TODAY’S SPEAKERS

• JOE RUSSELL – PRESIDENT – 30+ YEARS OF EXPERIENCE
• TOM CHRISTMAN – VICE PRESIDENT – 35+ YEARS OF EXPERIENCE
• JEFF BODENDORFER – TERRITORY MANAGER – 4 YEARS OF EXPERIENCE
• JON TIEGS – GENERAL MANAGER – 15+ YEAR OF EXPERIENCE
BASIC WATER CHEMISTRY - BOILERS

JOE RUSSELL, CWT
The amount of moisture on Earth has not changed. The water the dinosaurs drank millions of years ago is the same water that falls as rain today. But will there be enough for a more crowded world?
HYDROLOGIC CYCLE
WATER - IDEAL FOR INDUSTRIAL HEATING AND COOLING NEEDS

- Relatively abundant (covers ¾ of earth’s surface)
- Easy to handle and transport
- Non-toxic and environmentally safe
- Relatively inexpensive
- Exits in three (3) forms – solid(ice), liquid(water), gas(steam)
- Tremendous capacity to absorb and release heat
  - High Specific Heat
  - High Heat of Vaporization (970 B.T.U.’s/lb)
  - High Heat of fusion (143 B.T.U.’s/lb)
WATER – THE UNIVERSAL SOLVENT

BASIC WATER CHARACTERISTICS

III. Hydrological cycle

SOLVENT PROPERTIES

WATER CYCLE

CLOUD

RAIN

CO₂, O₂, SO₂

CO₂ + H₂O → H₂CO₃

Water

Carbonic Acid

SURFACE

MgSO₄

WELL

CaCO₃

H₂CO₃ + CaCO₃ → Ca(HCO₃)₂

Carbonic Acid

Calcium Carbonate (scale)

SHALLOW

Ca(HCO₃)₂

Calcium Bicarbonate

DEEP

FeO₃

Heat

CaCO₃ + H₂O + CO₂ → Ca(HCO₃)₂

Calcium Carbonate (scale)

Carbon Dioxide
## BASIC WATER CHARACTERISTICS

Comparative example of surface and ground water characteristics

<table>
<thead>
<tr>
<th></th>
<th>City of Milwaukee Linnwood Plant</th>
<th>City of Waukesha Sunset Drive (Well #6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Alkalinity (CaCO₃)</td>
<td>115</td>
<td>260</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.18</td>
<td>---</td>
</tr>
<tr>
<td>Carbon Dioxide (Free)</td>
<td>1.47</td>
<td>---</td>
</tr>
<tr>
<td>Calcium Hardness (CaCO₃)</td>
<td>89</td>
<td>205</td>
</tr>
<tr>
<td>Chlorides</td>
<td>9.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Copper</td>
<td>0.013</td>
<td>---</td>
</tr>
<tr>
<td>Fluoride (CaCO₃)</td>
<td>0.21</td>
<td>1.33</td>
</tr>
<tr>
<td>Hardness, Total (CaCO₃)</td>
<td>138</td>
<td>316</td>
</tr>
<tr>
<td>Iron</td>
<td>0.01</td>
<td>0.34</td>
</tr>
<tr>
<td>Magnesium (CaCO₃)</td>
<td>49</td>
<td>111</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.016</td>
<td>0.04</td>
</tr>
<tr>
<td>Nitrates</td>
<td>0.19</td>
<td>0.5</td>
</tr>
<tr>
<td>Oxygen, Dissolved (@ 68°F)</td>
<td>18.9</td>
<td>---</td>
</tr>
<tr>
<td>pH</td>
<td>8.23</td>
<td>8.0</td>
</tr>
<tr>
<td>Silica</td>
<td>1.03</td>
<td>7.0</td>
</tr>
<tr>
<td>Sodium</td>
<td>6.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Sulfate</td>
<td>27.5</td>
<td>64</td>
</tr>
<tr>
<td>Conductivity (mmhos)</td>
<td>295</td>
<td>627</td>
</tr>
</tbody>
</table>
SO WHY ALL THE FUSS??

