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

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.

Your position on site: Home / Institutional

Institutional

To get to know Bosch Thermotechnologie better

AFAQ ISO 9001

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.

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

Hydronic Considerations

- Science of Condensing
- How the FCX Works
- Hydronic Design/ Heat Emitters
- Controls
- Pumps

How Heat is Recovered?

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

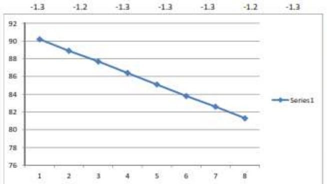
Reduction of the burn temperature (sensible heat). Oil burns at about 4000° F, the stack temperature normally is about 350° F. Further reduction leads to the 2nd Process.

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

%O2	200	250	300	350	400	450	500	550	600	650	700	750	800	%CO₂
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.

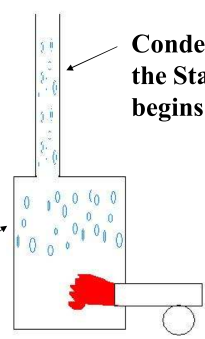
Any heat up the stack is LOST

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

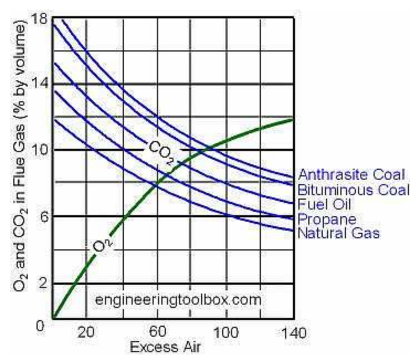
- **Note that any boiler can be made to condense**
- **Causes**
  - **Under Firing**
  - **Improper installation**
  - **Too cool return water**
  - **Controls not set properly**
  - **Improper Tuning**

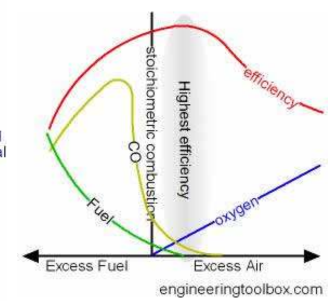


Condensing in the Stack begins first.

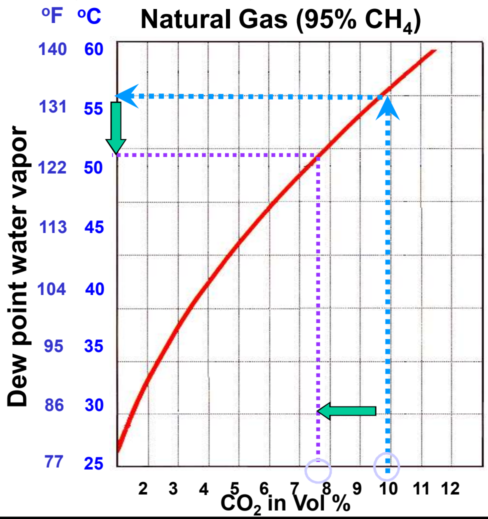
Condensing in the Boiler can follow.

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.

Stack Materials

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

The FCX Oil-Fired Condensing Boiler

FCX Oil-Fired Condensing Boiler

92-97% Efficient

The Most Efficient Oil-Fired Boiler

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°

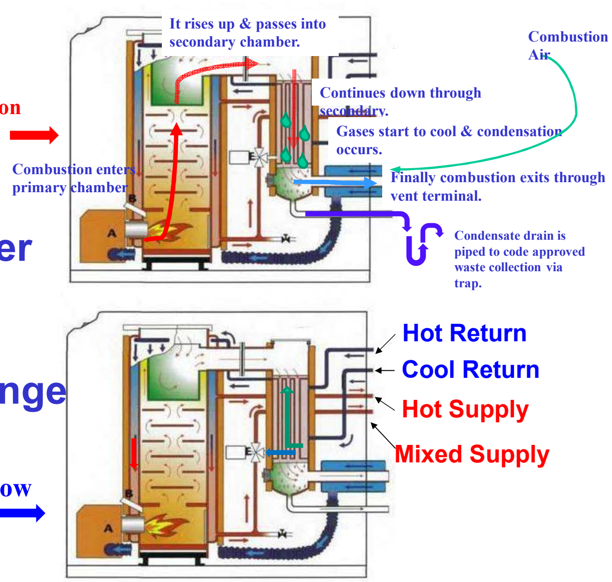
[In Parallel Flow] "…the temperature of the cold fluid exiting the heat exchanger never exceeds the lowest temperature of the hot fluid. This relationship is a distinct disadvantage if the design purpose is to raise the temperature of the cold fluid."

