CONDENSING BOILER TECHNOLOGY

Presented by:
Ted Schmelling
Mulcahy Company

Manufactures rep of:
Viessmann Manufacturing Co. (US) Inc.
45 Access Rd.
Warwick, RI

What is condensing boiler TECHNOLOGY

Non-condensing construction

Fin tube boiler
Cast-iron sectional boiler
**NATURAL GAS COMBUSTION**

- **Natural gas** $\text{CH}_4$
- **Oxygen** $\text{O}_2$
- **Nitrogen** $\text{N}_2$
- **Combustion**
  - **Carbon Dioxide** $\text{CO}_2$
  - **Water vapor** $\text{H}_2\text{O}$
  - **Nitrogen Oxides** $\text{N}_x\text{O}_y$

**Light** + **Heat**

**ENERGY CONTENT OF NATURAL GAS**

- **SENSIBLE HEAT** 89.8%
- **LATENT HEAT** 10.2%

*Latent – Definition: Latin for “hidden”*

Heat that can be measured or felt by a change in temperature.
Flue gas loss = 3 to 5%
Boiler stand-by and jacket loss = 3 to 5%
Seasonal efficiency of conventional boilers = 80%+

Fuel input = 100%
Sensible heat = 89.8%

- Water vapor turns to liquid when it is reduced in temperature.
- Energy is released when vapor turns to liquid (Condenses)
CONDENSING BOILER HEAT FLOW

- Fuel input = 100%
- Latent Heat 10.2%
- Sensible heat = 89.8%
- Flue gas loss < 1%
- Boiler stand-by and jacket loss < 1%
- Heat Loss < 2%
- Seasonal efficiency of conventional boilers = 82%+
- Seasonal efficiency condensing boilers = 96%+

MORE USABLE HEAT THROUGH CONDENSATION

- Condensing boiler
- Eff. From 85% to 98%
- Total heating value = 100%
- Sensible heat
- Useable heat
- Heating system
- Condensation
- Latent heat 10.2%

What influences the rate of condensation?
FACTORS INFLUENCING EFFECTIVENESS OF CONDENSING TECHNOLOGY

- Fuel
- Combustion air
- Burner type
- Heating system
- Effective use of condensing technology
- Piping layout
- Return water temp
- Emissions

Greatest Influence

- Heating system
- Effective use of condensing technology
- Return water temp
RETURN WATER TEMPERATURE

Boiler return water temperature determines condensing operation

TYPICAL HYDRONIC WATER TEMPERATURE REQUIREMENTS:

High temperature:
- Finned tube baseboard 140 - 190 °F
- Air heat fancoils 140 - 180 °F
- Pool/spa heat exchangers 160 - 180 °F
- DHW production 150 - 190 °F

Medium temperature:
- Cast iron radiators 100 - 140 °F
- Low mass radiant floor
  - ie: wood joist floors 100 - 150 °F

Low temperature:
- High mass radiant floor
  - ie: concrete floors 80 - 120 °F
- Snowmelting systems 80 - 120 °F
IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

Example 3: Supply/return temperature: 104/86°F

Outside temperature

System water temperature

Dewpoint temperature (natural gas 132°F)

Condensation range

Radiant floor

IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

Example 1: Supply/return temperature: 180/160°F

Outside temperature

System water temperature

Dewpoint temp 132°F

Condensation range

Fin tube
ASHRAE weather data for Boston, MA

**Condensation Range**

- Condensing: 24.3% 1497 hr
- Non-condensing: 7.7% 1675 hr

**Design Temperature**
- Boston: +7°F
- Supply: 180°F
- Return: 160°F

**Dewpoint Temp**
- 135°F

**System Water Temperature**
- 68°F to 176°F

**Outside Temperature**
- 68°F to 20°F

**Impact of System Temperatures on Condensation**

Example 2: Supply/return temperature: 160/140°F

- Condensation range: 11.3°F
- Dewpoint temp: 132°F

Hydro-Air radiators

Ashrae weather data, hours of occurrence: Sept - May

Design temperature Boston: +7°F
Supply 180°F
Return 160°F
Dewpoint temp

Ashrae weather data, hours of occurrence: Sept - May

IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

Example 2: Supply/return temperature: 160/140°F

- Condensation range: 11.3°F
- Dewpoint temp: 132°F

Hydro-Air radiators

Ashrae weather data, hours of occurrence: Sept - May

IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

Example 2: Supply/return temperature: 160/140°F

- Condensation range: 11.3°F
- Dewpoint temp: 132°F

Hydro-Air radiators

Ashrae weather data, hours of occurrence: Sept - May
ASHRAE weather data for Boston, MA