• BOILERS WILL EXPLODE WITH IMPROPER WATER TREATMENT/MANAGEMENT

• PREMATURE EQUIPMENT FAILURES AND UNSCHEDULED DOWNTIME WILL RESULT IF WATER SYSTEMS ARE NOT PROPERLY MAINTAINED AND CHEMICALLY TREATED.
## ASME GUIDELINES
### TABLE 2
**SUGGESTED WATER QUALITY LIMITS**

<table>
<thead>
<tr>
<th>Feedwater<strong>a</strong></th>
<th>MPa (psi)</th>
<th>0.2-07</th>
<th>2.08-3.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved oxygen (mg/l O₂) measured before chemical oxygen scavenger addition<strong>b</strong></td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td></td>
</tr>
<tr>
<td>Dissolved oxygen (mg/l O₂) measured after chemical oxygen scavenger addition<strong>b</strong></td>
<td>&lt;0.007</td>
<td>&lt;0.007</td>
<td></td>
</tr>
<tr>
<td>Total iron (mg/l Fe)</td>
<td>&lt;0.10</td>
<td>&lt;0.050</td>
<td></td>
</tr>
<tr>
<td>Total copper (mg/l Cu)</td>
<td>&lt;0.05</td>
<td>&lt;0.025</td>
<td></td>
</tr>
<tr>
<td>Total hardness (mg/l as CaCO₃)</td>
<td>&lt;0.5</td>
<td>&lt;0.3</td>
<td></td>
</tr>
<tr>
<td>pH range @ 25°C</td>
<td>7.0-10.5</td>
<td>7.0-10.5</td>
<td></td>
</tr>
<tr>
<td>Nonvolatile TOC (mg/l C)<strong>c</strong></td>
<td>&lt;1</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Oily matter (mg/l)</td>
<td>&lt;1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica (mg/l SiO₂)</td>
<td>&lt;150</td>
<td>&lt;90</td>
<td></td>
</tr>
<tr>
<td>Total alkalinity (mg/l as CaCO₃)</td>
<td>&lt;1000<strong>d</strong></td>
<td>&lt;850<strong>d</strong></td>
<td></td>
</tr>
<tr>
<td>Free hydroxide alkalinity (mg/l as CaCO₃)<strong>e</strong></td>
<td>Not Specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific conductance (μS/cm) (μmhos/cm) at 25°C without neutralization</td>
<td>&lt;8000<strong>f</strong></td>
<td>&lt;6500<strong>f</strong></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES FOR TABLE 2:**
- **a** Value in table assumes existence of a deaerator.
- **b** Chemical deaeration must be provided in all cases but especially if mechanical deaeration is nonexistent or inefficient.
- **c** Boilers with relatively large furnaces, large steam release spaces and internal chamfer, polymer and/or antifoam treatment can often tolerate higher levels of feedwater impurities than those in the table and still achieve adequate deposit control and steam purity. Removal of these impurities by external pretreatment is always a more positive solution. Alternatives must be evaluated as to practicality and economics in each individual case. The use of some dispersant and antifoam inorganic treatment is typical in this type of boiler operation so it can tolerate higher feedwater hardness than the boilers in Table 1.
- **d** Minimum level of OH⁻ alkalinity must be individually specified with regard to silica solubility and other components of internal treatment.
- **e** Alkalinity and conductance values consistent with steam purity target. Practical limits above or below tabulated values can be established for each case by careful steam purity measurements.
- **f** Nonvolatile TOC is that organic carbon not intentionally added as part of the water treatment regime.
- **g** Target value represents steam purity which should be achievable if other tabulated water quality values are maintained. The target is not intended to be nor should it be construed as to represent a boiler performance guarantee.
SO HOW DOES THIS WATER MEET THESE GUIDELINES?

<table>
<thead>
<tr>
<th>City of Milwaukee Linnwood Plant</th>
<th>WATER MANAGEMENT CHEMICALS</th>
<th>BOILER APPLICATIONS DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Alkalinity (CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide (Free)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium Hardness (CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride (CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness, Total (CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium (CaCO₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen, Dissolved (@ 68°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (mmhos)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Feedwater                         |                             |                          |

Dissolved oxygen (mg/l O₂) measured before chemical oxygen scavenger addition<sup>11</sup>  
Dissolved oxygen (mg/l O₂) measured after chemical oxygen scavenger addition<sup>12</sup>  
Total iron (mg/l Fe)  
Total copper (mg/l Cu)  
Total hardness (mg/l as CaCO₃)  
pH range @ 25°C  
Nonvolatile TOC (mg/l C)<sup>14</sup>  
Oil matter (mg/l)  
Boiler Water  
Silica (mg/l SiO₂)  
Total alkalinity (mg/l as CaCO₃)  
Free hydroxide alkalinity (mg/l as CaCO₃)<sup>15</sup>  
Specific conductance (μS/cm) (μmhos/cm) at 25°C without neutralization

