The elution brine study is a very effective investigation tool for water treatment engineers. Every softener used in industry should have an elution study done once per year. This procedure will save the troubleshooter time and resources and will only require a watch, a salinometer, and a piece of paper. The procedure is used to appraise the elution of brine on the resin bed and to detect the behavior during the regeneration cycle.

Ion exchange is a physical process involving velocity, concentration, and time. Regeneration of ion-exchange media is a combination of the same three ingredients and if one or two of the variables are off, proper regeneration will not occur. In other words, if the brine concentration is cut from 6% to 4% and contact time is reduced from 27 minutes to 11 ½ minutes the subsequent regeneration will result in steadily reduced throughput.

The elution is constituted from the ion displacement absorbed in an ion exchange material by solutions containing ions in extremely high concentrations. The experience with softeners has shown that improper regeneration is the main factor that has affected the performance and the useful life of the cationic resin of sodium cycle.

**REGENERATION**

Comprised of four basic stages whose meanings and operating sequences are presented below.

1. **Backwash**- It expands the bed a minimum of 50%, removes the accrued impurities during the service cycle and reranks the resin. This generally has 10 minutes duration time.

2. **Salt Passage**- Saturated brine is diluted to 10% with a fixed water flow and is applied to the resin. The minimum time allowed for the introduction of the brine is 15 minutes.

3. **Slow displacement and rinsing**- Extend the contact time among the resin and the salt using a displacement flow equal to the brine dilution flow. The minimum time of this stage is 10 minutes.
4. **Fast rinsing**—Removes all the remaining salt, so that the resin bed can be placed in service. This stage is ended when the Total Hardness of the effluent water reaches the incoming level.

To reach the maximum capacity of ionic exchange the contact time between the resin and the solution containing 7% of NaCl must be at least 20 minutes, but 30 minutes is preferable.

**APPLICATION OF THE ELUTION STUDY**

The steps used to perform the study are:

- Brine concentration measure (density, Baume)
- Measure of effluent density of softener immediately after the beginning of brine introduction and with intervals of 5 minutes between each reading
- Survey of curve % NaCl vs. Time (minutes)
- Analysis of the obtained curve.

Enhanced deviation of the ideal typical curve can be assigned to factors such as the below mentioned:

- Insufficient dilution water results in reduced flow through the resin bed at a high NaCl concentration.
- Dilution water in excess results in a very poor NaCl concentration contacting the resin. This situation can lead to significant loss of resin capacity.
- Short displacement or slow rinsing time.
- Other factors such as problems on the brine distribution system, resin impregnated with impurities, obstructed lines, bed support with faults, etc., can be identified when surveying the curve.
IMPORTANCE AND USE OF THIS STUDY

The elution study can be performed always when a sodium cycle softener has decreased efficiency. It should be done routinely once a year.

The analysis of the curve of brine elution along with the information obtained from the capacity assays and physical-chemical analysis of the resin will give a most detailed view of the real conditions of the softener.

AUXILIARY INFORMATION

Solubility of the Sodium Chloride

The below table shows the NaCl anhydrous quantity that is soluble in 100 grams of water at the indicated temperature.

### Density of NaCl Solutions

<table>
<thead>
<tr>
<th>°C</th>
<th>0°C</th>
<th>10°C</th>
<th>20°C</th>
<th>30°C</th>
<th>40°C</th>
<th>50°C</th>
<th>60°C</th>
<th>70°C</th>
<th>80°C</th>
<th>90°C</th>
<th>100°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.7</td>
<td>35.8</td>
<td>36.0</td>
<td>36.6</td>
<td>37.0</td>
<td>37.3</td>
<td>37.8</td>
<td>38.4</td>
<td>39.0</td>
<td>39.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Solubility of NaCl

<table>
<thead>
<tr>
<th>°C</th>
<th>Density</th>
<th>% NaCl @ 15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>1.004</td>
<td>0.528</td>
</tr>
<tr>
<td>1.1</td>
<td>1.007</td>
<td>1.056</td>
</tr>
<tr>
<td>1.6</td>
<td>1.011</td>
<td>1.514</td>
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<tr>
<td>2.1</td>
<td>1.015</td>
<td>2.112</td>
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<td>2.7</td>
<td>1.019</td>
<td>2.640</td>
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<tr>
<td>3.3</td>
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<td>3.167</td>
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<tr>
<td>3.7</td>
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<td>3.695</td>
</tr>
<tr>
<td>4.2</td>
<td>1.030</td>
<td>4.223</td>
</tr>
<tr>
<td>4.8</td>
<td>1.034</td>
<td>4.751</td>
</tr>
<tr>
<td>5.3</td>
<td>1.038</td>
<td>5.779</td>
</tr>
</tbody>
</table>

*Baume

**Formula to Density Conversion (p)**

\[
\text{DEGREE BAUME (°B) = 145 - 15 \cdot p} \\
\text{or \quad p = \frac{145 - \text{°B}}{15}}
\]

\[
\text{DEGREE TWADDEL (°T) = (p - 1) \cdot 200} \\
\text{or \quad p = \frac{\text{°T} + 200}{200}}
\]