HOW IMPORTANT IS STEAM TO YOUR PROCESS?

Don Williams
RF MacDonald Company Corporate Trainer
BACKGROUND

- U.S. Navy 1973 to 1988 (Active Duty and Reserves) – Machinist Mate 1st Class
- Westinghouse Marine Division 1984 to 1991 – Lead Turbine Tester - Propulsion Turbines and Reduction Gears
COEN Burner Company 1991 to 2000 – Product Line Manager, R&D Low NOx burners and controls

Proctor Sales 2000 to 2008 – Industrial Boiler Systems Sales and Design Engineer
R. F. MacDonald Company 2008 to present:
- Modesto Service Manager 2008 to 2010
- Corporate Trainer 2010 to present
TOPICS

- What is steam and its benefits?
- How do we generate steam?
- Why do you need to maintain your boiler?
- What will be the result of not maintaining your boiler?
STEAM

- Temperature is consistent based on pressure
- Sterile

<table>
<thead>
<tr>
<th>Pressure (psig)</th>
<th>0</th>
<th>10</th>
<th>80</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation Temp</td>
<td>212</td>
<td>239.5</td>
<td>323.9</td>
<td>337.9</td>
</tr>
<tr>
<td>Volume (ft³/lb)</td>
<td>26.4</td>
<td>16.46</td>
<td>4.66</td>
<td>3.89</td>
</tr>
<tr>
<td>Sensible Heat (btu/lb)</td>
<td>180</td>
<td>207.9</td>
<td>294.4</td>
<td>308.9</td>
</tr>
<tr>
<td>Latent Heat (btu/lb)</td>
<td>970</td>
<td>952.5</td>
<td>891.9</td>
<td>880.7</td>
</tr>
<tr>
<td>Total Heat (btu/lb)</td>
<td>1150</td>
<td>1160.4</td>
<td>1186.3</td>
<td>1189.4</td>
</tr>
</tbody>
</table>
Steam is used for various applications:
- Pasteurizing
- Comfort heating
- Humidification
- Cooking processes
- Feed preparation
STEAM
What do cattle eat?

Steam-flaked Corn

Feedyard Learning Center
STEAM
Steam flaking systems - conditioning
Calculating Steam Consumption
100% Quality Steam, 100% Efficiency

Assume: 10 Tons/Hour on Corn
Incoming temperature 60°F
Incoming moisture 14%
Condition to 212°F

10 Ton x 2,000#/Ton x .33 x (212-60) = 1,003,200 BTU Req

Saturated steam @ 212°F and ATM Pressure = 1150 BTU/#

1,000,000 BTU / 1150 BTU/# = 872# Steam Required

872# Steam (Water) / 20,872# Corn = Addition of 4.2% Moisture

Calculating Steam Consumption
80% Quality Steam, 80% Efficiency

Assume: 10 Tons/Hour on Corn
Incoming temperature 60°F
Incoming moisture 14%
Condition to 212°F

10 Ton x 2,000#/Ton x .33 x (212-60) / .8 = 1,254,000 BTU Req

80% Quality steam @ 212°F and ATM Pressure = 956 BTU/#

1,254,000 BTU / 956 BTU/# = 1312# Steam Required

1312# Steam (Water) / 21,312# Corn = Addition of 6.2% Moisture
BTU's Required to Heat Grain

- Grain Moisture, %

- BTU per Ton x 1000
Steam Flaking - Conditioning Costs

Assumptions: 100% make up water @ 50°F
Boiler pressure @ 120 PSI (350°F)
Boiler efficiency = 85%
Natural gas @ $0.27 / 100,000 BTU (Therm)

1% moisture addition per ton = 20# steam

$$20 \times ((350-50) + 970) \times \frac{1}{85\%} = 29,882 \text{ BTU's required}$$

$$\frac{29,882}{100,000} \times 0.27 = \$0.081 \text{ per 1% moisture addition per ton}$$
STEAM GENERATION

Mechanisms of Heat Transfer

Evaporation

Convection

Conduction

Radiation
STEAM GENERATION

- Firetube Boilers
- Watertube Boilers
STEAM GENERATION

Cleaver Brooks CBEX Boiler
STEAM GENERATION

Cleaver Brooks CBEX Boiler
STEAM GENERATION

Clayton Steam Generator

Spiral Spring Coil Construction allows rapid start-up without thermal stress.
STEAM GENERATION

