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

Presentation Outline

- Condensing Technology
- Condensing vs. Conventional
- Interesting Observations
- Condensing Boilers
- Will it Work in MY Home???

Condensing Technology

- **How is Heat Recovered**
- **What is Condensing?**
- **How Does it make for greater efficiency**

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.

What is condensing?

The products of combustion consist primarily of <u>CO2</u> and <u>Water Vapor.</u>

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.

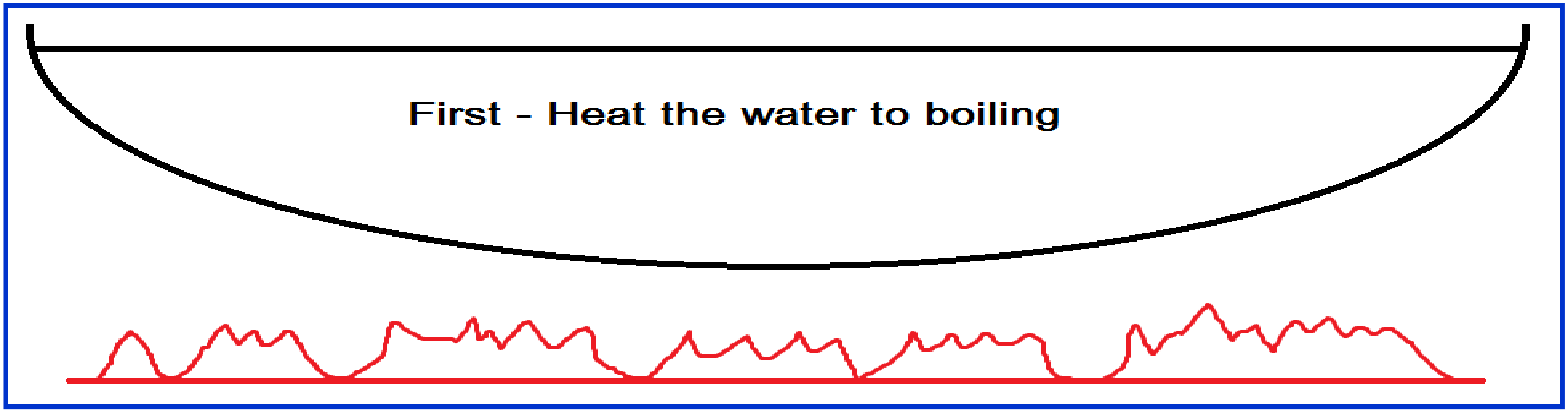
How does Condensing Make for Greater Efficiency

- **When water changes state from a gas to a liquid (goes from a <u>gas at 212°</u> to <u>liquid at 212°</u>), it gives off heat that is absorbed by the water in the boiler.**

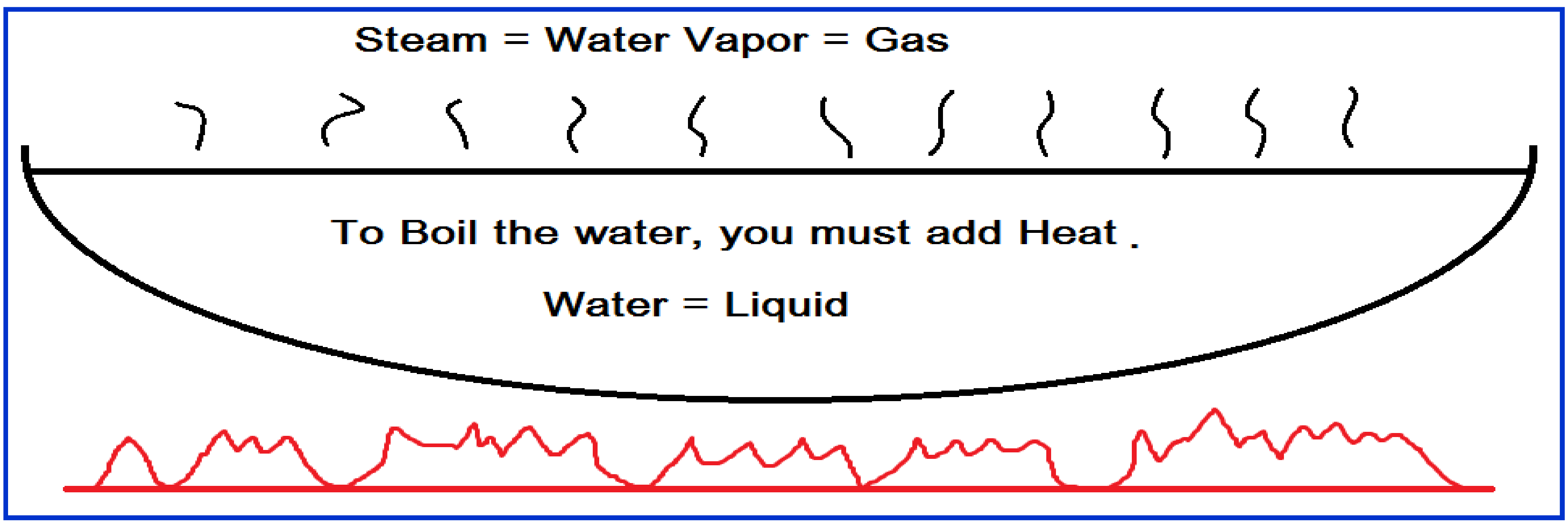
- **This process recovers the latent (hidden) heat of vaporization, and takes place in the condenser.**

