# Better Brining for Higher Efficiency

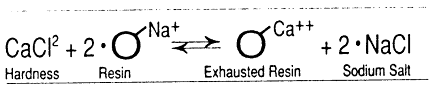
Slow, low-salt regeneration works better.

**By C.F. "Chubb" Michaud**

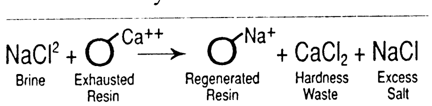
Softening water efficiently is a hot topic thanks to tougher regulation of softener discharges and concerns over water consumption. The make-up of softener brine, a major contributor to softener efficiency, is nonetheless often overlooked.

Brine discharge regulations have arisen as increased water demand has led many municipalities to recycle waste water. Water low in total dissolved solids (TDS) can be recycled less expensively, but brine-regenerated water softeners contribute TDS to waste water. Several communities in formerly drought-stricken Western states have attempted to outlaw softeners, leaving softener manufacturers scrambling to provide brine-efficient systems.

Brine-regenerated ion exchange resins contain a replaceable monovalent positive ion that readily exchanges for the divalent calcium and magnesium hardness ions. The process works like this:




Regeneration is accomplished by passing a salt solution through the resin bed to drive the reaction back the other way:




Theoretically, one equivalent of calcium (hardness) replaces one equivalent of sodium during softening. Regeneration, however, requires higher concentrations of regenerant to force the reaction back the other way. The percent of a softener's theoretical softening capacity regained per pound of regenerant used during regeneration is its "brine efficiency."

Four major factors affect brine efficiency. They are:

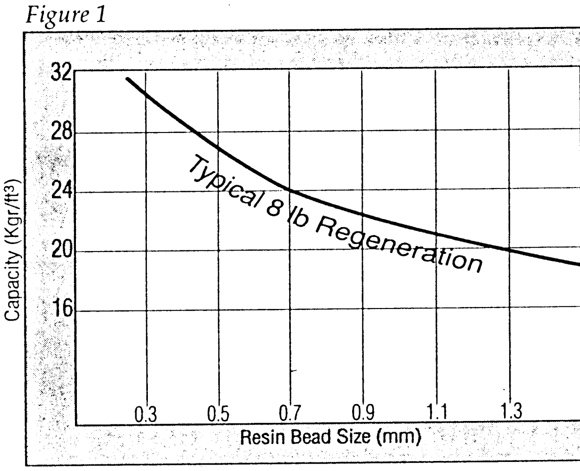
- Resin. Size, uniformity and cross-linking level are all considerations.
- Salt. Quantity, quality and concentration are important.
- Regeneration. Flow rates and direction have an effect.
- Influent. Total dissolved solids (TDS), hardness and exhaustion flow rate all relate to influent quality.

*Resin* size and uniformity both affect efficiency. Smaller resin beads regenerate more efficiently than larger ones (see Figure 1), but smaller, more uniform beads regenerate even more efficiently (see Figure 2).

*Salt quantities* used in regenera-

(Continued on page 62)

*Figure 1*




| Mesh | Size |
|---|---|
| 12 | 1.68mm |
| 16 | 1.19mm |
| 20 | 0.84mm |
| 30 | 0.59mm |
| 40 | 0.42mm |
| 50 | 0.30mm |
| 60 | 0.25mm |

