THE IMPORTANCE OF BOILER FEED WATER TREATMENT

Presented by Cleaver Brooks' Steve Connor & Jared Gabel
TODAY’S TOPICS

• What a sound water treatment program involves
• The mechanical elements
• Keeping the boiler and connected system safe, efficient & reliable
• The major chemical elements
• The chemical dosing systems and their applications
• Boiler dosing and expert coordination
• Dosing pump details
• Key points to be aware of
• The system options
Water is an excellent heat transfer medium, but it must be properly treated in both steam and hot water systems or serious problems will ensue, robbing energy and reducing the life of the asset.
PROPER BOILER WATER DOSING

Steam Systems
THE PROBLEMS
CHEMICAL DOSING ADDRESSES

- Scaling
- Porous Deposition
- Corrosion
- Efficiency Loss
- Life of the Asset
- Steam Quality
  - % moisture
- Steam Purity
  - Silica
  - Sodium ion
WHAT NEEDS TO BE REMOVED

• Dissolved Minerals
• Hard Scale Formers
  • Calcium
  • Magnesium
• TDS
  • Calcium (Scale)
  • Magnesium (Scale)
  • Sulfate (Instability)
  • Iron (Scale)
  • Silica (Deposition)
  • Chloride (Instability)
  • Alkalinity (Foaming)
• Dissolved Gas
  • Free Oxygen (Corrosion)
  • Free Carbon Dioxide (Corrosion)
MOST ECONOMICAL
LONG-TERM APPROACH

Mechanical

Chemical
WHAT NEEDS TO BE REMOVED

• **Dissolved Minerals**
  • Calcium
  • Magnesium

• **Hard Scale Formers**
  • Calcium (scale)
  • Magnesium (scale)
  • Sulfate (corrosion)
  • Sodium (deposition)
  • Silica (scale)
  • Chloride (instability)
  • Alkalinity (foaming)

• **TDS**
  • Calcium (scale)
  • Magnesium (scale)
  • Sodium (deposition)

• **Dissolved Gas**
  • Free Oxygen (corrosion)
  • Free Carbon Dioxide (corrosion)
SCALE AND DEPOSITS
FORM IN HIGH HEAT
FLUX AREAS

- **Effect of Scale & Deposits:**
- Calcium, magnesium inhibit heat transfer
- Raise tube metal temperature
  - Efficiency loss
  - Vessel failure
  - Downtime
MECHANICAL REMOVAL

Removes

- Calcium
- Magnesium

Twin Water Softener (Resin Tanks)

Brine Tank
WHAT NEEDS TO BE REMOVED

- **Dissolved Minerals**
- **Hard Scale Formers**
  - Calcium
  - Magnesium
- **TDS**
  - Calcium
  - Magnesium
  - Sulfate
  - Sodium
  - Silica
  - Chloride
  - Alkalinity
- **Dissolved Gas**
  - Free Oxygen
  - Free Carbon Dioxide

Waterside Corrosion

Waterside Scale
BOILER WATER
FOAMING & CARRYOVER
MECHANICAL REMOVAL PROCESS

Removes

- Bicarbonate & Carbonate Alkalinity
- Sulfate
- Silica
WHAT NEEDS TO BE REMOVED

• Dissolved Minerals
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• TDS
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  • Sodium
  • Silica
  • Chloride
  • Alkalinity

• Dissolved Gas
  • Free Oxygen
  • Free Carbon Dioxide

Waterside Scale

Waterside Corrosion
OXYGEN CORROSION
HOT CONDENSATE RETURNED

Boiler Feed System

Deaerator

Steam diffusing tube

Vented receiver

Pressurized receiver.
Chemicals are required too!
TOLERANCES ARE BASED ON PRESSURE & TEMPERATURE

Water Constituent Tolerance: 0-300 operating psig

<table>
<thead>
<tr>
<th>Feed Water</th>
<th>Boiler Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Silica</td>
</tr>
<tr>
<td>Iron &amp; copper</td>
<td>Total Alkalinity</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>Free OH Alkalinity</td>
</tr>
<tr>
<td>pH</td>
<td>Specific Conductance</td>
</tr>
<tr>
<td>Non-Volatile TOC</td>
<td></td>
</tr>
<tr>
<td>(Total Organic Carbon)</td>
<td></td>
</tr>
<tr>
<td>Oily Matter</td>
<td></td>
</tr>
</tbody>
</table>