- ***<u>The net result is greater efficiency</u>.***

Boiling water Example



Then



Condensing vs. Conventional

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

All Condensing Boilers Run at Lower Temperatures

Condensing boilers are defined by:

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

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

Lower Temperatures = $$$$$$

Stack Materials

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

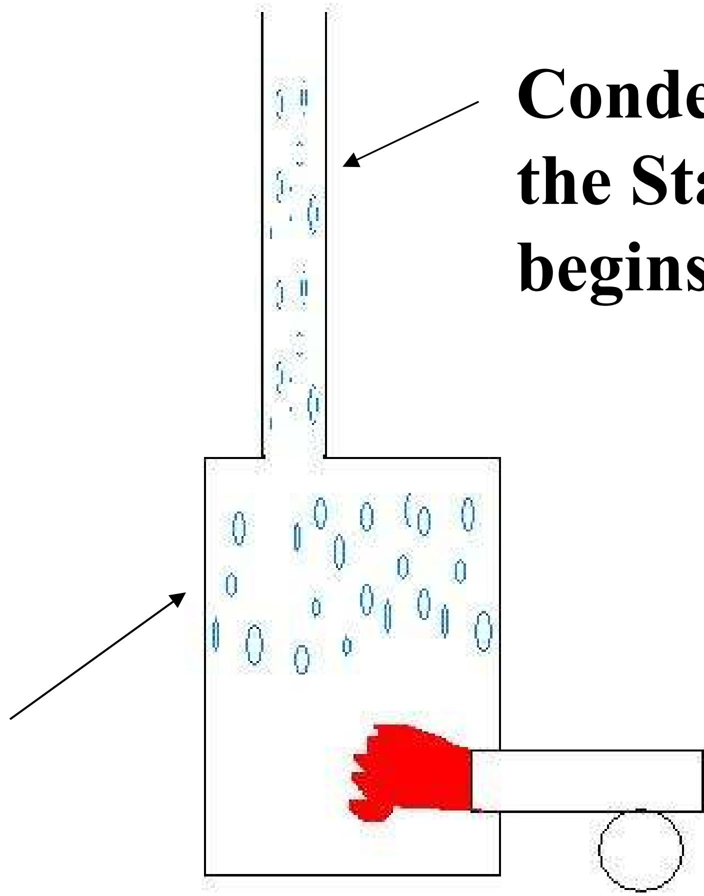
Why is Condensing Bad for Conventional Boilers?

- 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 Tuning
  - Improper installation
  - Too cool return water
  - Controls not set properly

Condensing in the Stack begins first.



Condensing in the Boiler can follow.

Some Interesting Observations

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

FACT

The confining factor in non-condensing boiler design is:

Return Water TEMPERATURE

&

STACK TEMPERATURE

***** ***NOT*** *****

EFFICIENCY

FACT

The primary purpose of the very expensive insulated stove pipe of a conventional boiler is not designed to protect your home from high stack temperatures but to hold the heat in so the flue gasses won’t condense.

Conclusions

Lower temperatures mean greater efficiency

Once the challenge of handling the condensate is solved, every degree the stack temperature is lowered is translated to $$$ saved.