<sup>11</sup> *1979 American Society of Mechanical Engineers
WATER USE AND YOUR BOILER WATER SYSTEM
850 uS Make Up
67,925 GPD
Condensate
92,455 GPD
58%

Setpoint
3,500 uS

Controller

360 uS
Feed Water
160,380 GPD

Heat Exchanger

Steam

Before
50,000 #/hr
Steaming Rate

Annual Make Up
23.77 MG
$45,170

Annual Blowdown
5.77 MG
$15,010

Blowdown
16,495 GPD

= 9.7 Cycles

360 uS

= 9.7 Cycles
850 μS Make Up
32,120 GPD

Condensate
119,565 GPD

Heat Exchanger

Steam

180 μS
Feed Water
151,686 GPD

Controller
Setpoint
3,500 μS

= 19.4 Cycles

After
50,000 #/hr Steaming Rate

<table>
<thead>
<tr>
<th>Annual Make Up</th>
<th>Annual Blowdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.24 MG</td>
<td>2.73 MG</td>
</tr>
<tr>
<td>$21,360</td>
<td>$7,098</td>
</tr>
</tbody>
</table>

79%

Annual Make Up
11.24 MG
$21,360

Annual Blowdown
2.73 MG
$7,098

Blowdown
7,801 GPD

Make Up
Condensate
Heat Exchanger
Steam

Annual Make Up
11.24 MG
$21,360

Annual Blowdown
2.73 MG
$7,098

Blowdown
7,801 GPD
<table>
<thead>
<tr>
<th></th>
<th>Make Up Flow</th>
<th>Make Up Cost</th>
<th>Blowdown Flow</th>
<th>Blowdown Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.4 Cycles</td>
<td>23.77 MG</td>
<td>$45,170</td>
<td>5.77 MG</td>
<td>$15,010</td>
</tr>
<tr>
<td>19.7 Cycles</td>
<td>11.24 MG</td>
<td>$21,360</td>
<td>2.73 MG</td>
<td>$7,098</td>
</tr>
<tr>
<td>Savings</td>
<td>12.53 MG</td>
<td>$23,810</td>
<td>3.04 MG</td>
<td>$7,912</td>
</tr>
</tbody>
</table>

Fuel Savings = $40,000 / year
Chemical Savings = $20,000 / year
Total Savings = $92,000 per year

125 psi boiler operating at 80% efficiency, 2012 city of Milw. Water cost, $4.50/MSCF gas cost, 160°F condensate temp.
TYPICAL BOILER SYSTEM LAYOUT

JEFF BODENDORFER
TYPICAL BOILER SYSTEM LAYOUT
Filtration
SOFTENERS

• WHAT IS THE MAIN FUNCTION OF WATER SOFTENERS?
• WHAT INFORMATION DO YOU NEED TO KNOW WHEN SIZING SOFTENERS?
• DON’T RUN ON HARD WATER!
SOFTENER REGENERATION
REVERSE OSMOSIS

• WHAT ARE THE BENEFITS TO USING RO WATER FOR BOILER FEED WATER?

• CYCLES OF CONCENTRATION

• BETTER WATER QUALITY (TOTAL DISSOLVED SOLIDS AND ALKALINITY REDUCTION) = BETTER WATER QUALITY
DEALKALIZERS AND DEIONIZERS

• DEALKALIZER FOR ALKALINITY REDUCTION
• DEMINERALIZER FOR REMOVAL OF BOTH ANIONS AND CATIONS
DEAERATOR VS. FEEDWATER TANK

- WHAT IS THE MAJOR DIFFERENCE BETWEEN A DEAERATOR AND A FEEDWATER TANK?
  - MUCH LOWER OXYGEN LEVELS

- WHAT ARE THE BENEFITS OF USING A DEAERATOR OVER A FEEDWATER TANK?
  - REDUCE CHEMICAL AND ENERGY USAGE, REDUCE EXPANSION AND CONTRACTION
BOILERS

- **WHAT TYPE OF BOILERS ARE THERE?**
  - FIRETUBE
  - WATERTUBE

- **WHAT ARE THE BOILERS WORST ENEMIES?**
  - SCALE
  - CORROSION
HOT WATER BOILERS AND LOOPS

- Common for comfort heating applications and smaller processes in plants
- What is important to protecting the hot water boiler and piping system?
BASIC BOILER TREATMENT PROGRAMS