ASME Guidelines:
Broken down by feed water and boiler water, and then by firetube andwatertube boilers.
# Suggested Water Chemistry Limits

Feedwater

<table>
<thead>
<tr>
<th>Drum Operating Pressure psig</th>
<th>0 - 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen ppm (mg/L) ( O_2 ) – measured before chemical scavenger addition</td>
<td>&lt;0.007</td>
</tr>
<tr>
<td>Total iron ppm (mg/L) ( Fe )</td>
<td>≤0.1</td>
</tr>
<tr>
<td>Total copper ppm (mg/L) ( Cu )</td>
<td>≤0.05</td>
</tr>
<tr>
<td>Total hardness ppm (mg/L) as ( \text{CaCO}_3 )</td>
<td>≤0.5</td>
</tr>
<tr>
<td>pH @ approx. 80 degrees F</td>
<td>8.3 -10.5</td>
</tr>
</tbody>
</table>
# Suggested Water Chemistry Limits

## Boiler Water

<table>
<thead>
<tr>
<th>Drum Operating Pressure psig</th>
<th>0 - 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica ppm (mg/L) SiO₂</td>
<td>≤150</td>
</tr>
<tr>
<td>Total Alkalinity ppm (mg/L) as CaCO₃</td>
<td>&lt;1000</td>
</tr>
</tbody>
</table>
CHEMICALS USED?
PRECIPITATING PROGRAMS

- Phosphate based
- Scale inhibitor
- Dosed based on hardness after softening
**THRESHOLD SCALE/DEPOSITION INHIBITOR**

- Combines phosphonate and polymer for dosing
- Distorts crystal structure
SOLUBILIZING PROGRAM

- All-polymer dosing
- Dosed based on hardness
- Conditions sludge and solubilizes hardness
OXYGEN SCAVENGING
Residual Sulfite dosing
MECHANICAL REMOVAL

- Automatic blowdown system senses anything that adds conductivity:
  - Calcium
  - Magnesium
  - Sodium
  - Silica
  - Sulfate
  - Chloride
  - Iron

Auto BD System

Conductivity Sensor
TDS CONTROL WITH BLOWDOWN HEAT RECOVERY
BLOWDOWN HEAT RECOVERY TYPES: BLOWDOWN HEAT RECOVERY UNIT

- Proportional blowdown heat recovery system
- Send to Atmospheric feed or deaerator tank
- Automatically controls TDS
- Single or multiple boilers
- Blowdown is cooled before discharge (code compliance)
CONDENSATE LINE
CORROSION

Figure 2

Figure 4: Initial Observation for Sample A
Figure 5: Initial Observation for Sample B
CONDENSATE LINE TREATMENT
Neutralizing & Filming Amines
LEARNING OBJECTIVES

By the end of this course you will be able to:

1. Provide a brief overview of dosing pumps and systems

2. Explain the mechanics of dosing pumps and system components

3. Describe typical control panels

4. Identify good installation practices.
Hydraulic Institute Definition:

A Metering Pump is a reciprocating pump used to accurately displace a volume of liquid in a specified time period.

- High flow accuracy and improved process control
- Effective handling of hazardous and/or expensive chemicals

www.pumps.org
A VARIETY OF STYLES AND CONFIGURATIONS

Stepper Motor Driven

Hydraulic Diaphragm

Mechanical Diaphragm

Motor Driven

Solenoid Driven
STEAM BOILER - SUPPORT SYSTEMS

- Surge tank
- Condensate tank
- Treatment system
- Deaerator tank
- Boiler
TYPICAL STEAM SYSTEM
CONSIDERATIONS FOR HANDLING AMINES

- Feed point for amine is directly into the steam header
- Ensures good volatilization and minimizes any potential losses from feeding to the DA or the boiler
- Injection nozzle shown is stainless steel and is good to 1000 psi, and 500 degrees F.
LIQUID PROPERTIES

1. Corrosive
2. Abrasive
3. Temperature
4. Viscosity
5. Specific Gravity
6. Entrained gas
7. Vapor Pressure
8. Concentration
Control
Flow rate is adjustable by varying the stroke length, stroke frequency or motor speed.