The confining design issue in condensing technology is now:

THERMODYNAMIC

Condensing Boilers

- Types
- Boiler Construction
- Stack Materials
- Handling the Condensate
- More on Efficiency
- Will it Work in My Home
- What can you expect
- Tax Credits

Types

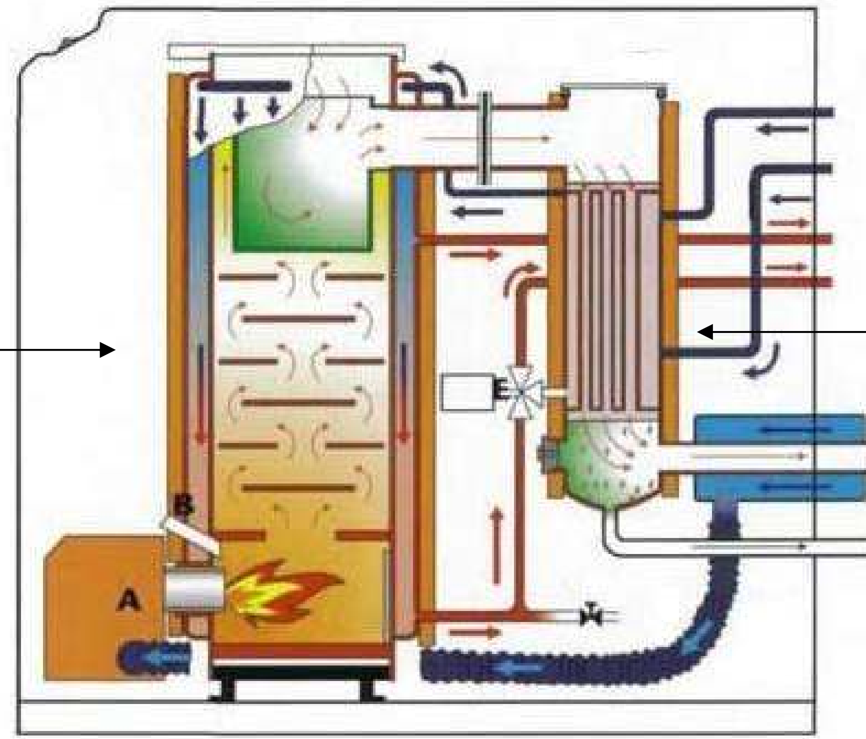
Condensing Boilers

2 Basic Concepts

Munchkin Natural Gas

100% Stainless Steel

FCX - Dual Heat Exchanger



Welded Steel Primary

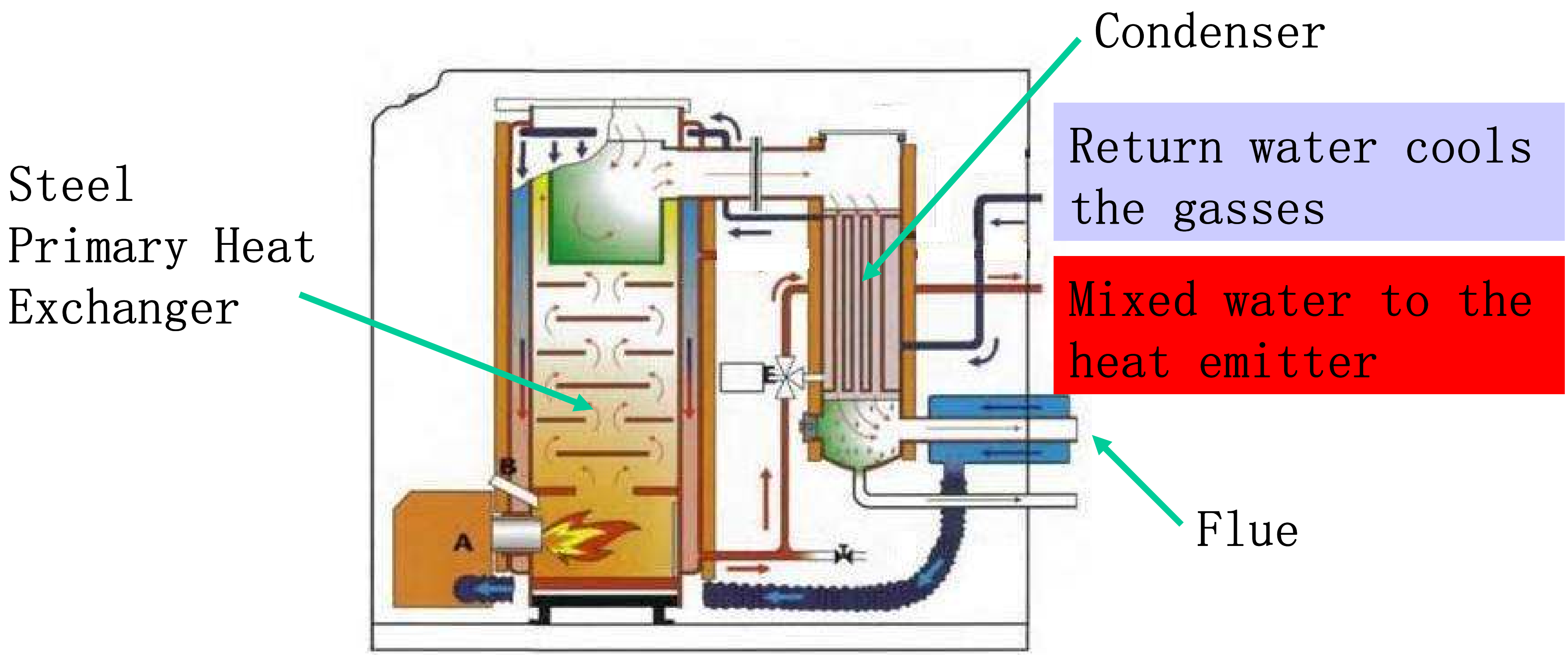