**Condensing / Non-Condensing Ratio**

- **Condensing**: 97%
- **Non-condensing**: 3%

**Condensation range**

- 72°F to 86°F
- 104°F to 122°F
- 140°F to 158°F
- 176°F

**System water temperature**

- Supply: 160°F
- Return: 140°F

**Design temperature**

- Boston: +7°F

**Dewpoint temp**

- 135°F

**Ashrae weather data, hours of occurrence: Sept - May**

- 1497 hr, 24.3%
- 1675 hr, 27%
- 627 hr, 10%
- 124 hrs, 2%
- 11 hrs, 0.2%

**System Water Temperature Drop**

- Typical system: 20°F
- Temperature drop: 180°F

- What about a higher temperature drop? 30°F...40°F?

- Benefits to this?

- 150°F
Low-Temp technology

Evolution of the heat exchanger

These can work very effectively at low water temperatures, as low as 90°F

TRUE SYSTEM EFFICIENCY
System Components

Fan coil sizing

Same BTU’s delivered

Air flow

180°F

160°F

140°F

120°F

Ashrae Presentation

April 2010
FACTORs INFLUENCING EFFECTIVENESS OF CONDENSING TECHNOLOGY

Effective use of condensing technology

Piping layout

USE OF MIXING VALVES WITH CONDENSING BOILERS

4-way mixing valve

Boiler return water temperature elevation

INCORRECT

3-way mixing valve

No boiler return water temperature elevation

CORRECT
INJECTION PUMPING WITH CONDENSING BOILERS

INCORRECT

CONDENSING BOILERS IN HIGH FLOW SYSTEMS

Hydraulic system decoupling

High temp system
Low temp system

How many have heard of this before?
COMMERCIAL LOW LOSS HEADER

For use with all commercial boilers

Benefits of LLH:
- Hydraulic separation
- Protects boiler from debris
- Air removal
- Optimum boiler operation

Low loss header

Air Bleed

T1 – Boiler supply temperature
T2 – Boiler return temperature
T3 – System supply temperature
T4 – System return temperature

V_{primary} – Boiler circuit flow rate
V_{secondary} – Heating circuit flow rate
Q_{primary} – Heat supplied by boiler
Q_{secondary} – Heat consumed by system

V_{primary} < V_{secondary}
T1 > T3
T2 = T4
Q_{primary} ≠ Q_{secondary}

What is going to happen here?

Temp Sensor needed

Debris can fall out

Debris can fall out
LOW LOSS HEADERS
Principle of operation

- \( V_p < V_s \)
- \( T_1 > T_3 \)
- \( T_2 = T_4 \)

Boiler supply 100 GPM
System supply 125 GPM
Bypass flow 25 GPM
System return 125 GPM

COMMERCIAL LOW LOSS HEADERS

Maximum system flow rate
Model 400/200 – 250 gpm
Model 400/400 – 528 gpm
LOW LOSS HEADER
From small to very big

COMBINATION OF BOILERS

System Supply

Boiler
Non-Condensing boiler
LAG BOILER

System Return

Condensing boiler
LEAD BOILER
MULTIPLE FUNCTION, MULTIPLE TEMPERATURE SYSTEM

Unique Germany piping and mixing system

FACTORS INFLUENCING EFFECTIVENESS OF CONDENSING TECHNOLOGY
MARKETING AND REALITY

99.8
THE MOST EFFICIENT BOILER

Thermal efficiency

...can reach efficiencies of 98% - and more....

