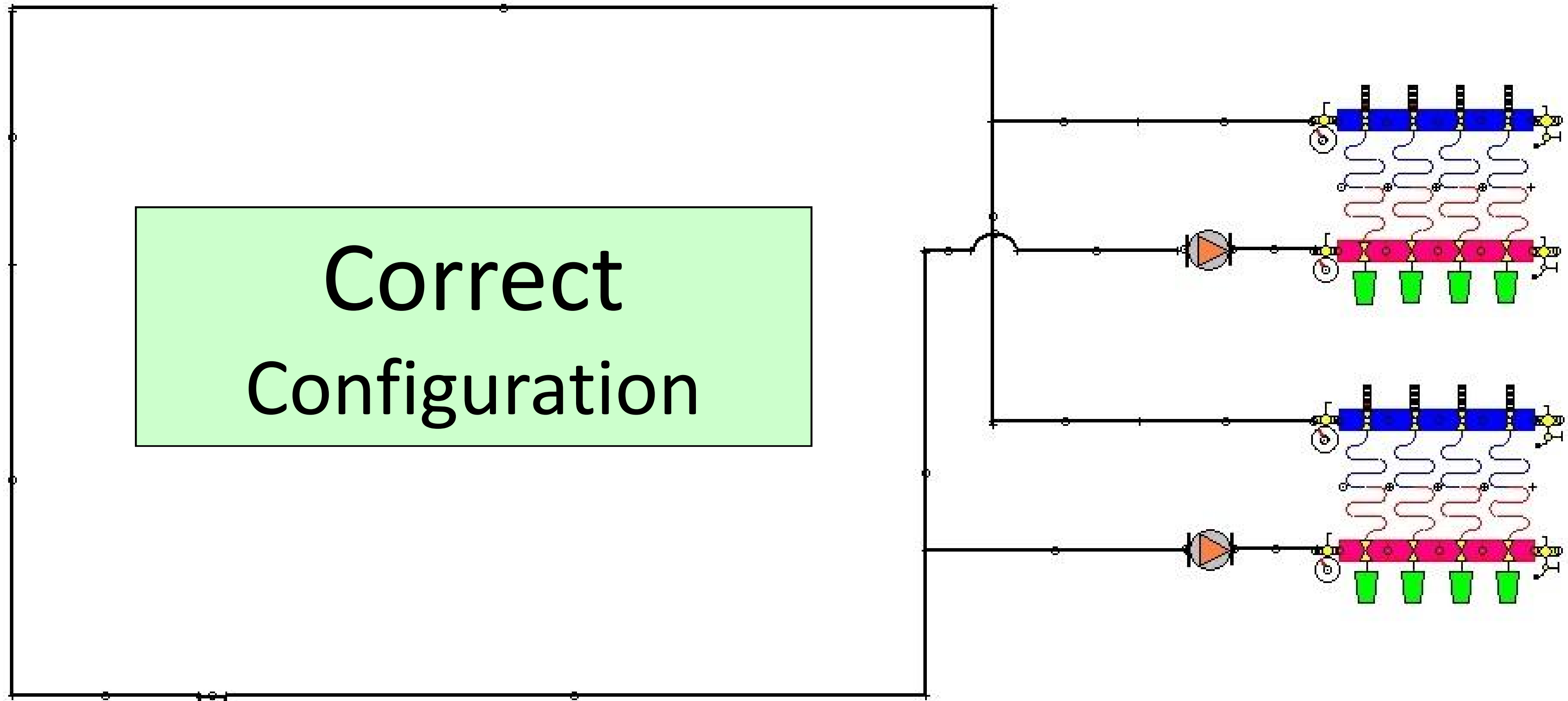


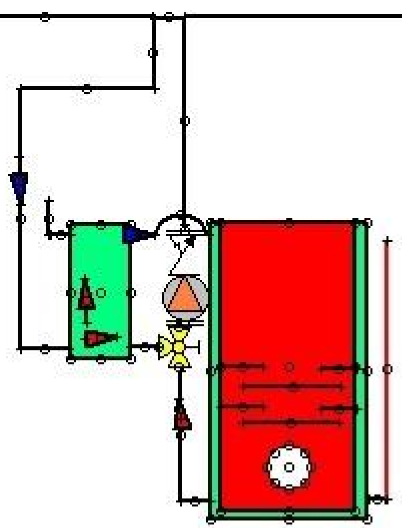
What is wrong with this configuration

Second set of heat emitters gets cooler water than the first

Primary pump will temper the return water temperature

Correct Configuration



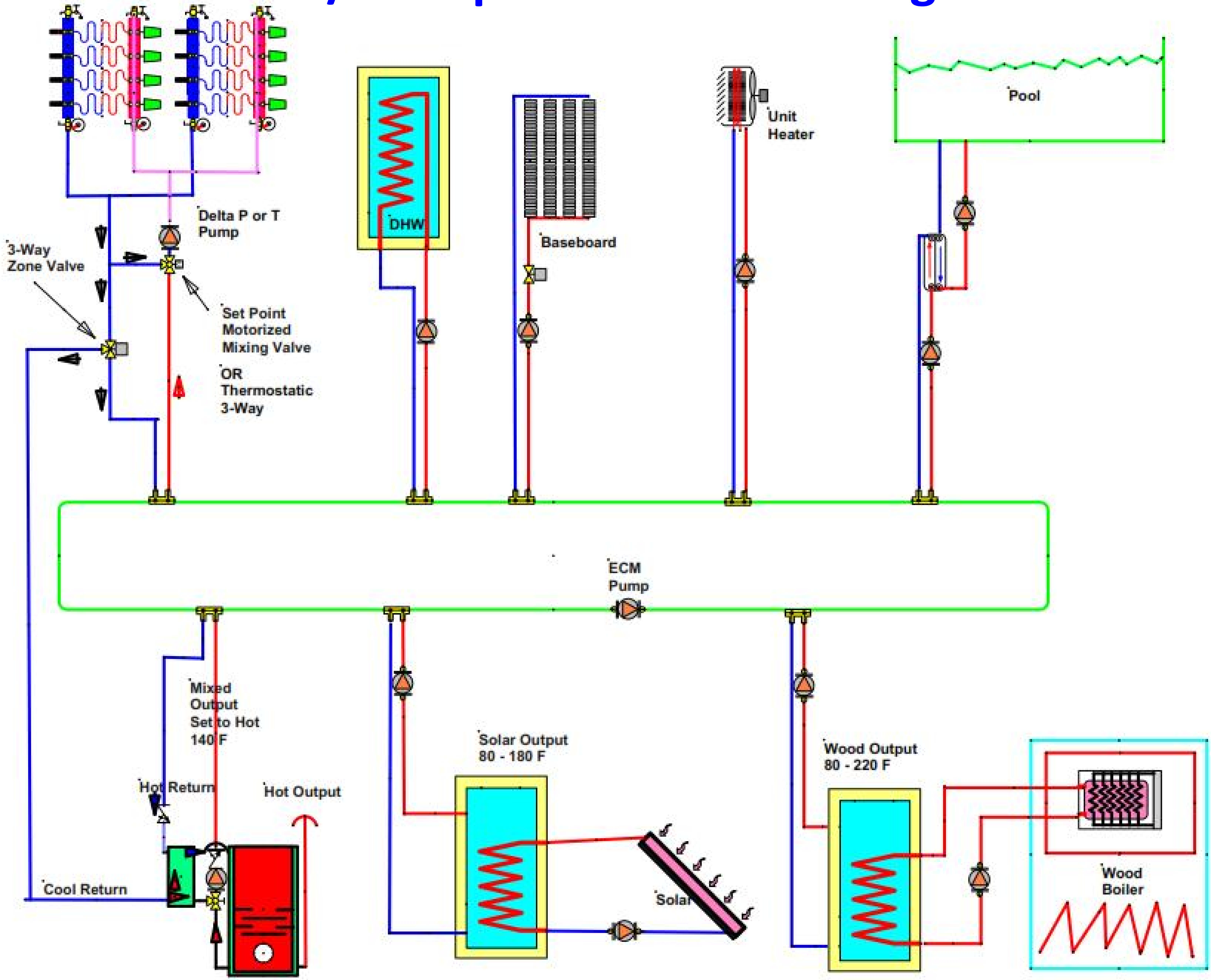


Second set of heat emitters are now in parallel – both receiving the same temperature water.

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