100% Stainless Steel Secondary Condenser

FCX Oil-Fired Condensing Boiler

92-97% Efficient

The Most Efficient Oil-Fired Boiler

Boiler Construction



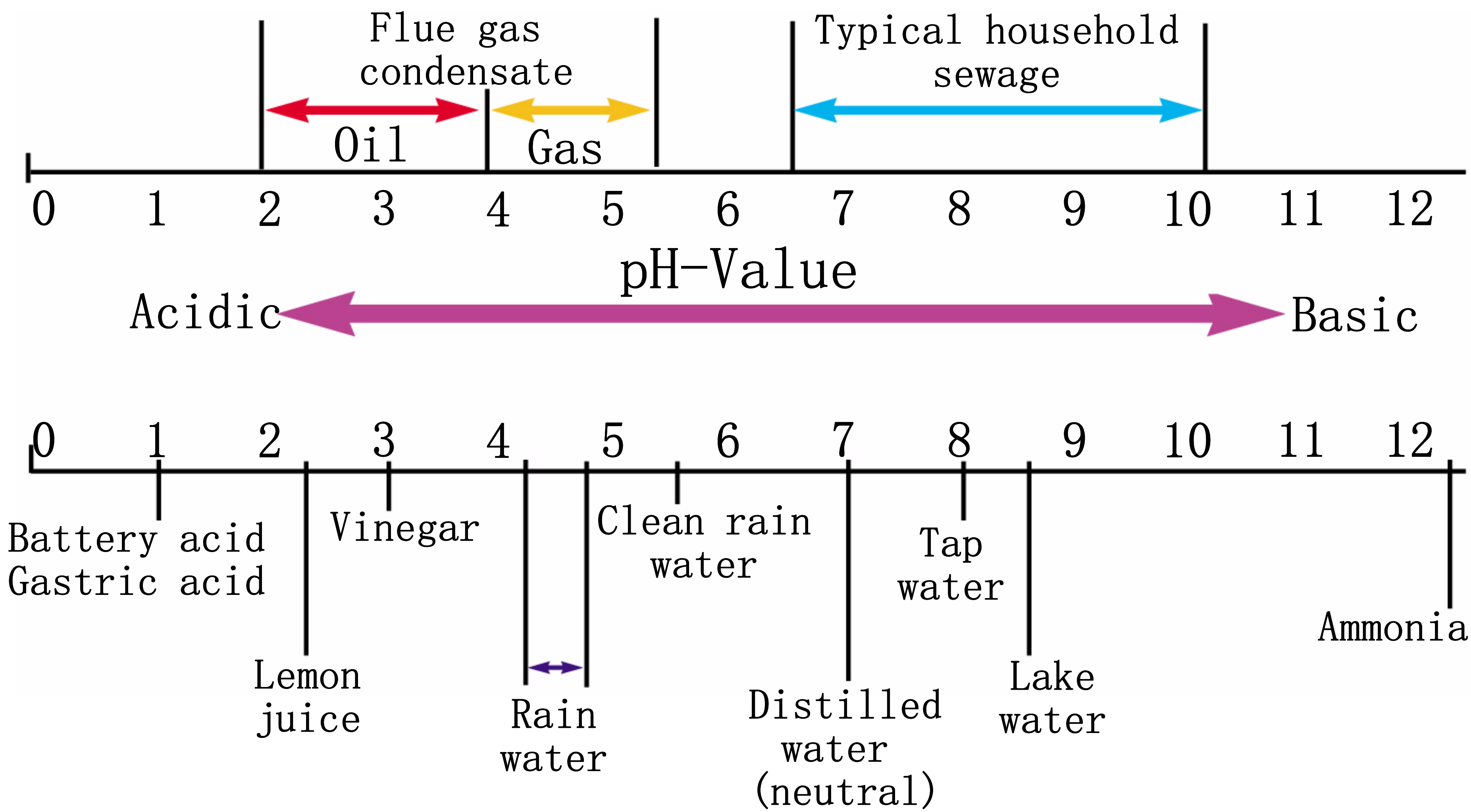
1. Combustion gasses rise thru the Primary and continue down through the Condenser and then to the flue.
2. Water flows counter to the direction of the gasses and enters the bottom of the condenser.
3. The flue gas is cooled enough to condense, and this adds the latent heat of vaporization into the water.

