Salt Reduction
## Project Charter

<table>
<thead>
<tr>
<th>Project Goals</th>
<th>Metric</th>
<th>Baseline</th>
<th>Goal</th>
<th>Entitlement</th>
<th>Actual Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease salt usage</td>
<td>Ave lbs of salt/40,000 gal</td>
<td>1064 lbs of salt/40,000 gal</td>
<td>20%</td>
<td>50%</td>
<td>31% reduction (739 lbs/40,000 gal)</td>
</tr>
<tr>
<td>Decrease water hardness alarms</td>
<td>Ave alarms/day</td>
<td>1.3 alarms/day</td>
<td>50%</td>
<td>80%</td>
<td>69% reduction (0.396 alarms/day)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected Business Results</th>
<th>Cost benefits: reduction in salt usage, increase efficiency of water softening without jeopardizing water quality, reduction in water hardness alarms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Customer Benefits</td>
<td>Cost benefits: reduction in salt usage, increase efficiency of water softening without jeopardizing water quality.</td>
</tr>
<tr>
<td>Team members</td>
<td>Laurie Schilling (TL Validation), Brad Chesmore (Maintenance &amp; Calibration Sr Mgr), Bill Kutz (TL Quality Systems), Melinda Austin (Sr. Director Quality), John Janzen (Sr Associate Process &amp; CI) Jeff Hankins (Wet Process Tech II)</td>
</tr>
<tr>
<td>Support Required</td>
<td>Team member commitment of 1-2 hrs./week for 6 months, sponsor support and project review minimum once per month. Project lead commitment of 20% of time to complete this project.</td>
</tr>
<tr>
<td>Risks/Constraints</td>
<td>Costs for process improvements, time for validating, availability of team members, increase scale on process equipment.</td>
</tr>
<tr>
<td>Project Schedule</td>
<td>Define Measure Analyze Improve Control</td>
</tr>
<tr>
<td></td>
<td>Jan-Feb Feb-Apr Apr-June June-July July-Aug</td>
</tr>
</tbody>
</table>
Supply of Softened Water Production

Addition of Salt
Salt delivery
Tops off salt bin weekly (standing order)

Water Softening
Salt w/ level sensor
Brine w/ level sensor
Resin Bed (regenerating) w/ flow meter
Resin Bed (backup) w/ flow meter
Resin Bed (running) w/ flow meter

Softener Regeneration

Resin Beds in Rotation
Water Hardness Monitor (BMS.144T42)
Water Hardness Monitor (BMS.144T45)

Booster Pump
Incoming City Water

CIP/COP Normal Operation

Hardness Alarm (>5ppm)
Hardness Alarm (>20ppm)

CIP/COP Production Inhibit

No
Yes

Define -> Measure -> Analyze -> Improve -> Control
Operational Definition (page 1 of 3)

- Salt concentration: Bags of salt used is logged by supplier. Each bag contains 40 lbs of salt.
- City water usage: Recorded using city water meter (gallons).
- Accuracy of city water meter:
  - According to City of Middleton, the city water meter is tested 2 to 4 year intervals. The meters are checked for accuracy between 97-103%. Meters are read each quarter and an audit for the amount of water used determines if the usage is significantly higher or lower than average. In the case where there is a discrepancy, a technician is sent out to inspect and replace if necessary.
  - See attached calibration certificate prior to water meter’s installation.
Operational Definition (page 2 of 3)

- **# of regenerations**: Calculated from incoming water/treated gallons before regeneration. Capacity of resin is 575,000 grains. Incoming water is assumed to be 30 grains/gallon which calculates out to 19,166 gallons/regeneration. This information will quantify waste brine.

- **# of alarms**: Recorded by BMS using two online HACH water hardness monitors (CT1104 and CT1201)
Operational Definition (page 3 of 3)

- Online water hardness monitors
  - Calibration of monitors performed monthly using two standards, 0ppm and 10,000ppm. Water hardness monitors are currently set to alarm at 5ppm and 20ppm.
  - Conducted study where high standard was diluted to level above alarm limits 5 and 20ppm.
  - Two test solutions were prepared with a hardness level of 10ppm and 30ppm. 10ppm solution was injected into the monitor with the 5ppm alarm limit and the 30ppm solution was injected into the monitor with the 20ppm alarm limit.
  - 5ppm water hardness monitor alarmed at 10ppm. 20ppm water hardness monitor alarmed at 30ppm.
  - Noted it took 5-10 minutes after removal of test solutions before alarms cleared themselves. Currently alarm delay set to only 2 minutes.
Red indicates identified root causes from Analyze. **Green** are upstream contributing factors but not controllable factors. **Blue** could be contributing factors but would require extensive re-validation and/or cost prohibitive. Remaining items have been determined to be low risk in the Measure and Analyze phases.
Root Cause #1: Slug of Hard Water After Resin Bed Change Over

Results from Causal Tree indicate the potential cause for water hardness alarms was due to a slug of hard water between resin bed change overs and the time necessary to remove the slug. Root cause #3, alarm setpoint set too low will be addressed in slide #35.
Each resin bed has 35 ft³ of resin.
Currently treating for an incoming water hardness level of 30gpg, using 15 lbs of salt per cubic foot (35 ft³ * 15 lbs) for a total of 525 lbs of salt.
Prior studies (see slide 16) show an average incoming water hardness of 25gpg. This would only require 8 lbs of salt per cubic foot, reducing salt usage to 280 lbs (35ft³*8 lbs).
This graph shows the linear relationship between the salt dosage set point and the amount of salt used per regeneration.
Root cause #2 is confirmed.
Root cause #3: Alarm Setpoint Set Too Conservatively
Water Hardness Level Test Results