Solution is to use a Delta T pump at for the zones, and a setpoint injection pump.

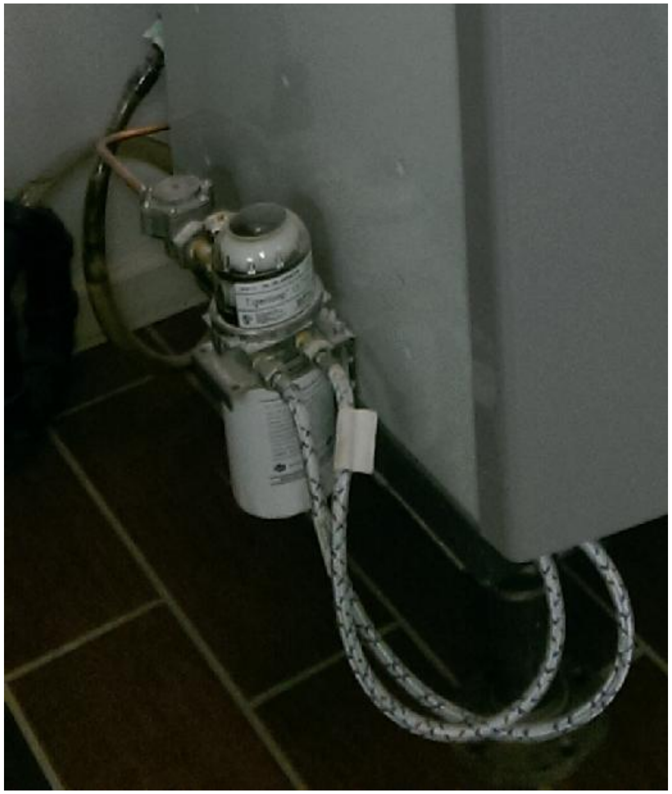
P/S Loop with a Condensing Boiler



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

Concentric – Sealed combustion

Combo

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

An Early Goof Up!!

Do not locate the stack under a roof with 4' overhang.

Condensate
Traps, Drains, Vacuum Breaks, Pumps

..\..\..\..\DreamWeaver\FCX_Alaska\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.