Clayton Steam Generator
STEAM GENERATION

Clayton Steam Generator
BOILER MAINTENANCE

- Annual inspections required all boilers operating at > 15 PSIG
- Hourly inspections required per California Title 8 Section 781 “Boiler Attendance”
- Water chemistry testing – should be completed daily at a minimum
- Testing Primary Low Water Cutout each shift
## BOILER MAINTENANCE

- Excerpt from Travelers Insurance Risk control maintenance guidelines for boilers

<table>
<thead>
<tr>
<th>Low pressure steam (pumped and gravity condensate return)</th>
<th></th>
<th>Daily</th>
<th>Annual</th>
<th>Rapid drain</th>
<th>Slow drain</th>
<th>Inspect</th>
<th>Operational</th>
<th>Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two LWCOs, the lower equipped with a manual reset</td>
<td>Annual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High pressure limit cutoff with manual reset</td>
<td>Annual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety valve</td>
<td>Every 3 Months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High pressure steam (automatically fired and unattended)</th>
<th></th>
<th>Daily</th>
<th>Annual</th>
<th>Rapid drain</th>
<th>Slow drain</th>
<th>Inspect</th>
<th>Operational</th>
<th>Manual</th>
</tr>
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<td>Two LWCOs, the lower equipped with a manual reset</td>
<td>Annual</td>
<td></td>
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<td>Annual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety valve</td>
<td>Every 6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High pressure steam (operator attended)</th>
<th></th>
<th>Each shift</th>
<th>Annual</th>
<th>Rapid drain</th>
<th>Slow drain</th>
<th>Inspect</th>
<th>Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>One LWCO</td>
<td>Annual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High and low water level alarms</td>
<td>Each shift</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety valve (400 psi or less)</td>
<td>Every 6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety valve (over 400 psi)</td>
<td>Every 3 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**BOILER MAINTENANCE**

- Clayton Boiler water chemistry requirements

<table>
<thead>
<tr>
<th>COIL FEEDWATER AT SAMPLE VALVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Limit Values:</strong></td>
</tr>
<tr>
<td>Hardness – 4 ppm maximum</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>Residual Sulfite</td>
</tr>
<tr>
<td>Limit dissolved solids – 8,550 ppm maximum</td>
</tr>
<tr>
<td>Free of suspended solids (mud, rust particles, etc.)</td>
</tr>
</tbody>
</table>
**BOILER MAINTENANCE**

- Typical Firetube water chemistry requirements

<table>
<thead>
<tr>
<th>Water Constituent Tolerance: 0-300 operating psig</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feed Water</strong></td>
</tr>
<tr>
<td>Oxygen</td>
</tr>
<tr>
<td>.007 ppm</td>
</tr>
<tr>
<td>Iron &amp; copper</td>
</tr>
<tr>
<td>0.1 &amp; 0.05 ppm</td>
</tr>
<tr>
<td>Total Hardness</td>
</tr>
<tr>
<td>0.3 ppm</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>8.3 – 10.0</td>
</tr>
<tr>
<td>Non-Volatile TOC (Total Organic Carbon)</td>
</tr>
<tr>
<td>1 ppm</td>
</tr>
<tr>
<td>Oily Matter</td>
</tr>
<tr>
<td>1 ppm</td>
</tr>
</tbody>
</table>
BOILER MAINTENANCE

- When making hourly rounds complete boiler log sheet
- Note boiler water level
- Note Feed water tank/DA Tank water level and pressure/temperature
- Inspect burner flame
- Note any leaks
BOILER FAILURES

- Typical boiler failures:
- Flame failure during run or pilot
- Low water shutdown
- Control faults
- Water chemistry out of compliance with established parameters
- Lack of maintenance

*Don’t ignore the problem, find the cause and resolve it!*
BOILER FAILURES

% Boiler Efficiency Loss Due to Scaling

Scale increases operating costs - $$$ lost
BOILER FAILURES

Poor water chemistry resulting in tube failure
Lack of maintenance
Auxiliary Low Water Cutout not tested correctly and had failed.
How important is steam to your process?

Without steam, no or limited production

No or limited production costs you $$$$ in potential feed sales

Customers will go to another supplier who can meet their immediate needs

By the way, those customers may not come back
Any Questions