Sulfate Removal System

Effectively and efficiently remove divalent sulfate ions from seawater down to the required level for injection

**APPLICATIONS**
- Removal of divalent sulfate ions from seawater to enable injection

**ADVANTAGES**
- High-quality injection water
- Avoidance of well workover
- Reduced HSE hazards
- Reduced need for biocides
- Reduced scaling in piping and equipment
- More effective squeeze treatments
- Control of bacterial well souring
- Lower operating costs
- Increased productivity

Increased technological and environmental demands are being placed on the oil and gas industry to find cost-effective methods to control scale formation apparent as a result of waterflood.

Where seawater contains sulfate and formation water contains barium and strontium, there is a potential for significant barium and strontium sulfate scaling and reservoir souring. Scale deposits are a common problem in water injection, and the type and severity of scaling varies between fields.

Sulfate removal technology can help solve the problem at the source, enabling increased productivity and lower operating costs. Removing sulfate before injection reduces the potential for barium and strontium sulfate scaling and helps to prevent reservoir souring.

Schlumberger offers membrane separation solutions for sulfate removal, either as stand-alone or turnkey systems depending on the customer’s specific requirements. The solutions provide a cost-effective technology for
- vertical production wells
- gravel-pack wells
- dilution water in HPHT environments
- horizontal wells with subsea tiebacks
- floating production systems
- reservoir souring control.

One of seven sulfate removal modules capable of producing 50,000 bbl/d (330 m³/h) of low-sulfate seawater for Kizomba A Field, West Africa.
Membrane separation is a method of sulfate reduction that is efficient and environmentally sound.

The low-sulfate seawater product is typically in the order of 40 mg/L and dependent on water temperature and other operating parameters. The percentage of product from feedwater is 75%.

<table>
<thead>
<tr>
<th>Sulfate Removal System (One Pass, Two Stage)</th>
<th>Feed, mg/L</th>
<th>Reject, mg/L</th>
<th>Permeate, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>460</td>
<td>583</td>
<td>419</td>
</tr>
<tr>
<td>Sodium</td>
<td>10,897</td>
<td>13,461</td>
<td>10,042</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1,388</td>
<td>5,269</td>
<td>68</td>
</tr>
<tr>
<td>Calcium</td>
<td>428</td>
<td>1,495</td>
<td>72</td>
</tr>
<tr>
<td>Strontium</td>
<td>8</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Carbonate</td>
<td>13</td>
<td>44</td>
<td>4</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>124</td>
<td>255</td>
<td>80</td>
</tr>
<tr>
<td>Chlorine</td>
<td>19,700</td>
<td>30,443</td>
<td>16,119</td>
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<tr>
<td>Sulfate</td>
<td>2,960</td>
<td>11,750</td>
<td>30</td>
</tr>
<tr>
<td>Silicon dioxide</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>36,959</td>
<td>63,332</td>
<td>26,835</td>
</tr>
<tr>
<td>pH</td>
<td>8</td>
<td>8.17</td>
<td>7.81</td>
</tr>
</tbody>
</table>

First sulfate removal system installed on floating production unit.

Typical sulfate reduction plant—performance vs. temperature.
Cost savings
Overall, the efficient removal of sulfate by membrane separation can reduce the risk of lost and deferred production. Considerable cost savings can be gained by the reduction, and in some cases elimination, of ineffective squeeze treatments.

The process is also considered the best overall solution given the complex nature of many recent developments—barium-present, deep subsea wells; long perforation intervals; and monitoring challenges.

Complete systems
To gain the maximum performance from membrane separation systems, correct pretreatment is important. It is normally recommended that the pretreatment and membrane packages are managed as a single system because of the complex process, control, and operating interfaces.

Aftersales service
Deployed by a dedicated team of experienced personnel, our service agreements include

- monitoring and diagnostic analysis of equipment performance
- prompt mobilization of onsite engineering assistance
- planned maintenance and survey regimes
- regular customer training of operational personnel.

Training
Schlumberger has the resources to provide both bespoke formal classroom and onsite training on the practical aspects of operating and maintaining these systems.
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Typical process flow schematic.

End view of membrane pressure vessels.