BROOKHAVEN NATIONAL LABORATORY

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

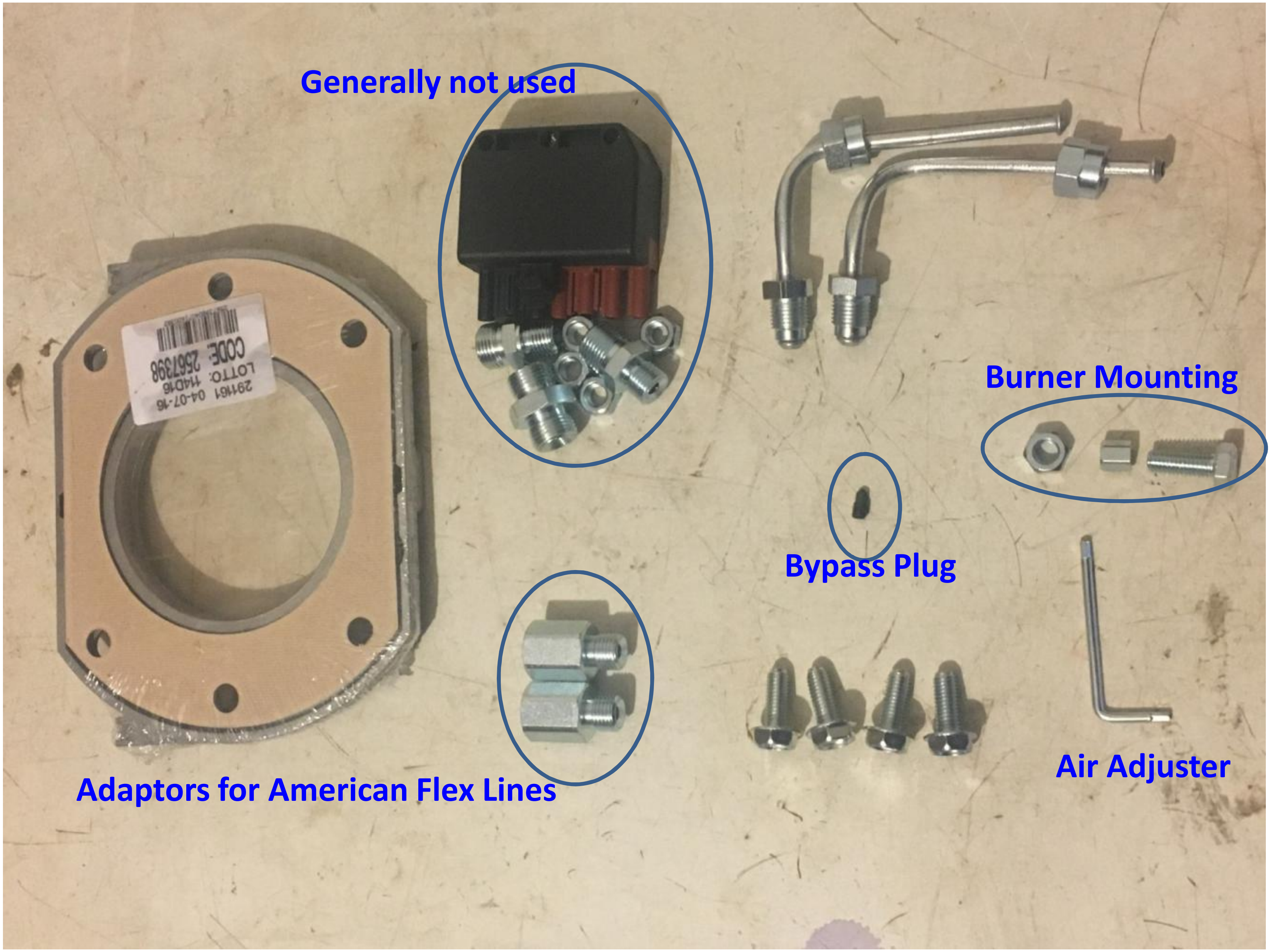
Startup

Commissioning the boiler

Riello Burner Setup

Riello RDB Burner

Riello Burner Parts



Mounting Instructions

Disassembly

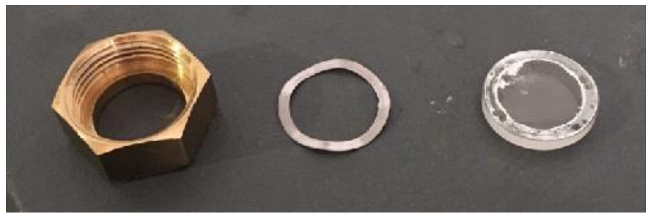
- 4 Bolts on Primary
- 1 Wingnut on Condenser
- 1 Nut Holding Burner
- 4 Screws on Control Panel

Disassembly and Assembly

Appling Anti-Sieze

Using a Teflon Paste as an anti-seize

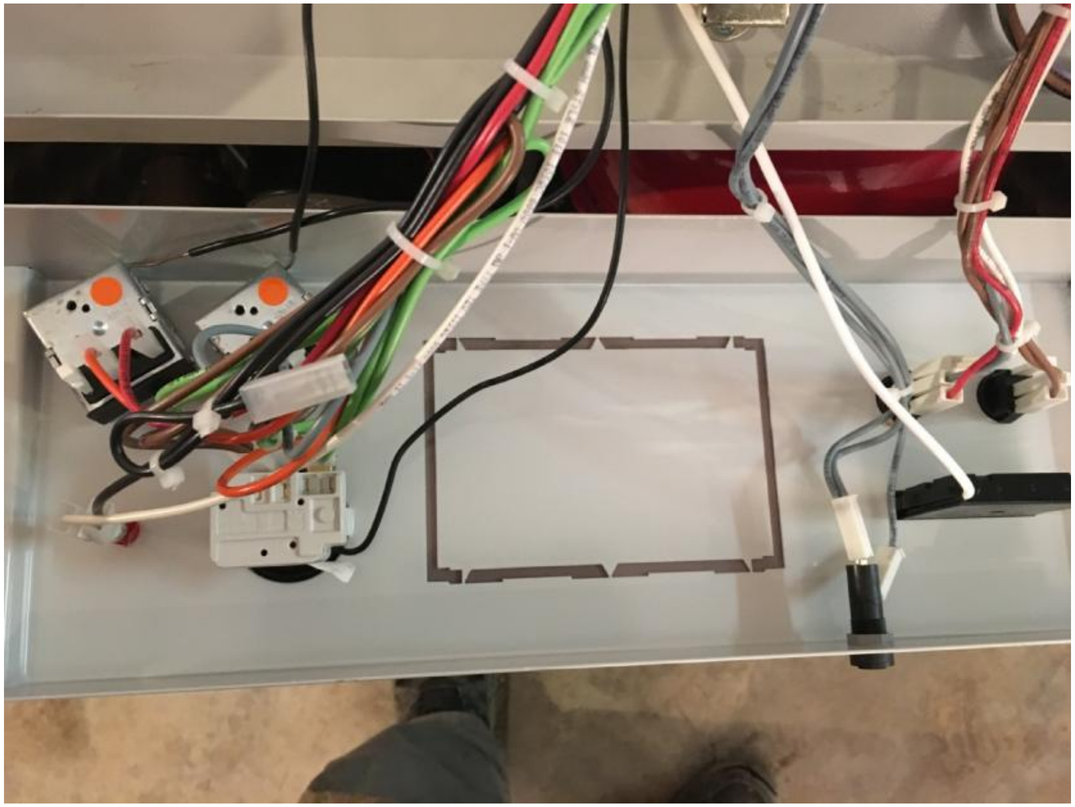
- View port
- Condenser gasket or lid
- 4 – Fastening bolts on primary