3800 F° — **Counter Flow of Water** — 80 F°

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

Combustion Gas Flow

Counter Flow Heat Exchange



Water Flow

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?

Warranty & Support

10 Years for Heat Exchangers and DHW Tanks

2 years on other parts

2 year Riello warranty

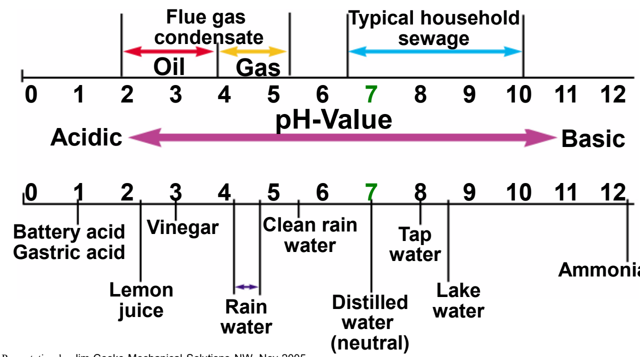
Comprehensive installation manual

Close technical support to the designer, installer, and serviceman

Fairbanks – Initial setup and tuning included

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.

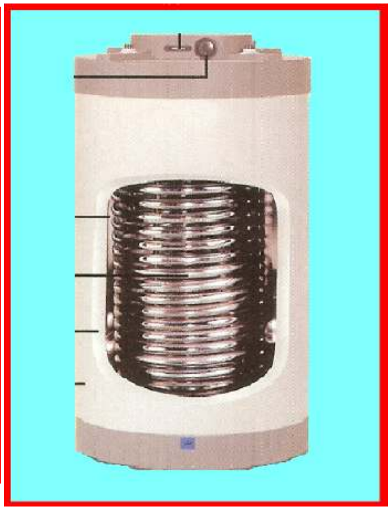
Twin Boilers - Lifewater Shop, Office, & Appts - 8000 SF

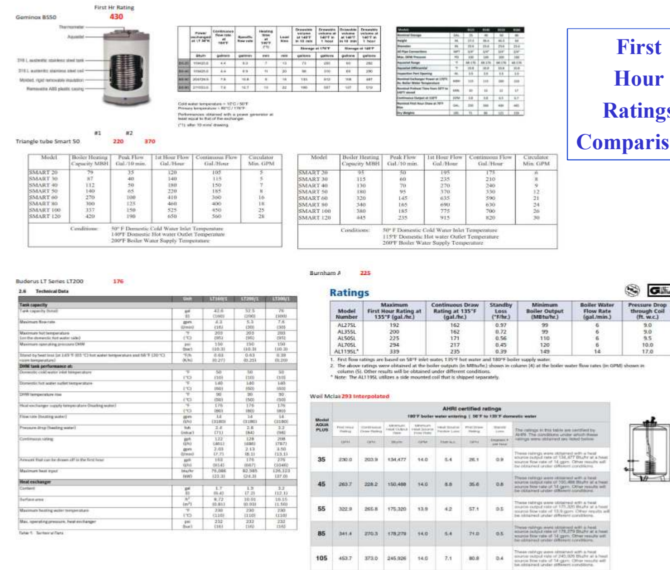
Handling the Condensate
Neutralization and Disposal