TOM CHRISTMAN
BASIC BOILER TREATMENT PROGRAMS

1. **OXYGEN SCAVENGER** – CORROSION CONTROL
2. **INTERNAL TREATMENT PROGRAM** – DEPOSIT CONTROL
3. **CONDENSATE TREATMENT** – CORROSION CONTROL
4. **MISCELLANEOUS** – ALKALINITY BUILDERS, ANTIFOAM
BASIC INTERNAL BOILER PROGRAMS

• **OXYGEN SCAVENGER**
  - SULFITE
  - DEHA, ERITHORBATE, HYDROQUINONE, HYDRAZINE, CARBOHYDRAZIDE, MEKOR
  - FEED TO STORAGE SECTION OF THE DA / FEEDWATER TANK BELOW THE WATER LINE
  - MAINTAIN A CONSTANT **RESIDUAL** OF OXYGEN SCAVENGER
O2 SCAVENGER PERFORMANCE MONITORING

• MONITOR YOUR DA / FEEDWATER TANK PRESSURE AND TEMPERATURE

• WATCH SCAVENGER CONCENTRATIONS
INTERNAL TREATMENTS

• INTERNAL DEPOSIT INHIBITOR
  • BLENDS OF POLYMERS, DISPERSANTS, SEQUESTRANTS, PHOSPHATE, CHELANTS
  • CONTROL OF DEPOSITS OF HARDNESS SCALES, IRON, COPPER, SILICA
  • FEED POINT VARIES DEPENDING ON THE TREATMENT PROGRAM AND WATER QUALITY
  • VARIOUS TEST METHODS TO DETERMINE ACTUAL CONCENTRATION IN BOILER WATER

• RECOMMENDATIONS
  • DON’T RELY ON INTERNAL TREATMENT TO DO ALL THE WORK
    • PROPERLY OPERATED PRETREATMENT EQUIPMENT IS CRITICAL
CONDENSATE LINE CORROSION CONTROL

• CARBONIC ACID ATTACK – LOW PH
  • FROM MAKEUP WATER ALKALINITY ---- CARBON DIOXIDE = CO₂
  • REMOVE THE CARBONATE ALKALINITY IN THE MAKEUP - PROPER PRETREATMENT

• OXYGEN ATTACK
STEAM / CONDENSATE TREATMENTS

• NEUTRALIZING AMINES
  • VOLATILE AMINES USED TO RAISE THE PH OF CONDENSATE TO PREVENT ACIDIC ATTACK
  • USUALLY A BLEND OF 2-4 DIFFERENT AMINES THAT PROVIDE TOTAL SYSTEM COVERAGE

• VOLATILE OXYGEN SCAVENGERS
  • USED TO PREVENT OXYGEN CORROSION FROM AIR INTRUSION INTO CONDENSATE SYSTEM
OXYGEN CONTROL IN CONDENSATE SYSTEMS

• **CAUSES AND TREATMENTS**
  - Enters through condensate receivers, vacuum pumps, process systems
  - Treated using volatile oxygen scavengers (V.O.S.) such as DEHA, hydroquinone, MEKOR, and filming amines
  - Blended amines and V.O.S.

• **MONITORING**
  - Watch iron and copper concentrations
  - Monitor pH levels because low pH levels and oxygen accelerate corrosion rates
  - Monitor VOS concentration
MISC. CHEMICALS

• ALKALINITY BUILDER
  • CAUSTIC SODA FED TO THE DA / FEEDWATER TANK

• ANTIFOAM

• SINGLE DRUM TREATMENTS
TYPICAL BOILER SYSTEM CHEMICAL FEED POINTS

- Make Up
- Condensate
- Heat Exchanger
- Steam
- Condensate Treatment
- Oxygen Scavenger
- Internal Treatment & Alkalinity Builders
- Feed Water
- Controller
- Blowdown
BASIC WATER CHEMISTRY – COOLING TOWERS

JOE RUSSELL, CWT
Approximately 70% of a plant's water use is for cooling, 20% for process and 10% for other uses.

Cooling towers provide the most efficient means of rejecting heat from open recirculating cooling water systems.
THE PROCESS OF EVAPORATIVE COOLING

- Circulating cooling water, after picking up heat from the process heat exchangers, passes through the tower.

