After SB1006:

Factors Affecting the Brine Efficiency of Softeners

Part 2 of 2

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Summary: *We began this discussion last month by relaying news that a compromise in legislation passed in California, Senate Bill 1006, this summer regarding water softeners meant higher brine efficiency standards there and likely nationwide eventually. As California goes, often so goes the nation, particularly with environmental issues. We continue here by considering ramifications of control valves, injector selection, tank configuration, resin selection and service flow toward more efficient salt usage.*

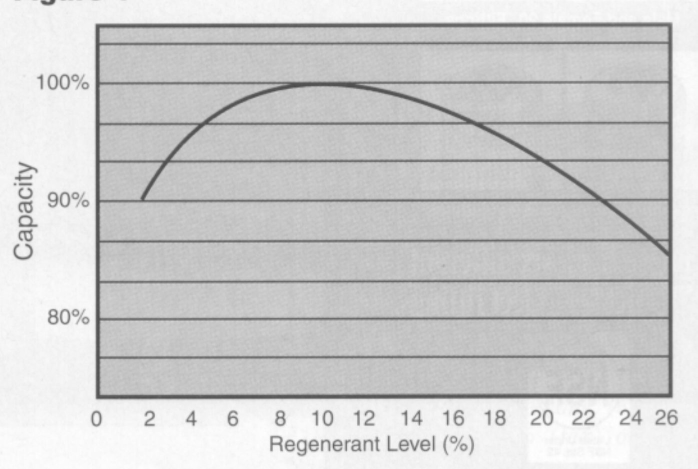
Valves with fixed time cycles will tend to use more water in the backwash and rinse cycles. This will further exhaust the bed and reduce the full capacity achieved during regeneration. Electronic valves with fully adjustable time setting can be set to use minimal backwash cycles (usually 10 minutes) and shortened rinses. This can save 50 gallons or more of water per cubic foot per cycle. This capacity can be added to the service cycle, thus improving efficiency. Electronic valves also incorporate timed brine refill levels. This is a far more accurate way to adjust the brine level, especially at the proposed lower levels suggested by this article.

Upflow brining is more efficient than downflow brining because it produces a bed with lower leakage characteristics that will help produce higher quality for a longer time.[4] Upflow generally gives better brine distribution during regeneration and reduces brine dilution by the freeboard headspace above the resin in the tank. A metered, upflow regenerating electronic valve with timed brine refill is best for realizing higher brine efficiency.

Brine injector size

The brine injector is a tiny device in the control valve that draws saturated brine into a dilution stream of water during the brining cycle. It also sets the flow rate of the diluted brine through the resin. Both brine concentration and brine flow rate can impact capacity and efficiency.[3] Figure 1 shows that 10 percent brine (40 percent saturated) is near optimum.

Figure 1



Extremes of feed pressure (below 20 or over 80 pounds per square inch, or psi) can result in higher dilution rates in the brine.[5] However, a larger negative impact is realized by too large an injector that draws the brine in too quickly. Since 10 percent brine contains approximately 1 lb of sodium chloride (NaCl) per gallon (gal) and since 10 minutes of brine contact is minimal, select a brine injector that will produce 0.5-to-0.6 gallons per minute (gpm) flow of dilute brine per cubic foot of resin. Use the smallest injector practical for the water condition and install a brine filter in-line, if needed, to avoid clogging the injector throat with debris from the salt.

Brine is diluted by the freeboard area above the resin. To compensate, the brine injector should deliver the brine to the top of the tank at near 15 percent. That's less than a 1-to-1 dilution ratio from the brine tank. Check the "rinse" rates for the injector you plan to use and compare this to the "draw" rate for the brine. You should select one for your feed pressure that has a higher brine draw than rinse rate. The total regeneration flow will be the sum of the two rates.

Tank configuration

All 1-cubic-foot softeners are not alike. Using too large a tank for the bed size results in excess brine dilution due to excess freeboard. Freeboard is necessary for proper bed expansion during backwash. This allows the bed to loosen, fluffs it up and rinses out dirt or sediment. Use an upper inlet screen on the control valve or upper distributors. Use a maximum of 33 percent freeboard (¼ of the tank height) instead of the usual 50 percent on city water and consider using a prefilter on all well water to minimize backwash requirements.

Tank diameter will also affect the bed depth of the resin. A narrower tank gives a deeper bed depth, which improves capacity (see *Figure 2*).[1] This also minimizes the headspace discussed previously.

