Softener Elution Studies

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Water softeners are critical components in many commercial and industrial water-using systems. By removing calcium and magnesium ions (hardness) from a facility's or system's water supply, a softener plays a key role in helping prevent hard water-related problems – scale, corrosion, boiler tube failure and flow restriction, to name a few. These and other problems caused by hard water cost business and industry millions, perhaps billions of dollars annually.

It is important, then, that a facility's softener be maintained in good operating condition to assure a continuous supply of soft water. A simple maintenance program will help keep a softener running at peak efficiency. This would include inspection of the softener's control head for proper operation, periodic laboratory analysis of the softener resin for physical condition and cleanliness, and the regular use of a resin cleaner to prevent fouling of the resin beads with iron, manganese and other contaminants.

With a properly operating control head and clean resin in good condition, a softener will perform at maximum efficiency and capacity if the regeneration procedure is correct. The regeneration procedure consists of four "cycles" – backwash, brine draw, slow rinse and fast rinse. Each cycle plays an important part in effecting good regeneration, and flow rates during each are critical.

During backwash, water flows upwards through the bed to flush particulate matter from the resin bed and to reclassify or "fluff up" the bed.

The backwash flow rate must be sufficient to expand the bed 1½ times for thorough reclassification and cleaning. This requires approximately 6 gallons per minute (gpm) per square foot of softener surface area. The backwash cycle should last 10-15 minutes.

In the brine cycle, water passing over a venturi educts brine from the brine tank. The eduction water and brine mix and pass down through the resin bed. The eduction water/brine flow rate are critical to assure the complete exchange of sodium ions onto the resin beads. Brine eduction (brine draw) should be completed in 12-20 minutes.

When brine draw is complete, water continues to flow through the resin bed in the slow rinse cycle. This slow rinse acts to push the brine through the bed and complete the ion exchange. Here again the flow rate is important because it must be fast enough to provide removal of the calcium and magnesium ions that the sodium ions have replaced, yet it must be slow enough to allow sufficient brine/resin contact. The slow rinse cycle should take about 30-45 minutes.

At the end of the slow rinse cycle, the ion exchange is complete, and the fast rinse cycle starts. The function of the fast rinse is to remove the remaining brine from the softener column. The flow rate is accelerated here to provide for complete flushing of the brine from the resin bed. A flow rate of 5-6 gpm per square foot of softener surface area is normally used for fast rinse. When the fast rinse is done (10-15 minutes), regeneration is complete and the softener is ready to be put back in service.

To reiterate, the flow rates of brine and/or water during each of the cycles in the regeneration procedure must be correct for proper regeneration of the resin bed to occur. In addition, the salt brine solution used must be saturated for the regeneration to be complete.

A useful tool for assuring correct flow rates and brine concentration is a softener elution study. An elution study procedure, work sheet and brine concentration curve graph follow this discussion. Use of this tool by the water treatment technician or plant operator will allow them to identify and correct problems in a softener's regeneration function

Softener Elution Study Procedure

Before beginning the study, make certain that the softener drain line is open so that samples can be collected. Ideally, there should be sufficient space beneath the line to place a 2½ gallon pail, or at least a one gallon jar or beaker. This is so that flow rates can be determined by recording the time necessary to fill a specified volume.

Using a salimeter, determine that the brine in the brine tank is at 100% of saturation. If brine is less than 100%, add salt and let stand until 100% saturation is attained.

Run elution study using the following procedures:

1. Place the softener into the regeneration cycle. First stage will be Backwash. Using either the one gallon or 2½ gallon container, time how long it takes to fill the container with the backwash water. Calculate the backwash flow rate. Proper backwash flow rate is 6 gpm per square foot of resin bed surface area. If the backwash flow rate is significantly greater or less than 6 gpm per square foot, contact a softener service technician to adjust the backwash to the correct flow rate. Backwash should continue for 10-15 minutes. Record this information on the Elution Study Worksheet.
2. When backwash is complete, the softener will go into the brine cycle. Before the brine cycle begins, record the brine level in the brine tank by measuring the distance in inches from the top edge of the brine tank down to the brine surface. This measurement will be used to determine the volume of brine drawn into the softener during the brine cycle. Also, make note of the time the brine cycle begins – brine draw should last for 15-20 minutes. Record the brine level measurement and the time the brine cycle starts on the Elution Study Worksheet.
3. At the beginning of the brine cycle, collect a softener effluent sample, fill the graduated cylinder with the sample, and measure the % saturation with the salimeter. The sample should measure 0% saturation at the beginning of the brine cycle. Continue sampling in this manner, taking a sample every two minutes for the duration of the study. Record sample times and % saturation measurements on the Elution Study Worksheet.
4. When brine draw stops, note the time, and measure the distance in inches from the top edge of the brine tank down to the brine surface. Compare this measurement with that taken at the beginning of the brine cycle to determine the inches of brine drawn down. The difference between the two measurements is the brine draw down. Record the inches of brine draw down and the time the brine draw stops on the Elution Study Worksheet.
5. Following brine draw, the softener will go into the slow rinse cycle. During slow rinse, continue to collect samples of the effluent every two minutes, measure the % saturation and record the results on the Worksheet. Slow rinse should continue for 30 to 45 minutes.
6. Following slow rinse, the unit will go into fast, or final rinse. The flow rate will increase to approximately that of backwash. Fast rinse should continue for 5-15 minutes. At the end of fast rinse, the % saturation should be 0.

At this point, conduct a chloride test on the softener effluent; the reading should be within 15% of the chloride reading in the raw make-up water. If the chloride level in the softener effluent is more than 15%

above the raw make-up water chloride level, the brine is not sufficiently rinsed from the softener, and the duration of the fast rinse cycle must be increased. Consult the softener operating manual or a softener service technician to increase the fast rinse cycle time. When the softener effluent chloride level is equal to that of the raw make-up, the softener effluent should contain less than 1 ppm total hardness and the softener is ready to be put into service.

Using the data recorded in the Salimeter Readings table on the Softener Elution Study Worksheet, plot the salimeter readings on the Softener Elution Study Brine Curve graph. The salimeter reading line should be above the 30% mark for at least 30 minutes. This would reflect a thorough regeneration of the resin bed. Anything less than this would represent less than complete regeneration and would result in less than maximum softening capacity.

If the brine curve is not at or above 30% for 30 minutes, the shape of the curve will give an indication of the problem. For example, a curve that rises sharply to peak substantially above 30% and then falls rapidly back below 30% means that the brine is being educted too quickly. In this case, the eduction water flow rate should be decreased to provide for a longer eduction time. A shallow curve that does not reach 30% of saturation indicates insufficient eduction water flow rate and/or insufficient total brine draw.

Softener Elution Study Worksheet

System Data

Number of softener columns_____
Diameter of softener column_____
Depth of resin bed_____
Amount of resin per column_____ cubic feet
Regeneration controlled by (check one):
Timer___
Metered through-put___

Elution Study Data

1. Backwash flow rate: _____gpm
2. Backwash duration: _____ minutes
3. Distance from top of brine tank to brine surface: _____inches
4. Time brine draw begins: _____
5. Time brine draw ends: _____ Brine draw duration: _____minutes
6. Distance from top of brine tank to brine surface after brine draw: _____inches
7. Brine draw down (#6 - #3): _____inches
8. Volume of brine used: _____gallons.
9. Amount of salt used: _____pounds (gallons used X 2.6 for saturated brine)
10. Salt rate (pounds of salt per cubic foot of resin per column)

Brine Hydrometer Readings

Time	Percent of saturation,NaCl	Time	Percent of saturation, NaCl
0	0	38 minutes	
2 minutes		40 minutes	
4 minutes		42 minutes	
6 minutes		44 minutes	
8 minutes		46 minutes	
10 minutes		48 minutes	
12 minutes		50 minutes	
14 minutes		52 minutes	
16 minutes		54 minutes	
18 minutes		56 minutes	
20 minutes		58 minutes	
22 minutes		60 minutes	
24 minutes		62 minutes	
26 minutes		64 minutes	
28 minutes		66 minutes	
30 minutes		68 minutes	
32 minutes		70 minutes	
34 minutes		72 minutes	
36 minutes		74 minutes	

Softener Elution Study Brine Curve