- Evaporation provides most of the cooling as the recycled water passes through the tower.

- As a result of evaporation, the dissolved solids in the water become concentrated.

- The rate of water discharge, blowdown, stabilizes the dissolved solids content of the water.

- The evaporative process also absorbs gasses from the air, particulate matte, nutrients - for biological growth- and reduces the solubilities of the solids remaining in the circulating water.
WATER – THE UNIVERSAL SOLVENT

BASIC WATER CHARACTERISTICS

III. Hydrological cycle

SOLVENT PROPERTIES
WATER CYCLE

CLOUD

RAIN

CO₂ + H₂O → H₂CO₃
Carbonic Acid

SO₂

Lake acidification

Acid rain

Acid snow

MgSO₄

WELL

CaCO₃

H₂CO₃ + CaCO₃ → Ca(HCO₃)₂
Calcium Carbonate

Calcium Bicarbonate

(scale)

FeO₂

DEEP

Ca(HCO₃)₂
Calcium Bicarbonate

Heat

CaCO₃
Calcium Carbonate

H₂O
Water

CO₂↑
Carbon Dioxide

CaO₂

O₂
TYPICAL SOURCES OF COOLING TOWER MAKE UP

- WELL WATER - SCALING
- MUNICIPAL SOURCE WATER - SCALING
- WASTE WATER -SCALING, CORROSIVE, FOULING
- REUSE WATER (RO CONCENTRATE) - SCALING
- PROCESS CONDENSATE (COW WATER) – CORROSIVE, FOULING

- EACH POSES DIFFERENT CHALLENGES
- PRETREATMENT MAY OR MAY NOT BE NECESSARY
- EACH SOURCE OF WATER WILL POSE UNIQUE CHALLENGES
LANGELIER SCALING INDEX – HOW TO PREDICT A WATER’S SCALE OR CORROSION TENDENCIES

• LSI PREDICTS THE SCALING/CORROSIVE TENDENCY OF WATER
• GOAL IS TO KEEP LSI BELOW 2.5
• INPUTS ARE TEMPERATURE, pH, CALCIUM HARDNESS, TOTAL ALKALINITY AND TOTAL DISSOLVED SOLIDS.
• RUN CYCLES OF CONCENTRATION AS HIGH AS POSSIBLE BUT KEEP THE LSI BELOW 2.5
• 4 – 5 CYCLES OF CONCENTRATION IS OPTIMUM.
COOLING TOWER WATER TREATMENT GOALS

• PUBLIC HEALTH AND SAFETY

• CONTROL FOULING AND CORROSION

• MINIMIZE WATER USAGE
CYCLES OF CONCENTRATION

BOILERS AND COOLING TOWERS

• BUILD-UP OF THE CONCENTRATION OF DISSOLVED SOLIDS IN RECIRCULATING WATER = “CYCLING UP”

• DETERMINE THE MAXIMUM NUMBER OF CYCLES OF CONCENTRATION TO RUN W/O FORMING DEPOSITS OR CAUSING EXCESSIVE CORROSION
  • YOUR WATER TREATMENT SUPPLIER IS RESPONSIBLE FOR THIS.
WATER USE AND YOUR RECIRCULATING COOLING WATER SYSTEM
BEFORE: TOWER @ 3 CYCLES

Controller
Setpoint
1,200 uS

30 GPM
Evaporation

= 3 Cycles

45 GPM
Make Up
400 uS

3,000 GPM Recirc Rate

Annual Make Up          Annual Bleed
22.86 MG                7.56 MG
$43,094                 $19,656

10°F △T

15 GPM
AFTER: TOWER @ 5 CYCLES

**Controller**

- **Setpoint**: 2,000 uS

**Evaporation**

- **30 GPM**

**Make Up**

- **38 GPM**
  - **400 uS**

**Recirc Rate**

- **3,000 GPM**

**Annual Make Up**

<table>
<thead>
<tr>
<th></th>
<th>Annual Make Up</th>
<th>Annual Bleed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19.15 MG</td>
<td>4.03 MG</td>
</tr>
<tr>
<td></td>
<td>$36,389</td>
<td>$10,483</td>
</tr>
</tbody>
</table>