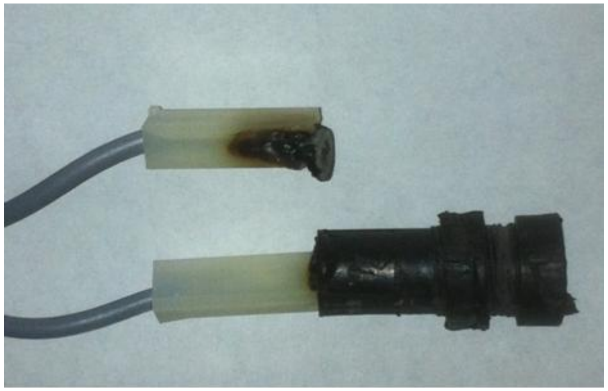


Don't lose spring

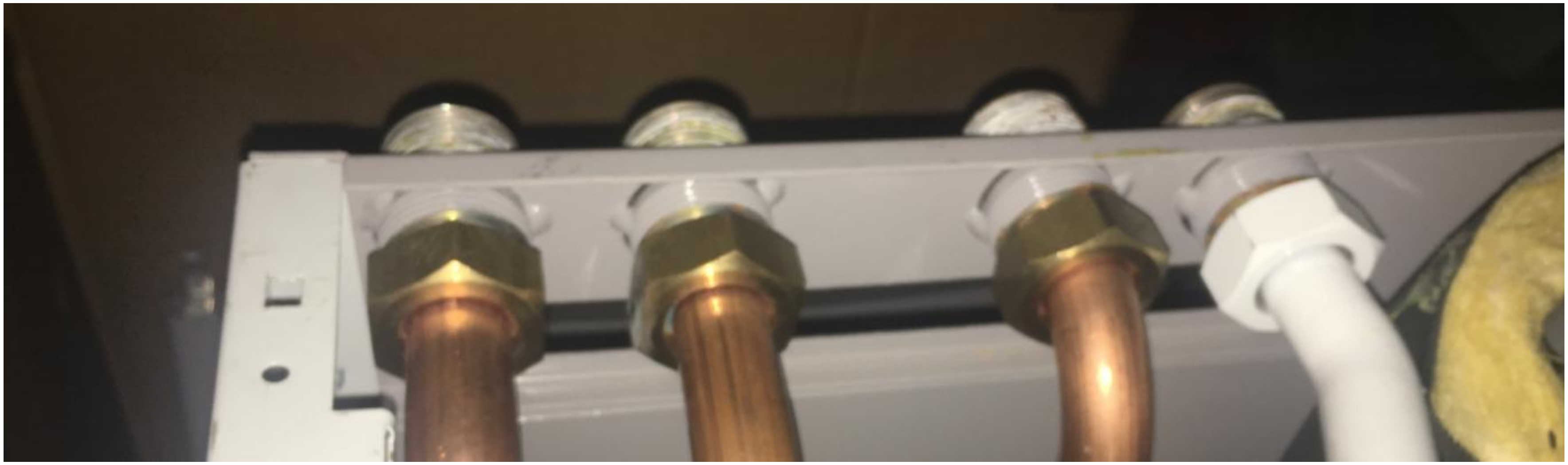
Inspecting Electrical Connections

Check all Spade Connectors

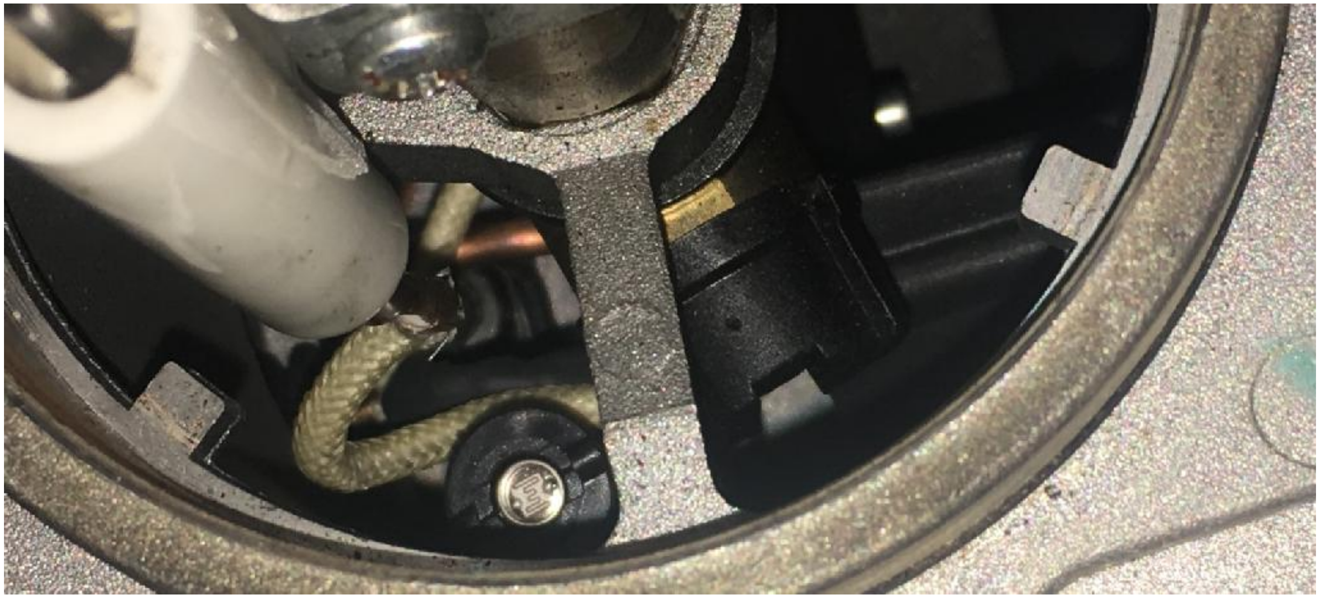




Check Gasketed Connections



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. (use no priority)

Manual Mix Control

Johnson 421 Settings

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 Best Solution

Tekmar 400 Series Digital House Controllers
Boiler / Mixing Valve / Temperature

Outside Reset
with
Indoor Feedback

This control is essential when retrofitting a Baseboard house because of the need to vary boiler temperature with the season. With radiant it provides additional efficiency, comfort, and boiler protection.

Tekmar 402
Settings

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

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

Disassembly and Assembly

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


Normal


Normal

Wasilla system, well maintained, about one year since cleaning.

Popcorn

Semi round hollow shells. Some adhered to the wall, some have fallen off. Easily crushed

Popcorn on my FCX, never seen before – Difficult to remove. After removal - a 20 degree drop in stack temperature.

Failure – Condensing in Primary ???

Rings are indentations in the metal and correspond to edges of swirlers where leakages of combustion gasses around the edges occur.

This has been observed twice before:

1. In a system with a 3rd party control set too low.
2. In a system the home was too large for the boiler to keep up with set back thermostats each morning.

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

Yellowish Deposits

Red Stuff

Secondary Heat Exchanger (Condenser)

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

Each condenser has one tube that does not have a turbulator.

In a system that is condensing properly, you should see when looking down tubes is a dusting of soot that extends approximately ½” to 1” down the tubes. Below that the tubes should be clean because the condensate is washing them.


NOT Normal


NOT Normal


NOT Normal-Plugged

Clean System 550 Gallons
Baseboard House with Tekmar 402

Condenser

Prior to Flushing

Tekmar 402 Installed


Plugged Primary

Results of Plugged Primary

The Danger of Continual Resetting

Blocked Stack

- Partially / Full
- Endless Purge Cycle
- Fixes

Pressure Testing a Failure – Electrolysis??