Utilizing as much of the resin bed as possible can be facilitated by the use of underbedding—usually sand or pea gravel. Water will not flow through resin sideways when it's buried beside or below the bottom outlet. Larger tanks require deeper levels of underbedding (see *Figure 4*). Underbedding can also act to lift the bed up, thus reducing the headspace above the resin. It can also help brine distribution by presenting some level of pressure drop during slow flow brining or "trickle" type low flow service demand (less than 1 gpm). Selecting a proper tank size with underbedding can prevent loss of 10 percent or more of capacity for a given system. This improves the brine efficiency by not allowing that capacity to be lost.

Figure 2

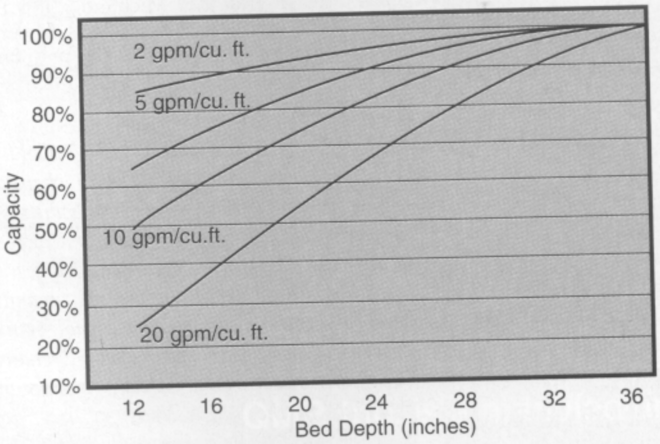
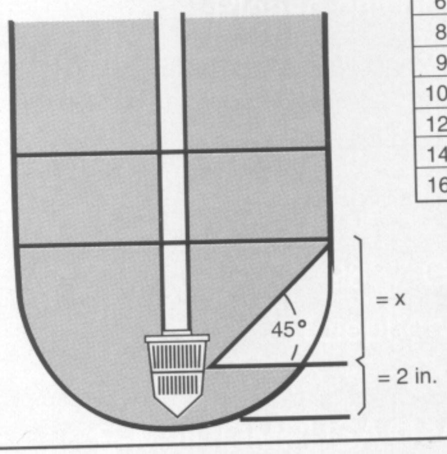


Figure 3

d = in	Depth = in	Time
6	4	3.7
8	5	7.8
9	5.5	9.5
10	6	14.4
12	7	24.0
14	8	32.0
16	9	44.0



Resin selection

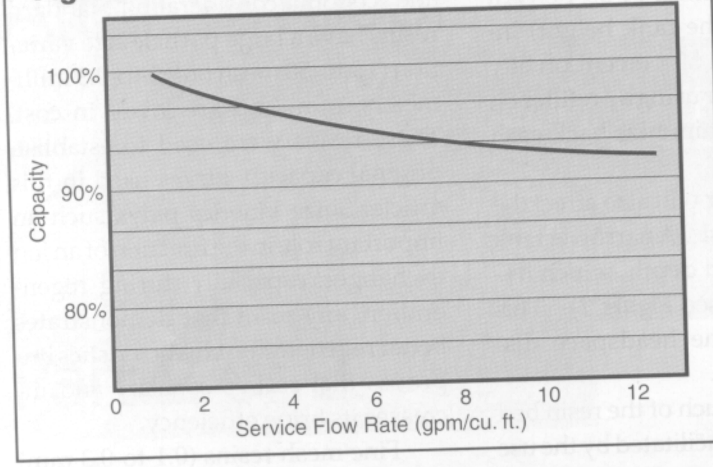
Softening resin can be purchased as "standard," fine mesh, uniform particle size or shallow shell. Each represents an answer to any given need and economic consideration. Standard resins have a large particle size variation (16-to-50 mesh or 1.2-to-0.3 millimeters, mm) and are lower in cost. These resins were used to establish original capacity curves used in this article. Since kinetics plays such an important role in the function of an ion exchanger, especially during regeneration, any resin that demonstrates better regeneration characteristics improves that resin's capacity and increases its brine efficiency.

Fine mesh resins (0.1-to-0.3 mm) can improve brine efficiency by 10 percent at the lower salt levels and they do regenerate more quickly.[2] Conversely, they do cause higher pressure drop, are more difficult to contain and cost more to make. Fine mesh resins are good filters and tend to pick up more suspended solids and/or dirt than standard resins, but they backwash very easily. They're a good consideration for larger diameter tanks with limited backwash flow available or can be used with smaller valves to take advantage of the lower backwash flow demand. Fine mesh resins backwash at about 40 percent of the flow rate needed for standard resins.