- **10°F**

- **8 GPM**

- **= 5 Cycles**
## SUMMARY OF COOLING SCENARIOS

<table>
<thead>
<tr>
<th></th>
<th>Make Up Flow</th>
<th>Make Up Cost</th>
<th>Bleed Flow</th>
<th>Bleed Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Cycles</td>
<td>22.86 MG</td>
<td>$43,094</td>
<td>7.56 MG</td>
<td>$19,656</td>
</tr>
<tr>
<td>5 Cycles</td>
<td>19.15 MG</td>
<td>$36,389</td>
<td>4.03 MG</td>
<td>$10,483</td>
</tr>
<tr>
<td>Savings</td>
<td>3.71 MG</td>
<td>$7,514 (-15.5%)</td>
<td>3.52 MG</td>
<td>$9,173 (-46.7%)</td>
</tr>
</tbody>
</table>

Chemical / Misc Savings = >$10,000 per year

Total Savings = ~$27,000
EFFECTIVE WAYS TO INCREASE CYCLES OF CONCENTRATION
RECIRCULATING COOLING WATER

1. Automate chemical feed and tower bleed
2. Soften the makeup water
3. Feed acid to control alkalinity and pH
4. Look for a better source of makeup water
5. Install “side-stream” filtration for solids removal
TYPICAL COOLING SYSTEM LAYOUT

JEFF BODENDORFER
COOLING TOWER SYSTEM OVERVIEW
Soft Water or not? Filtration?

• Pros vs. Cons of using soft water for cooling water makeup?
  • Lake Michigan vs. Waukesha water
  • Safety

• What kind of Filtration should you use?
Processes in plants that require cooling water

• What processes do you have that require cooling water?
• Chillers
• Heat exchangers
• How do they work?
Chilled Water Loops

• Concerns with chilled water loops
  - Corrosion
  - Microbiological growth
  - Scale

• What is important to protecting chilled water loops?
  - Scale and corrosion inhibitor
  - Filtration
  - Biocide
Cooling Towers

• What is the purpose of a cooling tower?
  • Reduce water usage/ recycle water

• Types of cooling towers
  - Induced draft
  - Forced Draft
COOLING WATER PROBLEM AREAS

TOM CHRISTMAN
COOLING WATER SYSTEM PROBLEM AREAS

- SCALE – CALCIUM, MAGNESIUM, IRON, SILICA
- CORROSION – LOSS OF METAL
- FOULING
  - MICROBIOLOGICAL – BACTERIA, MOLD, FUNGUS, ALGAE
  - WIND BLOWN DEBRIS, PROCESS CONTAMINATION
COOLING WATER SYSTEM PROBLEM AREAS

- Fouling
- Scaling
- Corrosion
BASIC COOLING WATER TREATMENT PROGRAMS

1. SCALE AND CORROSION INHIBITOR BLEND
2. BIOCIDES
   1. OXIDIZING
   2. NON-OXIDIZING BIOCIDES
3. ANTI-FOULANTS
SCALE AND CORROSION INHIBITOR

• BLEND OF POLYMERS, SEQUESTRANTS, DISPERSANTS AND CORROSION INHIBITORS
  • SPECIFIC BLENDS TO HANDLE VARIOUS WATER QUALITIES AND CONTAMINATION ISSUES
• FEED WITH OR WITHOUT ACID
  • ACID FOR ALKALINITY REDUCTION
• SOFT WATER MAKEUP – CORROSION CONTROL ISSUE
• LAB AND DIRECT MEASUREMENT TESTS FOR MONITORING
  • PTSA, POLYMER, PHOSPHONATE, MOLYBDENUM
• FEED PROPORTIONAL TO MAKEUP/BLEED VOLUME OR DIRECT MEASUREMENT
MICROBIOLOGICAL CONTROL

- Biocides to control bacteria, mold, fungus, algae
  - Inhibit heat transfer
  - Inhibit flow
  - Increase corrosion – “MIC” = microbiologically induced corrosion
  - Health and safety issue – Legionella
BIOCIDES

OXIDIZING
• CHLORINE
• BROMINE
• CHLORINE DIOXIDE
• HYDROGEN PEROXIDE, PERACETIC ACID

NON-OXIDIZING
• ISOTHIAZOLONE
• GLUTERALDEHYDE
• DBNPA
• QUATERNARY AMINE
• MANY MORE
BIOCIDES

1. DOSAGE IS BASED ON SYSTEM VOLUME
2. DIFFERENT BIOCIDES HAVE DIFFERENT REQUIREMENTS
   1. PH, AMMONIA, RETENTION TIME, ORGANICS
3. REQUIREMENTS FOR EFFECTIVENESS
   1. CORRECT CONCENTRATION
   2. SUFFICIENT CONTACT TIME
4. DUAL BIOCIDE PROGRAM WORKS BEST
ANTI-FOULANTS