Electrolysis vs. Galvanic corrosion

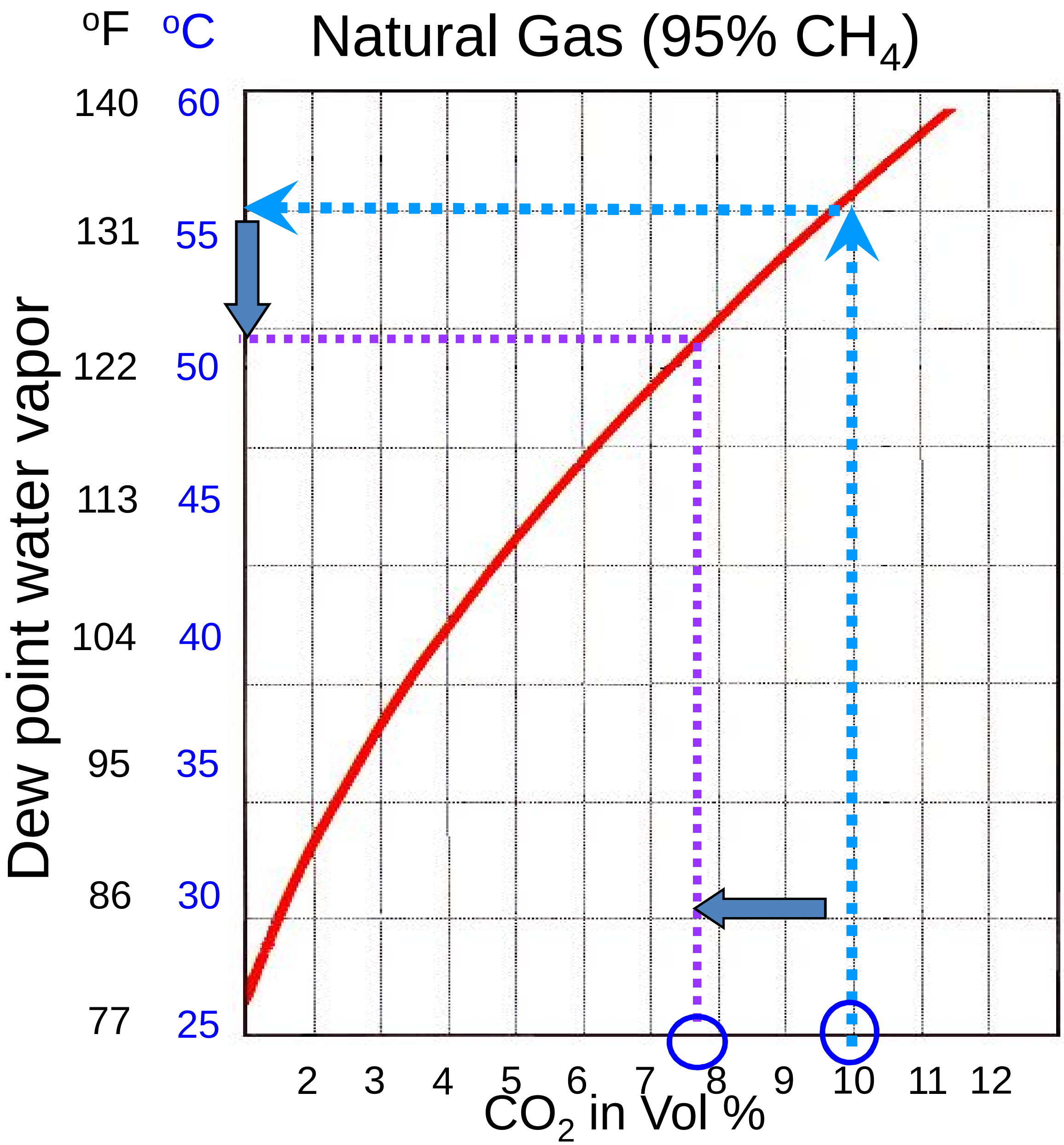
Electrolysis:
Chemical decomposition produced **by passing an electric current** through a liquid or solution containing ions.

Galvanic corrosion:
Is caused by self-induced current created by electrical potential of two **dissimilar metals** in contact with an electrolyte. It can occur when two **dissimilar metals** (such as copper tube and steel pipe) are connected in the presence of an electrolyte. Fresh potable water is a weak electrolyte.

Dielectric Couplings will prevent both of these.

Tuning

WATER VAPOR DEW POINT



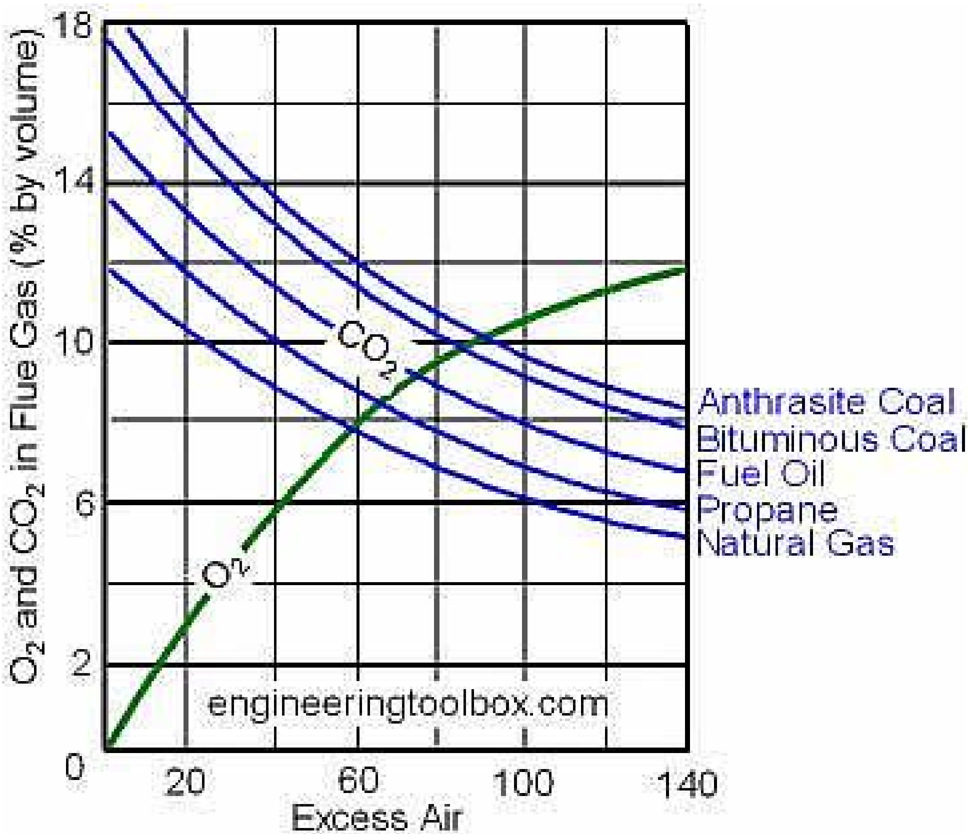
CO_2% of flue gas influences dew point temperature

