

## Water Softener Cycles of Operation

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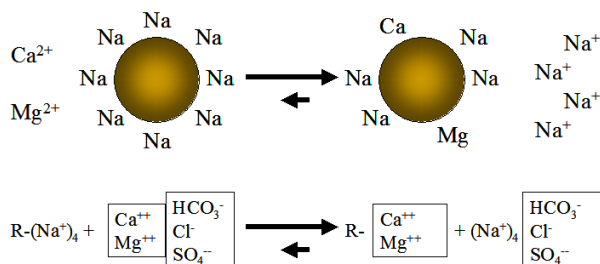
Sodium zeolite softeners are designed to remove hardness from water. The hardness constituents of calcium and magnesium are identified in most scale formations in boilers, cooling towers, and other water-related equipment. Properly controlled softeners will consistently provide effluent water quality of less than 1 ppm total hardness (expressed as CaCO<sub>3</sub>).

The softener cycles of operation include:

- Service
- Regeneration
- Backwash
- Brine Draw
- Displacement/Slow Rinse
- Fast Rinse
- Pre-Rinse

### Service

During the service cycle, calcium and magnesium ions are exchanged for the sodium ions attached to the active sites on and in the resin beads as shown below.



As more hard water is softened, eventually the exchange capacity is exhausted and hardness begins to leak past the resin bed. At this point or before (typically 85-90% of total capacity), the

softener is removed from service and regenerated.

### Regeneration: Backwash

Backwashing is important because during the service run, the resin bed becomes compacted from the continuous downward flow of water. Backwash water is introduced to the bottom of the softener and flows upward through the resin bed. The purpose is to “fluffup”



exchange sites prior to the brining. The backwash will also clean the resin by removing debris and any fines or particles of broken resin beads and will reclassify the resin bed. The backwash cycle is typically 10 minutes at a flow of 5-6 gpm/ft<sup>2</sup> or according to manufacturer recommendations.

### Regeneration: Brine Draw

The real heart of the ion-exchange operation is the brine draw regeneration cycle. This is where the variation of resin and control are of the greatest importance to the quality and quantity of water treated. The ion exchange reaction is reversed by introducing a preponderance of sodium ions in the form of brine (NaCl or salt water). Typically, brine is introduced at 30° salinity for 25 minutes at 0.5-1.0 gpm/ft<sup>3</sup> resin. Exceeding 45° salinity can result in “osmotic shock” and can cause the resin beads to split or crack. Dropping below 30° salinity will result in

an incomplete regeneration. The desired level of salinity is achieved by diluting 100% saturated brine using an eductor or pump system. Table 1 lists typical salt dosages and capacities.

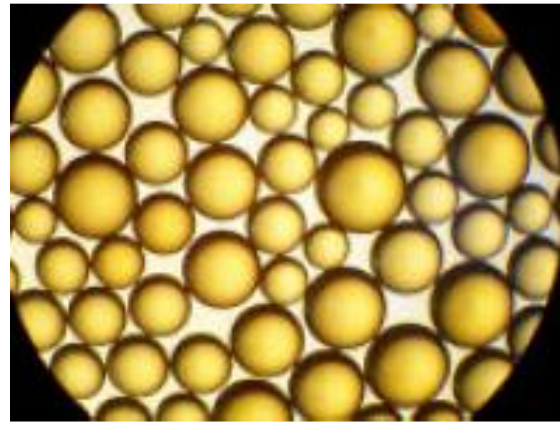
Salt (lb/ft <sup>3</sup> )	Capacity (grains/ft <sup>3</sup> )
6	18,000
8	20,000
10	24,000
15	30,000

### Regeneration: Displacement/Slow Rinse

After the introduction of the diluted brine to the resin bed has been finished, there remains a resin bed volume of regenerant that has to be displaced from the vessel to finish the regeneration. This last bit of regenerant is the highest quality with little calcium, magnesium, or other contaminants. It is important to fully utilize it by displacing it at the same flowrate as the brine draw to allow the resin ample reaction time. The dilution water used in the brine draw is continued at 0.5-1.0 gpm/ft<sup>3</sup> resin for around 15 minutes in order to push the brine through the rest of the resin bed in a piston-like fashion.

### Regeneration: Fast Rinse

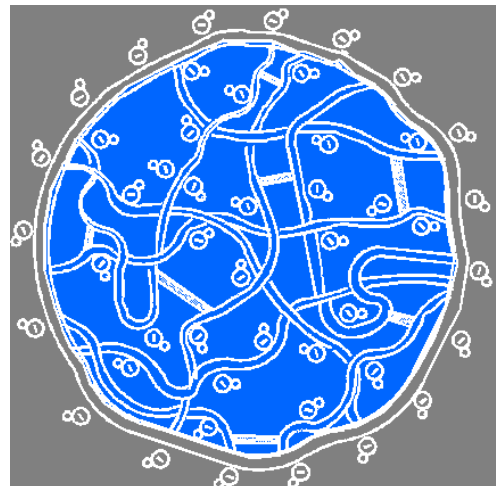
Following the displacement cycle, all excess salt and hardness (in the chloride form) must be rinsed from the unit. This happens at the softener's normal flowrate or 1.5-3 gpm/ft<sup>3</sup> resin for 25-30 minutes.



### Pre-Rinse

If the water softener is put directly into service after regeneration, then a pre-rinse is not required. However, if the softener unit sits in standby until needed, it may first be necessary to fast rinse the unit to achieve the desired water quality.

Why is pre-rinse required? As the unit has been in a no flow or static condition, the ions in the water have come in equilibrium with the ions on the resin beads. This means the initial water out of the softener may have some "standing hardness" in it. This standing hardness must first be rinsed from the unit before going online to ensure high quality soft water is produced.





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## Conclusions

Water softeners are used every day throughout the world. Understanding the cycles of operation will aid in the expectations and troubleshooting of water softeners.



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