...pending return water temperature, can reach efficiencies of 98% - and more.
<table>
<thead>
<tr>
<th>Input</th>
<th>BTU/Hr.</th>
<th>650,000</th>
<th>950,000</th>
<th>1,400,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KCal/Hr.</td>
<td>163,800</td>
<td>239,400</td>
<td>352,644</td>
</tr>
<tr>
<td>Output</td>
<td>BTU/Hr. (120°F in/140°F out)</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
</tr>
<tr>
<td></td>
<td>KCal/Hr. (411°F in/60°C out)</td>
<td>852,900</td>
<td>807,900</td>
<td>1,190,000</td>
</tr>
<tr>
<td>Fuel Consumption @ rated capacity</td>
<td>Natural Gas</td>
<td>139,200</td>
<td>203,500</td>
<td>289,745</td>
</tr>
<tr>
<td></td>
<td>M3/Hr.</td>
<td>650</td>
<td>950</td>
<td>1,400</td>
</tr>
<tr>
<td>Propane</td>
<td>FT3/Hr.</td>
<td>18.4</td>
<td>26.9</td>
<td>39.6</td>
</tr>
<tr>
<td>Unit Size/Output</td>
<td>BHP</td>
<td>7.3</td>
<td>10.8</td>
<td>15.9</td>
</tr>
<tr>
<td></td>
<td>KW</td>
<td>17.4</td>
<td>25</td>
<td>36.4</td>
</tr>
<tr>
<td>Electrical Requirements</td>
<td>Amps</td>
<td>120V, 50 CY, 1 Phase</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>240V, 50 CY, 1 Phase</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>MAWP</td>
<td>PSI</td>
<td>60 or 90</td>
<td>60 or 90</td>
<td>60 or 160</td>
</tr>
<tr>
<td></td>
<td>BAR</td>
<td>4.1 or 11.0</td>
<td>4.1 or 11.0</td>
<td>4.1 or 11.0</td>
</tr>
<tr>
<td>Water Content</td>
<td>GAL</td>
<td>34</td>
<td>42</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>LITERS</td>
<td>129</td>
<td>159</td>
<td>303</td>
</tr>
<tr>
<td>Approximate Shipping Weight</td>
<td>LB</td>
<td>2402</td>
<td>2640</td>
<td>2450</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>1092</td>
<td>1200</td>
<td>1114</td>
</tr>
</tbody>
</table>

**TECHNICAL DATA**

- **Boiler model**: 
  - COAL/ADA Input: 205,000/195,000
  - COAL/ADA Output: 291,000/277,000
  - Minimum Efficiency: 85.5% (as hot water boiler at 80 deg F inlet, 180deg F outlet water temp) - ANSI Z21.13;
  - Maximum Efficiency: 99.8% (as water heater at 50 deg. F inlet, 140 deg F outlet water temp) - ANSI Z21.10.3

- **Fuel**: Natural Gas
- **Electrical Rating**: 120 V, 2.4 A, 60 Hz, single phase
- **Heating surface**: 256
- **Boiler Shell Dimensions**: Width: 51 1/4 inches, Depth: 12 1/2 inches, Height: 54 inches
- **Overall Dimensions**: Width: 66 1/8 inches, Depth: 24 1/2 inches, Height: 66 inches

---

[Additional details not visible in the image]
EFFICIENCY

What does it all mean??

- Combustion Efficiency
- Cycle Efficiency or turn down
- AFUE (Seasonal Efficiency)
- Thermal Efficiency
- System Efficiency
- Manufactures claimed Efficiency

COMBUSTION EFFICIENCY

Testing for non-condensing gas commercial boilers


Delta T = 100°F

Heat exchanger

Constant load

180°F

80°F

Air Input
Fuel Input

CO₂ % T_out_gas

T_air

Condensate measured for condensing boilers test
CYCLE EFFICIENCY

Cycle Efficiency = \( \frac{\text{Total useful heat output (Btu/h) of boiler over a period of time}}{\text{Energy content of fuel (Btu/h) over same time period}} \)

Steady State Efficiency = 90%

Time required to reach Steady State depends on appliance

AFUE EFFICIENCY

Annual Fuel Utilization Efficiency

Seasonal efficiency test for boilers up to 300,000 Btu/h

Measured in test: \( \text{CO}_2, \text{O}_2\% , T_{\text{gas}}, T_{\text{room}} \)

Heated Space

Constant Load

One cool down cycle evaluated
Thermal efficiency:
The ratio of the amount heat absorbed by the water to the higher heating value (HHV) in the fuel burned