Uniform particle size (UPS) resins can boost brine efficiency by 10-to-15 percent with a combination of more uniform regeneration (reduced leakage) and shorter rinse requirements.[2] They may cost more depending on how they were produced. Modern, jetted resins that don't require mechanical size screening may be priced about the same as standard resins.

Shallow shell resins are standard size but have uniform reactive shells giving many of the advantages of higher capacity and shorter rinses.[6] Shallow shell resins regenerate very effectively with low salt levels, making them ideal candidates for commercial applications requiring low hardness leakages without the use of excessive amounts of salt. Current versions of these resins are not designed for residential applications due to their lengthy and more complex startup requirements.

Figure 4



They're higher in cost than standard resins.

Service flow

A final variable to be discussed is service flow rate. Newer residences with very high fixture counts requiring 20-to-25 gpm are driving down brine efficiencies by forcing manufacturers to make systems with lower pressure drops in order to achieve the perceived need of the higher flow demands. Fixture count standards vary from state to state according to which plumbing codes are in force. Fixture count flow is a theoretical value that essentially assumes that every plumbing fixture in the house may be turned on at the same time. This is a highly unlikely event. Normal water flows to a residence rarely exceed 5-to-7 gpm. Such flow rates are easily achieved without excessive pressure drops with 8- and 9-inch diameter softeners, and these will be more brine efficient for the variety of reasons discussed. Larger systems should be considered only where there's a true need established for higher flow, a feed pressure limitation or the feed hardness dictates a larger resin bed for throughput capacity.

On the negative side, raw water continuously flowing at high rates through a bed that's too small will result in a capacity reduction. This is certainly an important variable for installations needing a sustained flow. Figure 5 shows the general effect on capacity with increased flow rates.[3]

Another important variable to be considered is the effect of temperature on resin capacity. WQA is currently planning studies to better define this variable. Basically, cold water cannot only reduce capacity but may necessitate the need for a larger softener simply to avoid excessive pressure drop as well. Cold water is more viscous and offers more resistance to flow. Under normal conditions of 50-to-100°F, the capacity changes only a minimal amount. However as we go below 40°F, the softener kinetics—or speed at which the ion exchange process occurs—are so slow that you may have to oversize by 100-to-200 percent just to treat the water. In such circumstances, you could design a system that preheats the water to 55-to-60°F. A second hot water heater installed before the softener (set the thermostat at no higher than 70°F) could probably handle that very effectively.

Conclusion

By way of a recap, Table 1 lists the variables discussed here and their relative impact on brine efficiency losses.

Although the impact of any single variable may be minimal, the total impact of all of the "minimals" adds up to efficiency losses of 25-to-30 percent very easily. More than half of these losses can be recovered by proper systems design.

The size and shape of the softener for the new millenium will definitely change. Newer standards will place more emphasis on brine efficiency, which means deeper beds, counterflow brining and fully programmable electronic valves. These new systems will have a higher tech appearance, carry a higher tech sales pitch and be more "custom" engineered and maintained. The need for a more "environmentally friendly" system will underscore these designs.❑

Table 1. Summary of issues to improve brine efficiency

Variable	*Helps*	*Hurts*
hardness	higher	high TDS
regeneration level	lower	high regeneration flow
brine	10%	low concentration
valve	smaller injector	high flow pressure
tank	30" minimum bed	high head space
resin	many choices	no underbedding
hydraulics	slower flows	cold water

References

1. ANSI/NSF Standard 61, NSF *International*, Ann Arbor, Mich.
2. *The Purolite Company Engineering Manual*, Purolite Company, Bala Cynwyd, Pa.
3. *R&H Engineering Manual*, Rohm and Haas Company, Philadelphia, Pa.
4. Hunt, J., and J. Beauchamp, "Water Conditioners: Softener Calculations for Dealers—Salt Efficiency and System Sizing for Optimum Performance," *WC&P*, January 1999, pp. 60-63.
5. *Fleck 5600 Control Manual*, Fleck Controls, Brookfield, Wis.
6. Sabzali, J., and C.F. Michaud, "Ion Exchange: The Shorter Path to Success—Shallow Shell Resins," *WC&P*, March 1999, pp. 80-85.

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