*Figure 2*

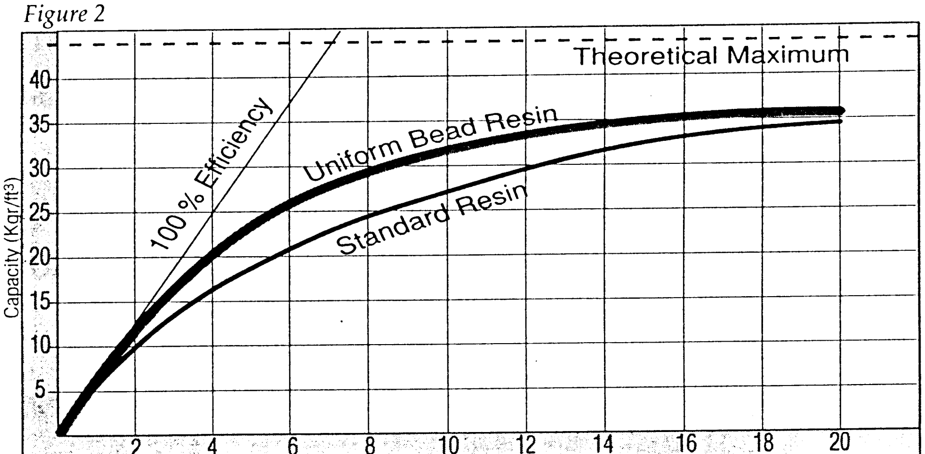
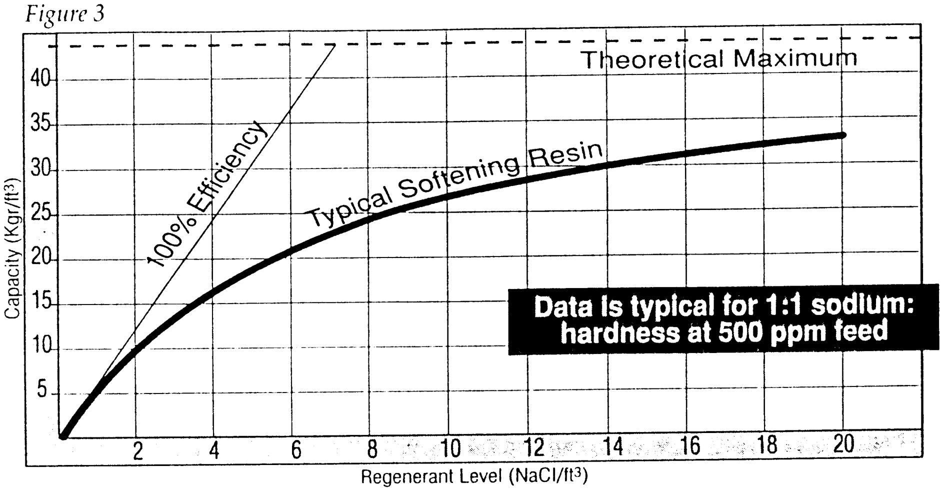


Figure 3




tion also influence softener efficiency. In general, the more salt used, the more softener capacity gained — but after a certain point, efficiency drops. (see Figure 3).

By using higher brine concentrations, residential softeners regenerate approximately 50 to 70 percent of resin's typical capacity of 22 to 30 Kgr per ft$^3$. There's a loss of efficiency, but hardness can leak through a softener prematurely if insufficient brine is used to push regeneration toward completion.

These different brine levels achieve different results:

- At 5 pounds salt/ft$^3$ resin, typical capacity regained would be 18.5 Kgrs, or 3700 grains per pound of salt. This is an overall efficiency of 62 percent.
- At 12 pounds salt/ft$^3$ resin, 28.7 Kgrs capacity would be regained, or 2390 grains per pound of salt. This is an overall efficiency of 40 percent.

*Regeneration flow* is also a key consideration. High-quality regeneration takes time: fast flows may be too short to drive hardness off the resin, while too slow a flow may result in improper distribution of regenerant.

For example, using 7 pounds regenerant in a 10 percent brine solution, a regenerant flow rate of 0.5 gpm/ft$^3$ increases capacity by one Kgr/ft$^3$ over a flow of one gpm. A flow of 1.5 gpm decreases capacity by one Kgr/ft$^3$.

Using counter-current regeneration is another way to increase efficiency. It's more efficient than co-current regeneration because it produces lower leakage at all brine levels. This enables you to use less salt (see Figure 4, page 63).