Thermal efficiency is sometimes confused with combustion efficiency

COMBUSTION EFFICIENCY TESTING
For condensing gas commercial boilers >300 MBH

BTS-2000

Constant Load

Air Input
Fuel Input

Boiler drain

Condensate measured for condensing boilers test

Heat Exchanger

180°F

80°F

80°F

100°F
CONDENSING BOILER EFFICIENCY

**TOTAL HEAT OUTPUT OF CONDENSING BOILER**

**SENSIBLE HEAT CAPTURED**

**LATENT HEAT CAPTURED**

Formula:

\[
\text{Efficiency of condensing boiler (\%)} = \frac{\text{Boiler input btu/hr (metered gas flow)} \times \text{Combustion eff. (measured)} + \text{Heat gain from condensate (btu/hr)}}{\text{Boiler input btu/hr}}
\]

Heat gain from condensate = 8783 Btu / usg of condensate

2320 Btu / ltr of condensate

---

***Sample project: Community College, Alberta***

- **CT3-89**
- **Low fire rate:** 1,008 MBH / 295 KWh
- **Return water temp.** = 113°F
- **Altitude** = 2091’

**Boiler efficiency (%)**

\[
= \frac{[1,008,000 \text{ btu/hr} \times 0.89] + [4.68 \text{ usg/hr} \times 8783 \text{ btu/hr/gal}]}{1,008,000 \text{ btu/hr}}
\]

\[
= \frac{897,120 \text{ btu/hr} + 41,104 \text{ btu/hr}}{1,008,000 \text{ btu/hr}} = 93.1\% 
\]
HIGH EFFICIENCY BOILERS

*Under what conditions??*

- Burner Efficiency (CO2%) or excess air
  - Sealed combustion?
  - Turn down ratio?
- System water temperatures (return water)
- Boiler Controls
- Boiler Construction and Materials

**WATER VAPOR DEW POINT**

| CO2% of flue gas influences dew point temperature |
|-------------------------------------------------
| Higher CO2 = Higher Dew point = More Condensation |
| Lower CO2 = Lower Dew point = Less Condensation |

CO2 in Vol %

Dew point water vapor

℃ (°F) Natural Gas (95% CH₄)

77 25
86 30
95 35
104 40
113 45
122 50
131 55
140 60

April 2010

Ashrae Presentation
DEW POINT AND ALTITUDE

Dew Point of Natural Gas
Based on 1000 btu/ft³, 50% RH and 60° F Room Air

Dew Point Temperature

Altitude – Feet above sea level

CONDENSING BOILER TECHNOLOGY

What influences the CO₂%?

THE BURNER!
PERFECT (STOICHIOMETRIC) COMBUSTION

When theoretical perfect air/fuel mixtures are applied, *Stoichiometric Combustion* is achieved.

Eg: 10 parts air to 1 part Natural gas, 25 parts air to 1 part Propane.

Each fuel has an Maximum CO₂ % if Stoichiometric Combustion is achieved:

- **Natural gas:** 11.9% CO₂
- **Propane gas:** 13.7% CO₂

THEORETICAL PERFECT NATURAL GAS COMBUSTION OR STOICHIOMETRIC

The CO₂ = 11.9%
The CO  = 0 ppm

1 part gas

9.7 parts air by volume

Excess air 0%
SAFE AND EFFICIENT COMBUSTION

Acceptable values for safe and efficient combustion:

- Excess Air: 17 - 30%
- Oxygen: 3 – 5%

Acceptable range of CO₂%:
- Natural gas: 9.1 – 10% CO₂
- Propane gas: 10.7 – 11.1% CO₂

REAL WORLD NATURAL GAS COMBUSTION WITH GOOD BURNER TECHNOLOGY

The CO₂ = 9.5 to 10%
The CO = 0 to 20 ppm

Excess air 20 to 25%

What can cause the amount of excess air to change after start-up?
COMBUSTION ANALYSIS RESULTS

Boilers with good burner technology should be able to get very low CO!