<table>
<thead>
<tr>
<th>Initial Hardness (gpg)</th>
<th>CIP 100 (mS)</th>
<th>Final Hardness (gpg)</th>
<th>Precipitate (Yes / No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5.2</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>5.2</td>
<td>6</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>5.2</td>
<td>7</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>5.0</td>
<td>9</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>5.1</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>5.0</td>
<td>12</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>5.1</td>
<td>13</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>5.1</td>
<td>13</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Study Y2016031, *Determining Scale Forming Water Hardness Level*, concluded that at a low concentration of CIP 100, no hard water scale was observed at ≤ 11gpg or 188ppm.
- The alarm hardness set point on the water hardness monitor is currently set to <1 gpg or 5ppm.
- Root cause #3, alarm setpoint set too conservatively is confirmed.
Summary of Analyze Phase

1. Slug of hard water after resin bed change over
   - Investigation of hard water alarm events determined a slug of hard water caused by resin bed switchovers was the main contributing factor.

2. Softener program too aggressive
   - Salt Dosage
     - Currently using an average of 1785 lbs of salt a day. (3.4 regens * 525 lbs).
     - Based on the manufacturer’s recommendation, this could be reduced to 952 lbs of salt a day (3.4 regens * 280 lbs).
   - Grains of hardness treated
     - Currently producing 19,166 gallons of water before regeneration.
     - This could be increased to 23,000 gallons of water.

3. Alarm setpoint set too conservatively
   - Because the alarm set point on the water hardness monitor is set to 5ppm, softeners are set to produce soft water not exceeding 1 gpg.
   - Study shows 11gpg or 188ppm is acceptable.
# Plan for Improvement Phase

<table>
<thead>
<tr>
<th>RC ID</th>
<th>Root Cause Description</th>
<th>Solution ID and Solution Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Slug of hard water after resin bed change over</td>
<td>1a: Increase alarm delay from 2 to 10 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1b: Shorten sample line to water hardness monitor</td>
</tr>
<tr>
<td>2</td>
<td>Softener program set too aggressively</td>
<td>2a: Decrease salt dosage from 15 to 8 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2b: Decrease grains treated from 30 to 25 gpg</td>
</tr>
<tr>
<td>3</td>
<td>Alarm setpoint set too conservatively</td>
<td>3a. Raise alarm setpoint from 5 to 100ppm</td>
</tr>
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</table>
## Cost /Benefit Analysis

<table>
<thead>
<tr>
<th>Solution ID (Solution)</th>
<th>Currently</th>
<th>Goal</th>
<th>Future</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a: Decrease salt dosage from 15 to 8lbs</td>
<td>$5,004.30/month</td>
<td>20%</td>
<td>$4,003.44/month</td>
<td>$1,000.86/month</td>
</tr>
<tr>
<td>2b: Decrease grains treated from 30 to 25gpg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a: Increase alarm delay from 2 to 10 min.</td>
<td>1 alarm/day</td>
<td>50%</td>
<td>&lt; 1 alarm/day</td>
<td>1 alarm/day</td>
</tr>
<tr>
<td>1b: Shorten sample line to water hardness monitor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3a. Raise alarm setpoint from 5 to 100ppm</td>
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Cost of salt per pound is 0.2625.
Predicted financial savings of $1,000.86 per month.
Predicted alarm occurrences reduced to <1 per day.
No cost to implement solutions.
Changing softener setpoints decreased salt usage from 1064 lbs/40,000 gallons to 739 lbs/40,000 gallons.
Increasing the alarm level from 5ppm to 100ppm, extending the alarm delay from 2 minutes to 10 minutes and relocation of the sample port decreased the alarm occurrences from 1.3 alarms per day to 0.396 alarms per day. This includes a 40% increase in production starting in July 2016.

*Nov-Jan 2016, plant was in shutdown.
*March-May 2016, no changes implemented yet.
**Project Charter Goal Met**

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<tr>
<th>Project Goals</th>
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<th>Actual Achieved</th>
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<tr>
<td>Decrease salt usage</td>
<td>Average lbs of salt / 40,000 gal</td>
<td>1064 lbs of salt / 40,000 gallons</td>
<td>20% reduction to 851 lbs of salt/40,000 gallons</td>
<td>31% reduction to 739 lbs of salt/40,000 gallons</td>
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<td>Decrease water hardness alarms</td>
<td>Average alarms per Day</td>
<td>1.3 alarms/day</td>
<td>50% reduction</td>
<td>69% reduction to 0.396 alarms/day</td>
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- Salt usage was reduced 31%; goal was 20%.
- Water hardness alarms were reduced from an average of 1.3 alarms/day to 0.396 alarm/day. This accounts for days with and without any alarm occurrences.
Brine Recovery System

An Additional Salt Use Reduction Project
Regeneration-Initial Step

DRAIN LINE FROM SOFTENER TO BRINE RECOVERY VALVE

TIMED BRINE RECOVERY VALVE
Regeneration-Recovery Step
New Controllers on Water Softeners

H-200M SERIES™
WATER CONDITIONING SYSTEM

Going Green

Brine Reclaim – The H200M standard electronic package is capable of reclaiming up to 30% of the salt used in regeneration for the next regeneration. Salt savings will vary depending on the lbs. of salt per cubic foot of resin used to regenerate. A brine reclaim kit is required for this option.

Water Reclaim – The H200M standard electronic package is capable of reclaiming much of the water used to regenerate the water softener and re-use that water to flush toilets. This water is typically soft and is free of the salt/brine discharge which is diverted to your standard drain/waste system. A water reclaim kit is required for this option.

SystemMate Controller

Pfizer GLOBAL SUPPLY
Salt Savings Projected to be ~20%

This equates to ~ 20,000 pounds annually

$4500 annually

Cost recovered in 2.5 years