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

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

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

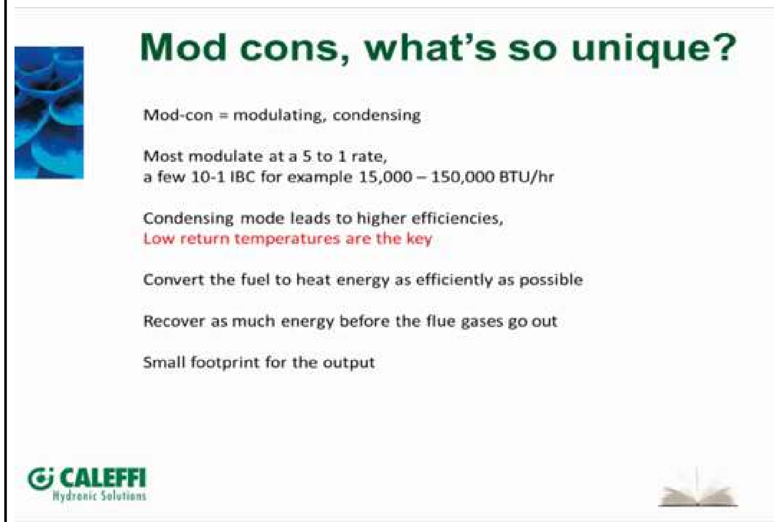
So…………

Do NOT Temper the Return Water

The FCX is Immune to Boiler Shock

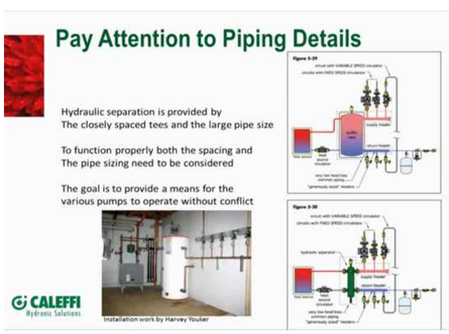
- No tempering circuits/valves
- No boiler circulation pumps
- No 4-way mixing etc.
- No Injection circulation loops
- No Buffer Tanks
- No Hydraulic Separators

The most important principle in condensing boilers



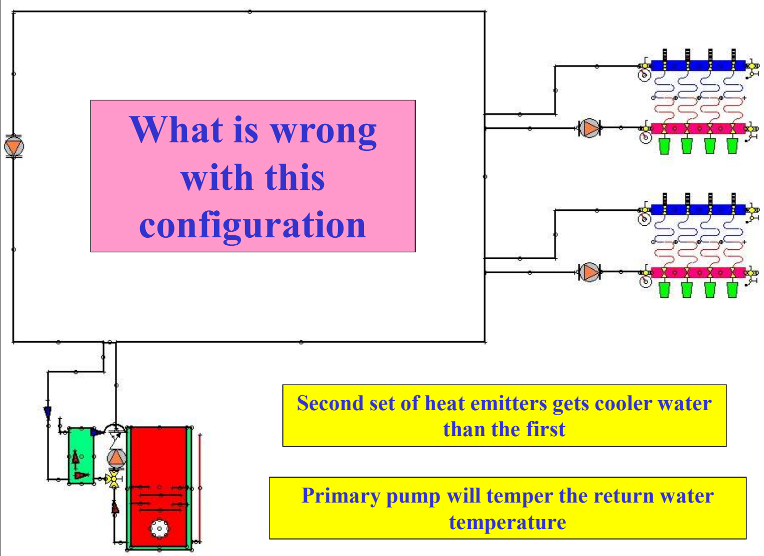
The Ill Effects of Hydraulic Separation

What not to do!!