<table>
<thead>
<tr>
<th>Combustible</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T. Room</td>
<td>57 °F</td>
<td></td>
</tr>
<tr>
<td>T. Gas</td>
<td>314 °F</td>
<td></td>
</tr>
<tr>
<td>O2</td>
<td>3.4 %</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>1 ppm</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>40 ppm</td>
<td></td>
</tr>
<tr>
<td>NO2</td>
<td>2 ppm</td>
<td></td>
</tr>
<tr>
<td>NOx</td>
<td>42 ppm</td>
<td></td>
</tr>
<tr>
<td>CO2</td>
<td>9.9 %</td>
<td></td>
</tr>
<tr>
<td>Eff.</td>
<td>84.2 %</td>
<td></td>
</tr>
<tr>
<td>Losses</td>
<td>15.8 %</td>
<td></td>
</tr>
<tr>
<td>Lambda</td>
<td>1.19</td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>-0.02 in. Hg</td>
<td></td>
</tr>
</tbody>
</table>

New power fired boilers

NATURAL GAS COMBUSTION

Power-fired burner technology

- 25% Excess Air
- 9.5% CO₂
- 4% O₂
**BURNER REQUIREMENTS FOR CONDENSING BOILERS**

- Combustion with minimal excess air
  - CO\(_2\): 9.5 to 10%
  - Excess air: 20 – 25%
- Fully modulating input
- Precise calibration thru entire firing range (Linkage-less control)
- O\(_2\) trim
- Low NO\(_x\) and CO emissions

### Combustion air temperatures

<table>
<thead>
<tr>
<th>CO(_2)%</th>
<th>0°</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>40°</th>
<th>50°</th>
<th>60°</th>
<th>70°</th>
<th>80°</th>
<th>90°</th>
<th>100°</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>-1.2</td>
<td>-1.1</td>
<td>+0.5</td>
<td>+0.8</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.3</td>
<td>-0.2</td>
<td>+0.2</td>
<td>+0.3</td>
<td>+0.5</td>
</tr>
<tr>
<td>11.5</td>
<td>-1.2</td>
<td>-1.1</td>
<td>-0.3</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.3</td>
<td>-0.2</td>
<td>+0.2</td>
<td>+0.4</td>
<td>+0.5</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>-1.3</td>
<td>-1.2</td>
<td>-1.0</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-0.4</td>
<td>-0.2</td>
<td>+0.2</td>
<td>+0.4</td>
<td>+0.5</td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>-1.4</td>
<td>-1.2</td>
<td>-1.0</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-0.4</td>
<td>-0.2</td>
<td>+0.2</td>
<td>+0.4</td>
<td>+0.5</td>
<td>+0.5</td>
</tr>
<tr>
<td>10.0</td>
<td>-1.4</td>
<td>-1.2</td>
<td>-1.0</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-0.4</td>
<td>-0.2</td>
<td>+0.2</td>
<td>+0.4</td>
<td>+0.6</td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>-1.5</td>
<td>-1.2</td>
<td>-1.0</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-0.4</td>
<td>-0.2</td>
<td>+0.3</td>
<td>+0.5</td>
<td>+0.7</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>-1.5</td>
<td>-1.4</td>
<td>-1.1</td>
<td>-0.9</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.3</td>
<td>+0.3</td>
<td>+0.5</td>
<td>+0.7</td>
<td>+0.7</td>
</tr>
<tr>
<td>8.5</td>
<td>-1.5</td>
<td>-1.4</td>
<td>-1.2</td>
<td>-1.0</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.3</td>
<td>+0.3</td>
<td>+0.5</td>
<td>+0.7</td>
<td>+0.7</td>
</tr>
<tr>
<td>8</td>
<td>-1.8</td>
<td>-1.5</td>
<td>-1.3</td>
<td>+1.0</td>
<td>+0.8</td>
<td>+0.5</td>
<td>+0.3</td>
<td>+0.3</td>
<td>+0.5</td>
<td>+0.7</td>
<td>+0.7</td>
</tr>
<tr>
<td>7.5</td>
<td>-1.9</td>
<td>-1.6</td>
<td>-1.4</td>
<td>-1.1</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-0.3</td>
<td>+0.3</td>
<td>+0.5</td>
<td>+0.7</td>
<td>+0.8</td>
</tr>
<tr>
<td>7</td>
<td>-1.9</td>
<td>-1.7</td>
<td>-1.4</td>
<td>-1.3</td>
<td>-0.9</td>
<td>-0.6</td>
<td>-0.3</td>
<td>+0.3</td>
<td>+0.6</td>
<td>+0.8</td>
<td>+0.9</td>
</tr>
<tr>
<td>6.5</td>
<td>-2.1</td>
<td>-1.8</td>
<td>-1.5</td>
<td>-1.2</td>
<td>-0.9</td>
<td>-0.6</td>
<td>-0.3</td>
<td>+0.3</td>
<td>+0.6</td>
<td>+0.9</td>
<td>+0.9</td>
</tr>
<tr>
<td>6</td>
<td>-2.3</td>
<td>-2.0</td>
<td>-1.7</td>
<td>-1.3</td>
<td>-1.0</td>
<td>-0.7</td>
<td>-0.4</td>
<td>+0.3</td>
<td>+0.7</td>
<td>+1.0</td>
<td>+1.0</td>
</tr>
<tr>
<td>5.5</td>
<td>-2.5</td>
<td>-2.2</td>
<td>-1.8</td>
<td>-1.4</td>
<td>-1.1</td>
<td>-0.7</td>
<td>-0.4</td>
<td>+0.4</td>
<td>+0.7</td>
<td>+1.1</td>
<td>+1.1</td>
</tr>
<tr>
<td>5</td>
<td>-2.7</td>
<td>-2.4</td>
<td>-1.9</td>
<td>-1.5</td>
<td>-1.1</td>
<td>-0.8</td>
<td>-0.4</td>
<td>+0.4</td>
<td>+0.8</td>
<td>+1.1</td>
<td>+1.2</td>
</tr>
<tr>
<td>4.5</td>
<td>-3.0</td>
<td>-2.6</td>
<td>-2.2</td>
<td>-1.7</td>
<td>-1.3</td>
<td>-0.9</td>
<td>-0.5</td>
<td>+0.4</td>
<td>+0.8</td>
<td>+1.2</td>
<td>+1.2</td>
</tr>
<tr>
<td>4</td>
<td>-3.4</td>
<td>-2.9</td>
<td>-2.5</td>
<td>-2.0</td>
<td>-1.5</td>
<td>-1.0</td>
<td>-0.5</td>
<td>+0.5</td>
<td>+0.9</td>
<td>+1.4</td>
<td>+1.4</td>
</tr>
</tbody>
</table>