Stack Materials

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

Handling the Condensate

pH VALUES OF VARIOUS FLUIDS



ASHRAY Presentation by Jim Cooke Mechanical Solutions NW, Nov 2005

Neutralization and Disposal

- Neutralization
  - How to do it
  - Is it necessary?
- Disposal
  - Down the drain
  - Pump it away

Efficiency vs. Stack Temperatures

As Stack temperature rises, efficiency decreases. Note that these readings are calculated.

Efficiencies – Methods of Measurement

Annual Fuel Utilization Efficiency (AFUE)

vs.

Seasonal Efficiency

VS.

Burn Efficiency

VS.

Fuel Savings

- AFUE is the only APPLES to APPLES comparison available.
- Your AFUE and Seasonal efficiencies ***can never exceed your burn efficiency***.
- Start with the most efficient technology available and build on that with controls and energy saving techniques.
- **THE BOTTOM LINE What ever heat goes up the chimney 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.

A Condensing Boiler

Will it work in my home?

If your home has radiant heat the answer is an emphatic

YES.

Otherwise. There are more factors to consider:

1. Is the boiler large enough?
2. Do you need high water temperatures? Many well insulated homes do not. Can you utilize the lower water temperatures condensing boilers normally use.
3. If not, can you add more emitters (baseboard, unit heaters, radiant panels, etc.) to lower the temperature of the supply water needed.
4. Can you add more heat exchangers to lower the temperature of the return water and promote more condensing?

What You Can Expect

Out of the box in a radiant home you will get the 93% that is common to all oil-fired condensing boilers. With natural gas you will probably get slightly higher – there is more water in gas.

By using some basic controls and condensing enhancing techniques such as stack robbers, domestic water preheating, and HRV air preheating, you can reach 97% to 98%.

Conclusions Reinforced

Once you can handle the condensate, 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*).

THE BOTTOM LINE

Any heat that exits through the stack is lost.

LAST BUT NOT LEAST

No
Federal Energy Tax Credit
for 2015

Call Your
Congressman

So Again…

Will this boiler work in my home?

Baseboard Home #1

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 3^{rd} 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

Baseboard Home #2

Chris S.:

- 2,550 SF all heated
- 2 x 6 walls with fiberglass batts, and double pane windows, 1000 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
- Grundfoss 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

Baseboard Home #3

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, 1000 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

Multi-Heaters

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**

Buckland – Integrated HRV

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

Habit for Humanity - Baseboard

HfHbb.MOV

CONDENSING BOILER TECHNOLOGY

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

James Romersberger
Quintessence Corporation