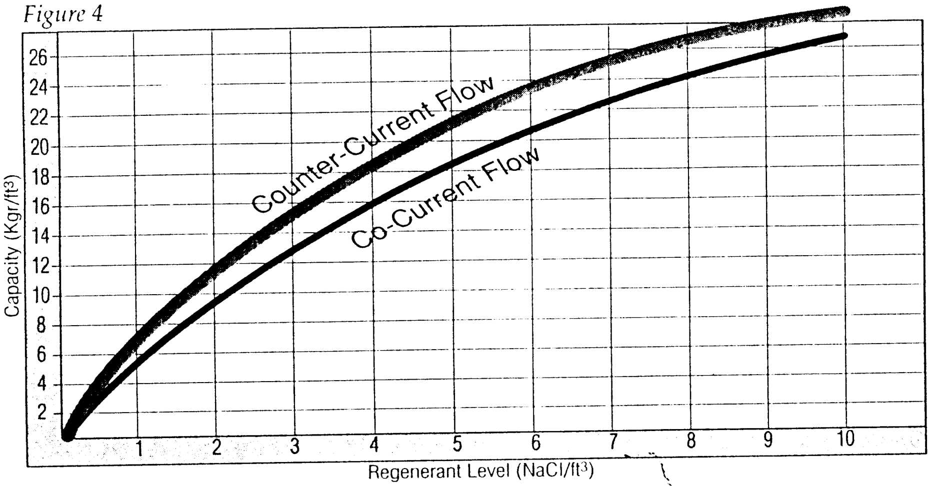
*Influent quality* is the one variable affecting efficiency that you have little control over.

For example, it may be possible to soften residential water up to 100 grains hard if the water composition is primarily hardness and alkalinity. The resulting water quality would have a leakage of only six to eight parts per million (ppm) hardness regenerating with 10 pounds NaCl and less than one grain regenerating with 5 pounds.

If, however, feed water contained 100 grains hardness and an equal amount of sodium, hardness leakage would be about 40 ppm regenerating with 10 pounds NaCl, or 170 ppm regenerating with 5 pounds. Reducing leakage to one grain hardness would require 25 pounds of salt.

Thus, a 2000-ppm TDS influent is the practical upper limit for residential softening. At that TDS level, less than one grain leakage can be achieved with 8 to 12 pounds NaCl, depending upon water composition, but the resulting effluent

*Figure 4*




would be a 2000-ppm salt solution.

For boiler feed water applications where less than one ppm hardness is required, the practical limit is reduced to about 1000 ppm TDS in influent and brine levels of 15 pounds salt/$ft^3$ resin.

A primary softener followed by a polishing softener can achieve less than one ppm leakage at influent TDS levels up to 5000 ppm. The polisher is generally counter-flow regenerated, but brine efficiency of such systems isn't usually a prime concern.

*Exhaustion flow rate* is the final variable that must be considered. While you might assume softeners won't perform as well at higher flow rates, the effect is surprisingly minimal.

Most manufacturers rate their resin performance at two gpm/$ft^3$, for example. Slowing down to one gpm only buys a capacity increase of about 0.5 Kgr/$ft^3$ regenerating with 7 pounds NaCl. Conversely, increasing flow to 10 gpm decreases capacity by about one Kgr/$ft^3$.

Of the variables affecting brine efficiency, the pounds of salt used per cubic foot of resin has the largest impact. The goal is to use the lowest salt setting that meets capacity and leakage requirements.

Brine levels of 7 to 8 pounds salt/$ft^3$ resin produce 50 to 55 percent efficiency on most softeners. Using up-flow regeneration improves efficiency by another 10 to 15 percent.

Brine concentrations of 8 to 12 percent with 20 to 30 minute contact cycles are more efficient than short cycles with highly-saturated brine or higher flow. Selecting the more brine-efficient uniform particle size resins can enable you to lower brining levels and increase efficiencies another 15 percent.

Combining the right resin, salt concentrations, brine levels, flow directions and twin alternating systems can dramatically improve efficiency. There are no 100-percent efficient systems and no need to perfect softeners to such a degree, but efficiencies of 75 percent are well within the grasp of every equipment supplier. ❑

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*We'd like to know what you think. Fax your comments on this article or the topic of brine efficiency to us at (518) 783-1386.*