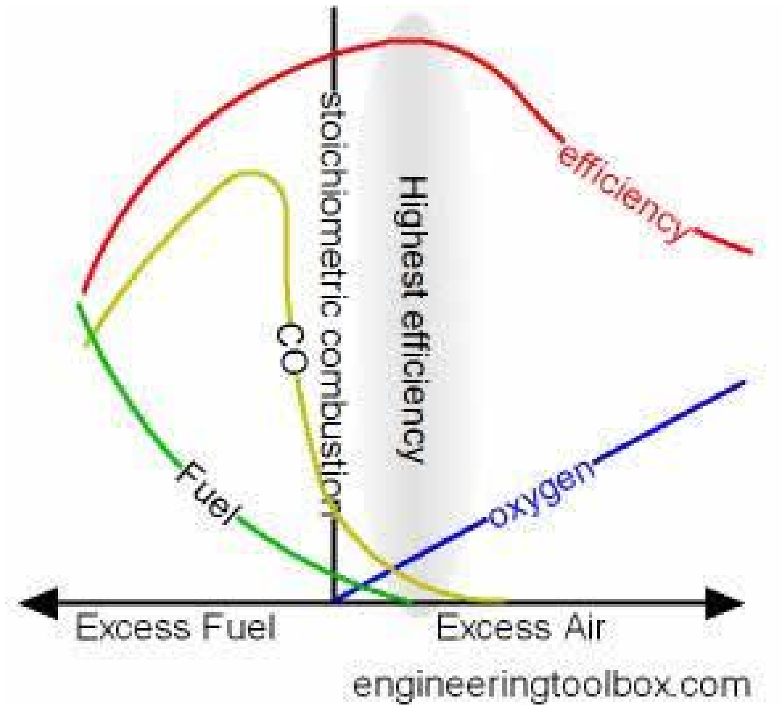
Higher CO_2
=Higher Dew point
=More Condensation

Lower CO_2
=Lower Dew point
=Less Condensation

Maintenance

Tuning a Condensing Boiler



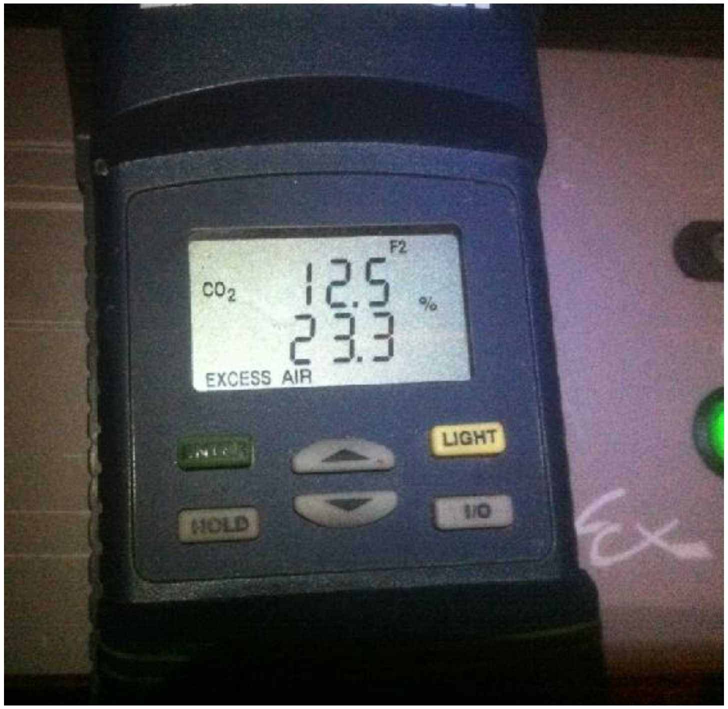


Tuning

** 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
- CO_2 / Excess Air - Calculated
  - CO_2 – 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