Hydronics – Unique to Condensing

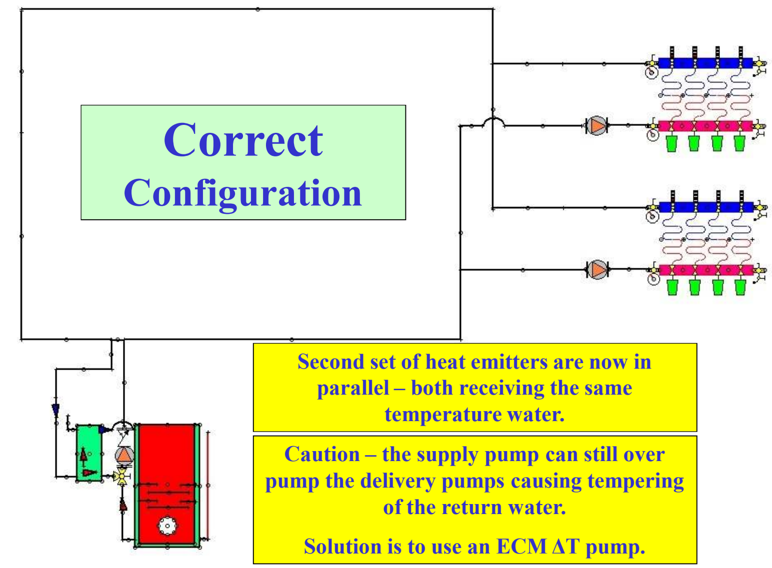
Considerations for Injection Pumping



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 ECM ΔT pump.

Hydronics WORKSHOP

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.

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Solar Thermal Notebook

John Siegenthaler, P.E.

Hitting a home run

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

Figure 1.

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

Solar Design Notebook

Figure 2.

Making it happen

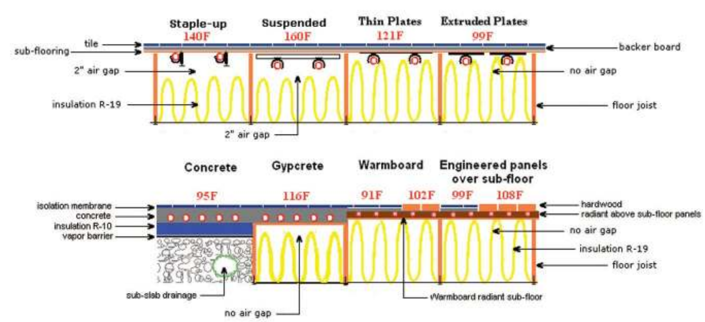
Emitter evolution

Radiant panel solutions

Typical Floor Types

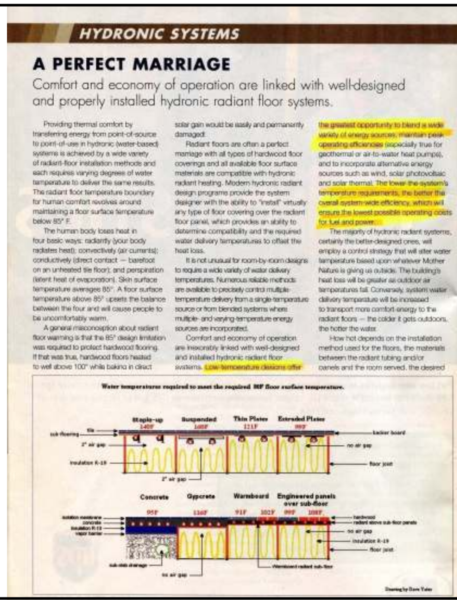
The Major Factor: "The lower the systems temperature requirements, the better the overall system-wide efficiency, which will ensure the lowest possible operating costs for fuel and power." [and the Most Condensing and Lowest Stack Temperatures]

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



Radiant Floor Guide 2013

Drawing by Dave Yates



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

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

Drawing by Dave Yates

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]

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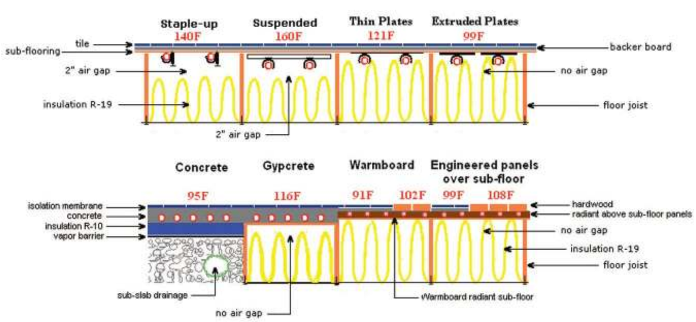