• DISPERSANTS FOR WIND BLOWN DEBRIS, PROCESS CONTAMINANTS, OIL AND GREASE
• USUALLY SLUG FED
• MAY CAUSE FOAM
• SOME INCREASE THE EFFECTIVENESS OF BIOCIDES BY ACTING AS A WETTING AGENT AND ALLOWING THE BIOCIDES TO PENETRATE THE BIO-MASS.

ANTIFOAMS

• FOR CONTROL OF FOAM CAUSED BY BIOCIDES, ANTIFOULANTS OR PROCESS CONTAMINATION
5 KEY TAKEAWAYS TO REDUCE COSTS

1. KNOW YOUR WATER AND BE COMMITTED TO YOUR WATER MANAGEMENT PROGRAM.

2. KNOW YOUR PRETREATMENT EQUIPMENT AND MAKE SURE IT IS OPERATING PROPERLY AND EFFICIENTLY.

3. INSTALL MAKE UP AND BLOWDOWN WATER METERS ON ALL OF YOUR EQUIPMENT WHERE APPLICABLE. KNOW WHERE YOU USE AND DISCHARGE WATER AND HOW MUCH

4. UNDERSTAND CYCLES OF CONCENTRATION TO OPTIMIZE AND REDUCE WATER, ENERGY, CHEMICAL AND SALT USAGE

5. CONSIDER UTILIZING AUTOMATED SYSTEMS TO MONITOR, CONTROL, ALARM AND TREND CRITICAL WATER SYSTEMS.
COOLING TOWER & BOILER WATER EQUIPMENT & CONTROLLERS

JON TIEGS
BOILER SYSTEM – COMMON CONTROLS

• CONDUCTIVITY CONTROL
• CHEMICAL FEED CONTROL
BOILER CONDUCTIVITY CONTROL

• CONDUCTIVITY INTERMITENT SAMPLE
  • Determine conductivity reading
  • Interval
  • Duration of sample
  • Hold time

• BLOWDOWN CONTROL
  • Open blowdown valve based on conductivity
  • Set point
  • Blowdown time
**BOILER CHEMICAL FEED CONTROL**

- **FLOW BASED FEED**
  - Internal Treatment, Oxygen Scavenger, Alkalinity Builder
  - Assign Meter(s)
  - Volume to Trigger Output
  - Output On Time per Unit Volume

<table>
<thead>
<tr>
<th>Relay Control Mode</th>
<th>Flow Based Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assign Makeup Meter 1</td>
<td>Make-up Meter (DLB)</td>
</tr>
<tr>
<td>Assign Makeup Meter 2</td>
<td>Not Used</td>
</tr>
<tr>
<td>Assign Makeup Meter 3</td>
<td>Not Used</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Status</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulated Volume</td>
<td>6.00 gal.</td>
</tr>
<tr>
<td>Custom Name</td>
<td>3518 COND</td>
</tr>
<tr>
<td>Unit Vol. to Trigger Output</td>
<td>18 gal.</td>
</tr>
<tr>
<td>Output O/C Time Per Unit Volume</td>
<td>0 (Sec.) 12 (Min.)</td>
</tr>
<tr>
<td>Output Time Limit</td>
<td>30 (0 to 1440) Min.</td>
</tr>
<tr>
<td>Output Mode</td>
<td>Hand</td>
</tr>
<tr>
<td>Hand Time Limit</td>
<td>2 (1 to 1440) Min.</td>
</tr>
</tbody>
</table>

**Mutual Interlocks**
- Alarm (R1)
- N/A (R2)
- N/A (R3)
- Boiler Blowdown (R4)
- 3450 OX Scav (R6)
- 3060M Dispersant (R7)
- 3730 ALKALINITY (R8)

**Event Log**
- View Log File
BOILER SYSTEM – COMMON PROBLEMS

• 90% OF THE PROBLEMS RELATED TO BOILER CONTROLS HAVE TO DO WITH POOR
  CONDUCTIVITY CONTROL
  • IMPROPER INSTALLATION OF EQUIPMENT
  • INACCURATE CONDUCTIVITY PROBE
  • LEAD/LAG ON SMALL BOILERS
PROPER INSTALLATION OF COMPONENTS IS