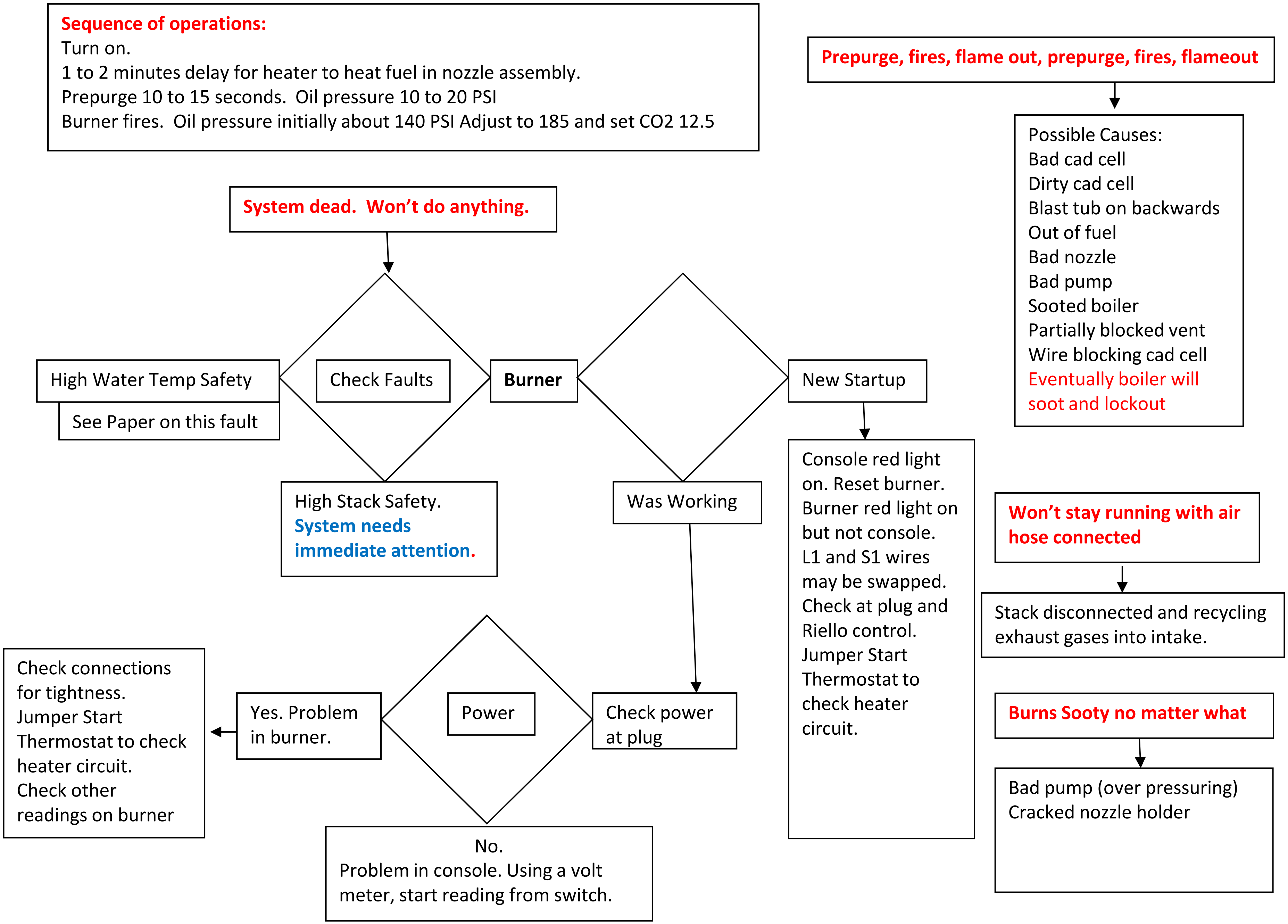
Set: CO2 = 12.5 Pressure = 185

Corresponding O2 = ±4%, CO < 30ppm

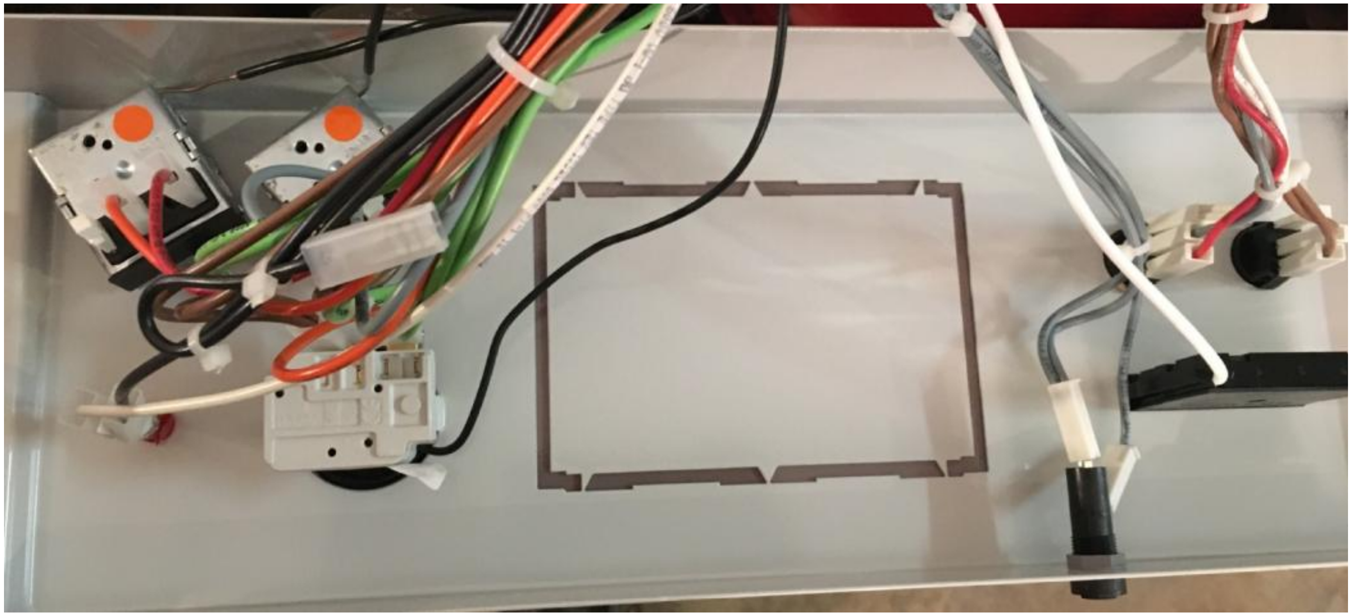
Last and Most Important

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
Possible Causes:
Bad cad cell
Dirty cad cell
Blast tub on backwards
Out of fuel
Bad nozzle
Bad pump
Sooted boiler
Partially blocked vent
Wire blocking cad cell
Eventually boiler will soot and lockout
System dead. Won't do anything.
High Water Temp Safety
See Paper on this fault
Check Faults
Burner
New Startup
High Stack Safety. System needs immediate attention.
Was Working
Console red light on. Reset burner. Burner red light on but not console. L1 and S1 wires may be swapped. Check at plug and Riello control. Jumper Start Thermostat to check heater circuit.
Won't stay running with air hose connected
Stack disconnected and recycling exhaust gases into intake.
Check connections for tightness. Jumper Start Thermostat to check heater circuit. Check other readings on burner
Yes. Problem in burner.
Power
Check power at plug
Burns Sooty no matter what
Bad pump (over pressuring)
Cracked nozzle holder
No.
Problem in console. Using a volt meter, start reading from switch.

Console



Check safeties first

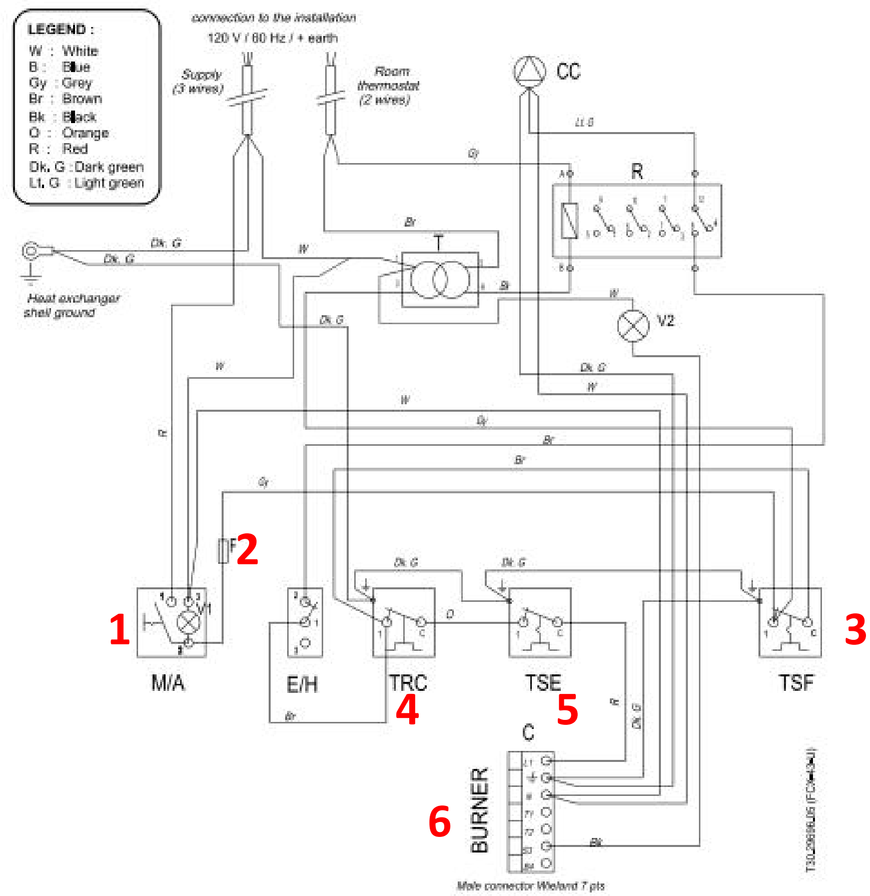
Safeties do not stick out when tripped, listen for click when reset.

