Liquid Filtration for Chlor-Alkali Plants

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What are the 3 most important parameters in operating a chlor-alkali plant?
1. Brine Quality
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2. Brine Quality
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3. Brine Quality
Agenda

• Overall brine treatment process and how it fits into chlor-alkali plant
• Salt impurities dissolved into brine
• Precipitation to remove impurities
• Removal of precipitants by filtration
• Benefits
• Experience
Typical Block-Flow Diagram for Membrane Process with Conventional Brine Treatment and Filtration

- **Saturation**
  - Lean Brine
  - Salt
  - $\text{H}_2\text{O}$

- **Precipitation**

- **Clarification Filtration Polishing**
  - Flocculants Filter aid

- **Ion Exchange**

- **Electrolysis**
  - Chlorine
  - NaOH

- **Chemicals**
  - Sludge
Salt impurities dissolved into brine

1. CaSO4 = Blue, Ca precipitated as CaCO3 (1 ppm to over 6,000 ppm)
2. MgSO4 and MgCl = Light Green, Mg precipitated as Mg(OH)2 (1 ppm to over 600 ppm)
3. Silicates = Dark Green

Analysis membrane = Red (Nylon)

Also important at other customer sites:
4. Fe(OH)3
5. Al(OH)3
6. BaSO4
7. HgS (amalgam process)
8. Strontium
9. Nickel
10. Organics

Brine sample filtered over an analysis membrane. Surface analysis using a combination of Scanning Electronic Microscopy and X-ray Fluorescence Spectroscopy
Dissolved salt impurities in brine reduced to:

<table>
<thead>
<tr>
<th></th>
<th>Membrane cell room</th>
<th>Diaphragm cell room</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium chloride</td>
<td>290-305 g/l</td>
<td>320 g/l</td>
</tr>
<tr>
<td>calcium and magnesium</td>
<td>20 ppb</td>
<td>5 ppm</td>
</tr>
<tr>
<td>sodium sulfate</td>
<td>7 ppm</td>
<td>5 ppm</td>
</tr>
<tr>
<td>silicon dioxide</td>
<td>5 ppm</td>
<td>0.5 ppm</td>
</tr>
<tr>
<td>aluminum</td>
<td>50 ppb</td>
<td>0.5 ppm</td>
</tr>
<tr>
<td>iron</td>
<td>0.5 ppm</td>
<td>0.3 ppm</td>
</tr>
<tr>
<td>mercury</td>
<td>0.01 ppm</td>
<td>1 ppm</td>
</tr>
<tr>
<td>heavy metals</td>
<td>0.05 ppm</td>
<td>0.05 ppm</td>
</tr>
<tr>
<td>flouride</td>
<td>1 ppm</td>
<td>1 ppm</td>
</tr>
<tr>
<td>iodine</td>
<td>0.4 ppm</td>
<td></td>
</tr>
<tr>
<td>strontium</td>
<td>0.5 ppm</td>
<td></td>
</tr>
<tr>
<td>barium</td>
<td>0.4 ppm</td>
<td></td>
</tr>
<tr>
<td>TOC</td>
<td>1 ppm</td>
<td>1 ppm</td>
</tr>
<tr>
<td>pH</td>
<td>2.0 - 11.0</td>
<td>2.5-3.5</td>
</tr>
</tbody>
</table>
How to remove impurities – First using precipitation (chemicals and reactions)

Calcium and Magnesium reduction

• **Na₂CO₃ (soda ash)** + CaSO₄ => CaCO₃ + 2NaSO₄  results in Ca removed down to 0.6 ppm

  Particle size produced is about 2 microns in size

• **2NaOH (caustic)** + MgCl₂ => Mg(OH)₂ + 2NaCl results in Mg removed down to single digits ppb

  Particle size if flash precipitated can be as small as 0.1 micron in size

Silica reduction

• **MgCl₂** + SiO₂ + 2NaOH => (MgO)x(SiO₂)x*(H₂O) +2NaCl or Si removed by solids contact or evap

Sulfate reduction

• **BaCO₃** + NaSO₄ => BaSO₄ + Na₂CO₃ or brine purge or by RO

  With brine wells, a Sulfate Solubility Inhibitor (SSI) can be added directly to the well to prevent the sulfate going into solution in the first place.

Further metal reduction

• An additional precipitation/coagulation step to remove iron, aluminum at low pH using FeCl₄
Conventional brine treatment – after precipitation – 3 step filtration

1. Clarifier
2. Sand Filter
3. Polish Filter

Treatment Tanks
Salt
Saturator
Brine Storage
Ion Exchange
Precoat
Sludge
Brine Treatment and Purification with non-Precoat Filtration - One Step Brine Filtration

Sludge

or

Salt

Treatment Tanks

Saturator

Brine Storage

Ion Exchange
Tubular Back-Pulse Filter

On-line Filtering

- Filtrate
- Slurry
- Filter Cake/Underflow

Back-Pulsing

- Plant air
- Filtrate
- Slurry
- Filter Cake/Underflow
Back-pulse of filter cake in brine slurry
Examples of GORE Filter Media

GORE Filter sleeve/sock

GORE Filter Tube Assembly – 2.5 times the filtration area of sleeve/sock
Benefits of GORE Back-Pulse Filters

- Reduces capital equipment costs by 50% and significantly reduces plant equipment footprint
- Fully automated
- No need for a standby filter
- Eliminates use of precoat and flocculants
- Higher solids concentration sludge, so if further dewatering is required, filter press is designed for solids loading, not hydraulic loading.
- Reduces 3 process steps down to 1
- Works with all different types of salt sources
- No longer have to handle sluice, as none is produced
- Quite often reduces chemical treatment costs, sometimes savings of over $1 million/year
- Eliminates power outage issues that precoat filters are sensitive to
- Eliminates issue of clarifier rolls due to large outdoor temperature swings
- Reduces amount of sludge produced, saving landfill costs or less contaminates sent back to the brine well
- Extends life of Ion Exchange Column resin and reduces cleaning frequency
- We have a value spread sheet that helps quantify the savings
Experience

- Experience with brine filtration in both Caustic Chlorine plants (also referred to as Chlor-Alkali plants), salt to Bleach, and Sodium Chlorate plants.
- Began developing the brine application back in the early 90’s with our CPVC fluted support element dressed with our filter sleeve. Over 10 years ago, developed the GORE Filter Tube assembly to reduce size/quantity of filters required.
- Learned filtration flux rate dependent on impurities makeup. The higher the Ca to Mg ratio, the higher the flux rate. Some salts had an organic content – especially solar salts – which we initially avoided. Developed the optimum chemical precipitation reaction conditions for optimum filtration performance. Eventually solved the organic issue with Hygiene Wash (Patented).
Installations

More than 100 commercial installations of GORE Filter Tube Assemblies or Fluted element with sleeve around the globe

Experience with various types of salt
Including vacuum salt, rock salt, solar salt
(Chilean, Indian, Mexican, Australian),
and well brine

Caustic Chlorine (C/A), salt to Bleach, & Sodium Chlorate Plants
China – +95% of C/A plants use non-precoat technology. +95% use membrane electrolyzers. Solar and rock salt
Americas – diaphragm and membrane electrolyzers. Rock, well brine, and solar salt.

Our filtration technology is now coupled with the latest membrane electrolyzer technology, resulting in the most efficient chlor-alkali plant operation – located in China.
Gore Sealants for Chlor- Alkali

**GORE® Sealants** for meeting the production challenges of corrosion, bolt load retention, leakage and overall reliability in Chlor- Alkali production