**THE MOST IMPORTANT**

FACTOR FOR EFFECTIVE BOILER CONDUCTIVITY CONTROL
BOILER CONTROL INSTALLATION

RECOMMENDED INSTALLATION
INTERMITTENT SAMPLING
BOILER CONTROL INSTALLATION

• WATER LEVEL IN BOILER MUST BE 4-6” ABOVE THE SKIMMER LINE
• MAINTAIN ¾” PIPE FROM THE SKIMMER LINE TO THE CONDUCTIVITY PROBE
• INSTALL A FULL-PORT VALVE UPSTREAM OF PROBE TO PROVIDE MEANS OF REMOVING PROBE FOR CLEANING AND REPLACEMENT
• INSTALL THROTTLING VALVE DOWN STREAM OF PROBE AND AUTOMATIC BLOWDOWN VALVE
• INSTALL PROBE SO THAT OPENING IS IN THE DIRECTION OF FLOW
BOILER CONDUCTIVITY PROBE NOT ACCURATE

- PROBE OUT OF CALIBRATION (CALIBRATE ON A REGULAR SCHEDULE)
- CHECK WIRING FOR LOOSE OR CORRODED WIRES
- CHECK TEMPERATURE READING (CONDUCTIVITY IS TEMPERATURE DEPENDENT)
THE BOILER CONDUCTIVITY CONTROL IS CRITICALLY IMPORTANT FACTOR FOR EFFECTIVE BOILER CONDUCTIVITY CONTROL INVEST IN SPARE PARTS
SMALL BOILERS RUNNING IN LEAD/LAG SETUP

**Situation:** Blowdown while in lag/stand-by reduces conductivity

**Action:** Provide a boiler status input to the controller

**Result:** Lockout of blowdown valve when boiler is not running will prevent sampling and help maintain conductivity.
COOLING TOWER SYSTEM OVERVIEW
COOLING TOWER SYSTEM – COMMON CONTROLS

- CONDUCTIVITY CONTROL
- CHEMICAL FEED CONTROL
CONDUCTIVITY CONTROL

- CONTROL SET POINTS
  - Set Point
  - Dead Band
  - Time Period & % of Period
  - Control Direction (Force Lower)

- ACTIONS
  - Bleed opens at Set points
  - Bleed closes at Set Point – Dead Band
INHIBITOR FEED – FLOW BASED FEED

• SET POINTS
  • Assign Meter(s) to Control
  • Volume to Trigger Output
  • Output On Time per Unit Volume
  • Output Time limit – Max continuous run time (Requires manual reset)

• ACTIONS
  • Relay turns on when Accumulated Volume is achieved.
  • Relay turns off when Output OnTime is achieved.
INHIBITOR FEED – PTSA (ENVIRODOSE)

- **SET POINTS**
  - Setpoint
  - Deadband
  - Time period & % of period

- **ACTIONS**
  - Bleed opens at Set points
  - Bleed closes at Set Point – Dead Band
ORP BASED BIOCIDE FEED

• SET POINTS
  • Setpoint
  • Deadband
  • Time period & % of period

• ACTIONS
  • Bleed opens at Set points
  • Bleed closes at Set Point – Dead Band
TIME BASED ORP FEED

• SET POINTS
  • Select Days, Times & Feed Time Period
  • Bleed Lockout
  • Prebleed (Time or Conductivity)
  • Mutual Interlocks (Lockouts)

• ACTIONS
  • At selected day & time relay feed event occurs.
  • If using Prebleed then Bleed Valve relay will open.
  • Once Prebleed is complete then Chemical Pump relay will turn on for specified time.
COOLING TOWER SYSTEM – COMMON PROBLEMS

• CONDUCTIVITY PROBLEMS
• CHEMICAL FEED PROBLEMS
POOR CONDUCTIVITY CONTROL

• PROBE OUT OF CALIBRATION
• DIRTY PROBE OR CORRODED PROBE
• CHECK WIRING
• INADEQUATE FLOW
• NO BLEED FLOW
  • INOPERABLE BLEED VALVE OR CLOGGED BLEED LINE
CHEMICAL FEED PUMPS NOT PUMPING

- LOSS OF PRIME
  - EMPTY TANK
  - OFF GASSING / AIR LOCKED
  - CRACKED SUCTION TUBE
- CLOGGED INJECTION VALVE