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

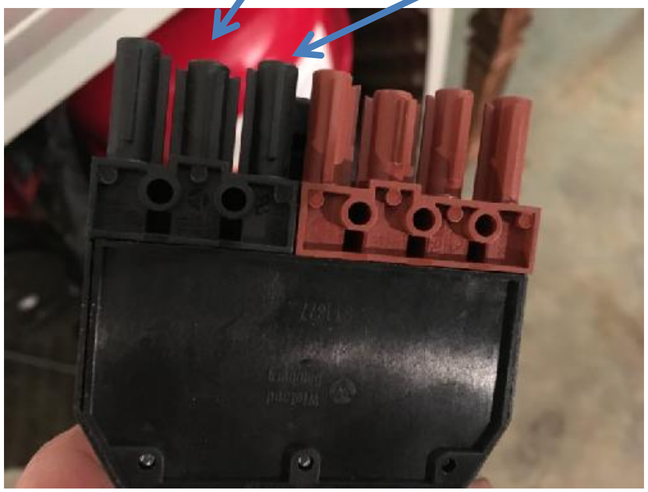


LEGEND :

L :	Phase	V1:	On light
N :	Neutral	V2:	Burner safety shutdown light
M/A:	On/Off switch	C :	Burner connector
E/H:	Summer/Winter switch	F :	Fuse (6,3 A)
TSE:	Overheat safety cutout aquastat	R :	Relay
TRC:	Adjustable thermostat	T :	Main transformer 120/24 volts
TSF:	Flue gas safety cutout thermostat	CC :	Circulating pump

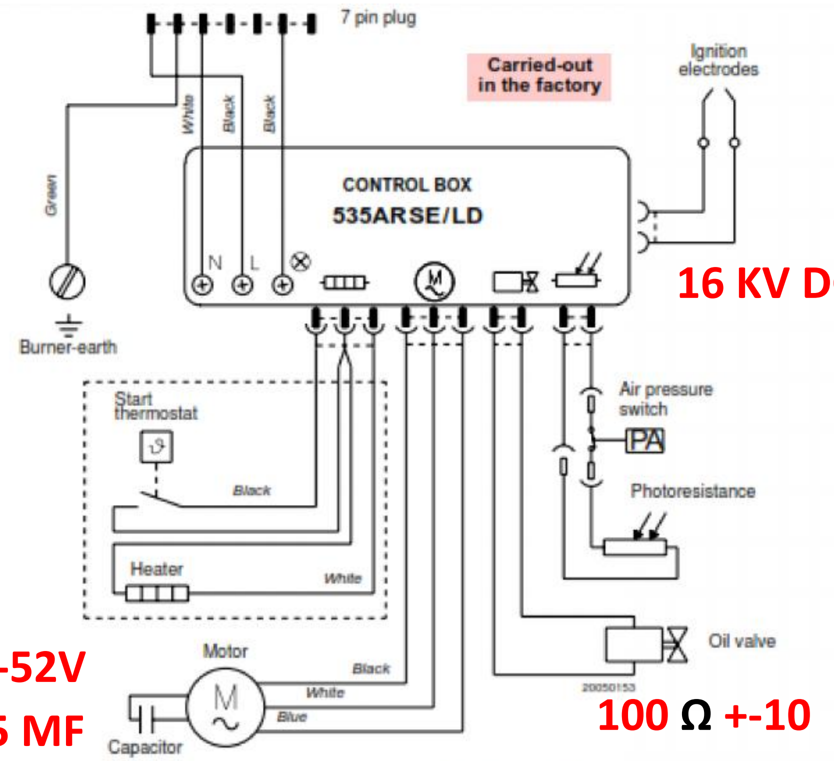
Boiler Side Plug

Power Ground Neutral



Boiler dead
Power on
Wont fire

Jumper the thermostat

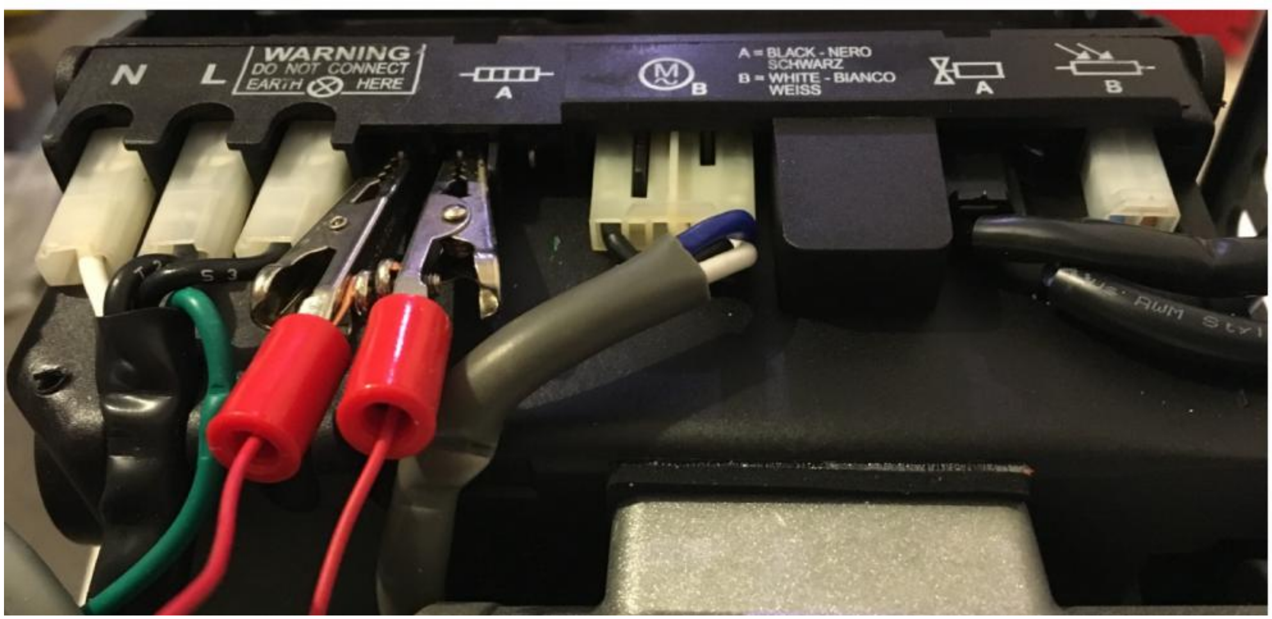


16 KV DC

Motor White to Blue 42-52V

12.5 MF

100 Ω +-10



Riello 535ARSE/LD Readings - FCX 22/30

Motor

	Unpluged 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