Motor
Can be constant speed, variable speed or it may be a solenoid.

Liquid End
Type of liquid end and materials of construction determined by application.

Drive
Converts rotary motion into reciprocating motion.
CONTROLLING VOLUME
METERING PUMPS:
Two Basic Types

- Hydraulically
- Actuated
- Diaphragm

- Mechanically
- Actuated
- Diaphragm
What types of Drivers are available?

- Conventional motor
- Stepper motor
- Solenoid
SETTING DOSE RATE

Stroke Frequency Control
Stroke Length Control
Motor speed control

Stepper Motor

VFD
Definition of “Turndown”

A statement of relationship between the maximum flow indicated on a pump’s chart and the minimum flow that the same unit can dose with accuracy.
Flow Range:

.00066 gph to 9000 gph
or
1/100 of a teaspoon per minute to 150 gpm
How is injection flow rate determined?

- Flow rate in process water.
- Nature and concentration of the treatment liquid
- Desired concentration in liquid to be treated
PUMP MATERIALS AND LIQUIDS

Start with chemical compatibility guides

- Cole-Parmer
- Manufacturers pumped liquid guides
Dosing Pump Sizing and Selection Questions

September 15, 2016

New application or replacement pump?
If new, do you need just a pump or a complete injection system? If just a pump:

<table>
<thead>
<tr>
<th>Item</th>
<th>Question</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What type of treatment system are we dealing with</td>
<td>30</td>
<td>Is UL listing or recognition required</td>
</tr>
<tr>
<td>2</td>
<td>What are we pumping into</td>
<td>31</td>
<td>What is the injection rate required</td>
</tr>
<tr>
<td>3</td>
<td>How important is accuracy</td>
<td>32</td>
<td>Is a flow safety factor required (for priming issues)</td>
</tr>
<tr>
<td>4</td>
<td>Is flow pulsation an issue</td>
<td>33</td>
<td>Might the flow rate change in the future</td>
</tr>
<tr>
<td>5</td>
<td>What fluid are you injecting</td>
<td>34</td>
<td>What psi is required at the injection point</td>
</tr>
<tr>
<td>6</td>
<td>Can you provide an MSDS</td>
<td>35</td>
<td>How far from the point of injection will the pump be located</td>
</tr>
<tr>
<td>7</td>
<td>Is the liquid expensive</td>
<td>36</td>
<td>Might the psi requirement change in the future</td>
</tr>
<tr>
<td>8</td>
<td>Maximum liquid temperature</td>
<td>37</td>
<td>What is the suction lift in feet</td>
</tr>
<tr>
<td>9</td>
<td>Minimum liquid temperature</td>
<td>38</td>
<td>What is the suction piping specification</td>
</tr>
<tr>
<td>10</td>
<td>Any abrasives</td>
<td>39</td>
<td>Is the suction vessel vented to atmosphere, or</td>
</tr>
<tr>
<td>11</td>
<td>Any entrained gases</td>
<td>40</td>
<td>What is pressure of atmosphere in vessel if it is not vented</td>
</tr>
<tr>
<td>12</td>
<td>Any piping system pressure limits</td>
<td>41</td>
<td>What voltage</td>
</tr>
<tr>
<td>13</td>
<td>What is the viscosity of the liquid</td>
<td>42</td>
<td>What Hertz</td>
</tr>
<tr>
<td>14</td>
<td>What is the specific gravity of the liquid</td>
<td>43</td>
<td>What phase</td>
</tr>
<tr>
<td>15</td>
<td>At what intervals must the liquid be injected</td>
<td>44</td>
<td>What environment - is it hazardous</td>
</tr>
<tr>
<td>16</td>
<td>What will be used to monitor the needed injection rate</td>
<td>45</td>
<td>What motor enclosure</td>
</tr>
<tr>
<td>17</td>
<td>How will feedback on this be provided to the pump</td>
<td></td>
<td></td>
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<tr>
<td>18</td>
<td>Will the pump controls be manual or automatic</td>
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<tr>
<td>19</td>
<td>Is it constant control, or</td>
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<tr>
<td>20</td>
<td>Is it batch control, or</td>
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<td>21</td>
<td>Is it feed forward control, or</td>
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<td>22</td>
<td>Is it feed back control, or</td>
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<tr>
<td>23</td>
<td>Is it combined control</td>
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<td>24</td>
<td>What pump materials are dictated by the fluid</td>
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<td>25</td>
<td>What o-ring material is required</td>
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<td>26</td>
<td>What valve ball material is required</td>
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<td>27</td>
<td>What ball seat material is required</td>
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<td>Are there any applicable specifications</td>
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<td>Are any national or local Standards or Codes referenced</td>
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From the above you must determine:

a. Is the liquid toxic
b. Is it corrosive
c. Is it hazardous
d. Is it expensive
e. What is the vapor pressure of the fluid
f. Is there adequate NPSHa
g. Do we need anti-cavitation provisions
h. What psi will the pump be exposed to
i. Will turndown impact pump flow rate

It is a good idea to know:

Who will do installation and start up
BENEFITS OF PACKAGED DOSING SYSTEMS

- Easy plug and play solutions to chemical feed
- Pre-engineered to specific needs
- Factory tested as one unit
- One phone call for support
TYPICAL SYSTEM COMPONENTS
INJECTION NOZZLE
TYPICAL SYSTEM COMPONENTS

TYPICAL INSTALLATION

1. GRIFFCO Back Pressure/Anti-Syphon Valve
2. GRIFFCO Sight Flow Indicator
3. GRIFFCO Calibration Column
4. GRIFFCO Isolated Pressure Gauge
5. GRIFFCO Corporation Stop
6. GRIFFCO Pulsation Damper
7. GRIFFCO Isolated Pressure Gauge (Discharge)
8. GRIFFCO Suction Stabilizer

Chemical Tank

Drain Valve

Vent Valve

Relief Valve Flow Indicator

Chemical Feed Pump

Drain Valve

Y Strainer

Isolating Ball Valves
PANEL OPTIONS

JBox

- Lock out (on/off)
- Terminal Block
- Power supply

HOA

- Emergency Stop
- HOA switches for each pump
- Run Lights
- Alarm Lights
- Lock out
- Terminal Block
- Power supply

Power Receptacle
GOOD INSTALLATION PRACTICES:
Avoid long or complex suction lines
MORE INSTALLATION TIPS:

Avoid long or complex suction lines

Avoid gas traps in suction lines
MORE INSTALLATION TIPS:

Flexible suction line

Rigid suction line

Keep foot valve 3” to 6” off bottom of tank to keep debris out.
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TODAY’S TAKE-A-WAYS

• Proper water treatment is a combination of mechanical and chemical remediation
• Has significant impact on efficiency and reliability attainment
• Increasing cycles of concentration saves fuel dollars
• Heat from continuous blow down for TDS control can be recouped
• Proper and reliable chemical dosing is paramount for assuring steam boiler system reliability and life.
• A chemical metering pump is a reciprocating pump used to accurately dispense a specific volume of liquid in a specific amount of time.
• Amine injection is in the steam line to assure proper volatilization and dispensing throughout the piping system especially the condensate line(s).
• All metering pumps have a motor, drive assembly, liquid end, and a control adjustment.
• Liquid properties in the chemical to be dispensed need to be evaluated for proper pump type selection and its materials of construction.
• Normally mechanically actuated pumps are used for steam boiler applications because they have adequate pressure tolerance and provide the suction lift often required.
• When selecting a chemical dosing pump what is important is the maximum and minimum pumping limits.
• Packaged dosing systems offer a high degree of assurance the chemicals are being properly dispensed while including ongoing monitoring and alarms.
QUESTIONS?

Steve Connor
Consultant: Marketing & Technical Services
sconnor@cleaverbrooks.com
262-377-6347

Jared Gabel
Senior Product Specialist
jgabel@grundfos.com
913-227-3553