SALT EFFICIENCY

FOR

SOFTENER REGENERATIONS

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by

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SOFTENER OPERATING STEPS

The operation of a typical softener includes a service mode and a regeneration mode

During the service mode, hard water is allowed to flow through the softener until either a sudden increase of hardness at an undesirable concentration is detected in the effluent of the unit or a pre-set amount of water has been softened. The unit is then taken out of service for regeneration.

The regeneration steps include a backwash step, a regeneration step, a slow rinse step, and a fast rinse step.

The backwash step consists of passing water through the softener in the reverse direction to its service flow in order to expand the resin bed and allow removal of solid material such as silt, iron, dirt & resin fines.

The regeneration step involves the passage of a concentrated brine solution through the resin bed, most often in the same direction as the service flow, in order to chemically replace the calcium & magnesium ions which have been attached to the resin during the service mode with sodium ions.

The slow rinse step involves the passage of water through the softener in the same direction as the brine in order to remove the excess brine from the unit.

The fast rinse step involves the passage of water through the softener in the same direction as the brine in order to not only complete the removal of excess salt, but also to flush out the calcium & magnesium ions which were liberated during the regeneration step.

The set points for operating parameters such as flow rates and timer settings for each operating mode are usually established at the design stage by the manufacturer and supplier of the equipment. However, most softener installations are designed to accommodate field adjustments, particularly for the regeneration step, which will allow the operator to select the characteristics that he feels are important for his particular operation. The set points which will allow the operator to select the most efficient use of salt for his particular operation are discussed herein.

SOFTENING CAPACITY

The softening capacity of a resin is defined as a measure of the quantity of hardness ions which are removed from the water by a given amount of resin. In North America capacity is generally expressed in terms of kilograins per cubic foot of resin and hardness concentration is expressed as either grains per US gallon or ppm. In order that all concentrations may be put on a common or equivalent basis all ions are mathematically converted to and expressed as $CaCO_3$.

Thus, it is understood that capacities and hardness concentration are expressed as kilograins CaCO3 per cubic foot of resin and grains CaCO3 per US gallon (or ppm CaCO3) respectively.

New resin may be placed into immediate softening operation without regenerating it since it is supplied in the sodium form. Due the manufacturing process, the initial capacity of the resin is at a very high level of approximately 41 kilograins per cubic foot. In subsequent operation however, the quantity of salt used during the regeneration step will determine the effective exchange capacity of the resin, but it is at a much lower level, typically within the range of approximately 15-30 kilograins per cubic foot of resin. Therefore, end of runs should not be established until the softener has gone through at least two service/regeneration cycles

The effective capacity of the resin and the hardness leakage during the run are related to the TDS concentration of the feedwater to the unit and the regeneration level. This relationship is illustrated in Table 1 overleaf

Table 1: Capacity Vs. Water Quality, Regeneration Level, and Hardness Leakage

TDS of Water (ppm CaCO3)	Regeneration Level (lb salt/cu ft)	Capacity (kgrn/cu ft)	Hardness Leakage (ppm CaCO3)
200 or less	6	22	0.5
	10	26	0.3
	15	32	0.1
500 or less	6	20	4.0
	10	22	1.5
	15	24	0.6
1000 or less	6	20	15.0
	10	22	6.5
	15	24	3.0
1500 or less	15	22	6.0
3500 or less	15	20	30.0
5000 or less	15	20	75.0

As indicated in Table 1, a water with a TDS concentration of 200 ppm will have a hardness leakage of approximately 0.5 ppm during the run if it is regenerated at a salt level of 6 lb/cu ft, whereas a water with a TDS concentration of 5000 ppm will have a hardness leakage of approximately 75 ppm during the run if it is regenerated at a salt level of 15 lb/cu ft.

Most softener applications in Alberta Public Works utilize waters with a TDS concentration of 500 ppm or less and require a maximum hardness leakage of less than 2 ppm. Therefore, as indicated in Table 1, a regeneration level within the range of 10-15 lb salt/cu ft resin will give an effective capacity of 22-24 kgrn/cu ft resin and an acceptable leakage of 0.6-1.5 ppm during the run.

Similarly, if the TDS concentration of the supply water is only 200 ppm, a regeneration level of 6 lb/cu ft resin will give an effective capacity of 22 kgrn/cu ft resin and an acceptable hardness leakage of 0.5 ppm during the run.

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As indicated in Table 2 below, the most efficient use of salt is obtained with low salt dosages. That is, a regeneration level of 6 lb salt/cu ft resin will remove 20-22 kgrns of hardness for a salt efficiency of 0.29 lbs salt/kgrn hardness, whereas a regeneration level of 15 lb salt/cu ft resin (ie., more than twice as much salt) will remove 24-32 kgrns of hardness for a salt efficiency of 0.54 lb salt/cu ft resin.

Table 2: Regeneration Level Vs. Capacity & Salt Efficiency

Regeneration Level (lb salt/cu ft)	Capacity (kgrn/cu ft)	Salt Efficiency (lb salt/ kgrn)
6	20-22	0.29
10	22-26	0.42
15	24-32	0.54

In general, low dosage, high efficiency regeneration is practiced in municipal and industrial softening installations, whereas relatively high-dosage, low efficiency regeneration is more common in household domestic softeners

The actual salt level may be determined for each site by referring to Table 3 below.

Table 3: Brine Tank Diameter Vs. Salt Level

Brine Tank Diameter (inches)	Salt Level (lb salt/in of brine soln) *
18	2.86
20	3.48
24	5.07
30	7.9
36	11.4
42	15.5
48	20.2

* Note: It is assumed that the brine solution is saturated to a level of 25 wt% (ie., an S.G. of 1.19).

CASE HISTORY

If a softener which contains 5 cu ft of resin is used to soften a water that has a TDS concentration of 200 ppm and a total hardness concentration of 80 ppm, its run at a regeneration level of 6 lb salt/cu ft resin is calculated as follows:

$$Q = \frac{17.1 \text{ USG}}{80 \text{ grns}} \times \frac{22,000 \text{ grns}}{\text{cu ft resin}} \times 5 \text{ cu ft resin} = 23,513 \text{ USG}$$

Similarly, the run of the same softener at a regeneration level of 15 lb salt/cu ft resin would be 34,200 USG. That is, 45% more water is softened, but 150% more salt is used.

In this example, if the demand for soft water is 5,000 USG/day, the annual cost for salt at the lower regeneration level would be approximately $159.35 and the softener would be regenerated 78 times per year, whereas the annual cost for salt at the higher regeneration level would be approximately $275.81 and the softener would be regenerated 54 times per year, thus resulting in a savings for salt of $116.46/year at the lower regeneration level