Radiant Floor Guide 2013

Drawing by Dave Yates

What Every New System Should Have

- **A Condensing Boiler**
- **Radiant Floors or Low Temperature Emitters (example Heating Edge)**
- **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

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

Hydronics – Unique to Condensing

Heat Emitters

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- 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

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

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

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.

All controls, piping, gages etc. mounted on boiler and DWH with gasketed fittings provides easy shipping and simple assembly.

Habit for Humanity - Baseboard

Habit for Humanity - Baseboard

Testimonials

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

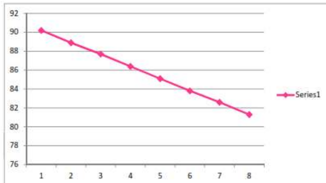
- Short Cycling
- High Stack Temperatures – 1.3% per every 50 degree drop
- Tuning - AFUE vs. Actual – under/over Performing, CO2, Excess Air, Stack Temps
- Boiler Temperatures - 1% loss per 10 degree
- Return Water Temperatures
- Condensing Effect
- Cold Starting
- Side Arms

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 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	%CO₂
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, 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.

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 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 Priortization
    - 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 Cadillac

Tekmar Digital Controller

Boiler / Mixing Valve / Pump / Temperature

This control is a must when retrofitting a Base Board House

Smart Pumping

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

Venting With No Barametric Damper

Venting / Stacks

Concentric Options - Balanced

- Side Wall - up and out
- Side Wall - straight out
- Vertical
- Condensate drain tees

Single Wall Options

- Vertical – best choice
- Horizontal – caution recommended
- Manufactured condensate tee
- Single Wall balanced – Direct to boiler

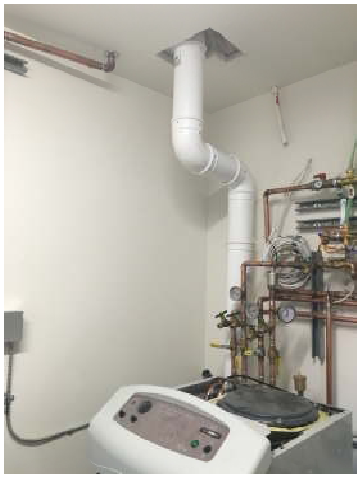
3 Types of Venting are Available

Singlewall – Inside Combustion Air

Concentric – Sealed combustion

Combo

Concentric Stack



Single Wall Stack

Habit for Humanity - Baseboard

Venting / Stacks

Combustion Air

- During construction
- Consider an Air filter

Known Problems

- Clogged air filter
- Back drafting and negative pressures - Even in "sealed" boiler rooms

Maintenance

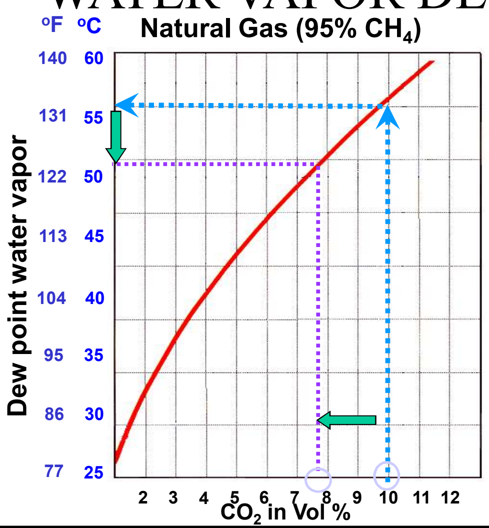
Maintenance
Cleaning and Inspection

- 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

Maintenance
Tuning a Condensing Boiler

- Slides with charts
- CO2, O2, CO Levels
- Excess Air
- Smoke

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