Air temperature correction chart from an Analyzer Company
BOILER EFFICIENCY

Supply / Return at 100% Load (Design Conditions):
- 104°F/86°F, 40°C/30°C
- 140°F/120°F, 60°C/49°C
- 167°F/140°F, 75°C/60°C
- 194°F/158°F, 90°C/70°C

CONDENSING BOILER TECHNOLOGY

Construction requirements of condensing boiler technology
PHYSICAL REQUIREMENTS OF THE HEAT EXCHANGER SURFACES

Best material for condensing boilers:
- Single wall
- Highly conductive
- Smooth surface

Flue Gas

- Boiler Water 122°F
- Heat Flow
- Condensate formation

Flue gas

- Boiler Water
- Flue gas
- Condensate

Correct

Incorrect

Flue gas and condensate must flow in the same direction (parallel flow)
Condensing boiler requirements:
- Counterflow principle for flue gas and boiler water – optimal heat transfer
- Parallel flow direction for flue gas and condensate – uniform flow with self-cleaning effect of heat transfer surfaces

Why is material construction of the boiler heat exchanger so important?
pH VALUES OF VARIOUS FLUIDS

<table>
<thead>
<tr>
<th>Fluid</th>
<th>pH-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flue gas condensate</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td></td>
</tr>
<tr>
<td>Typical household sewage</td>
<td></td>
</tr>
<tr>
<td>Acidic</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td></td>
</tr>
<tr>
<td>Battery acid</td>
<td></td>
</tr>
<tr>
<td>Gastric acid</td>
<td></td>
</tr>
<tr>
<td>Vinegar</td>
<td></td>
</tr>
<tr>
<td>Lemon juice</td>
<td></td>
</tr>
<tr>
<td>Rain water</td>
<td></td>
</tr>
<tr>
<td>Distilled water (neutral)</td>
<td></td>
</tr>
<tr>
<td>Tap water</td>
<td></td>
</tr>
<tr>
<td>Lake water</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td></td>
</tr>
</tbody>
</table>

MATERIAL REQUIREMENTS FOR CONDENSING BOILERS

- Highly corrosion resistant
- High strength with thin wall thickness
- Formable
- Long term reliability