Fundamentals of Water Softening

"Hard water explained"

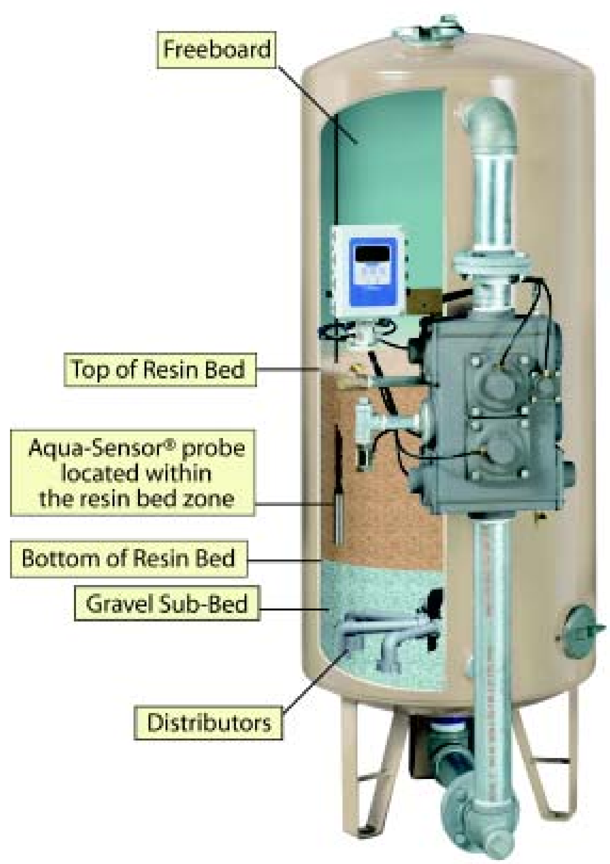
As rain falls through the atmosphere, it often adsorbs traces of acidic gases from the air (carbon dioxide, sulfur dioxide, etc.). When the water reaches the ground, it percolates through the soil and dissolves certain soil components. The greater the acidity of the rain water, the more soil material dissolved. Ground waters (wells, springs) and surface waters (rivers, lakes, oceans) contain a certain amount of dissolved matter. Many of these substances are chemical compounds, which can dissolve in water to form electrically charged particles called ions.

Two of the most commonly occurring ions in natural waters are calcium and magnesium. Both are positively charged ions called cations, and each carries two unit charges. The presence of these two minerals in natural water causes "hardness", which produces a scum or curd with soap, and forms a hard scale in piping and water heaters. Other cations present in natural waters may include sodium, potassium, iron and other metallic components, but primarily calcium and magnesium make water "hard".

"Softening explained"

Problems associated with hard water can be minimized by using a water softener. Conventional softeners operate on the principle of ion exchange. The most common ion exchange method used today is the sodium cycle operation. In this process, calcium and magnesium ions are removed by exchanging places on an ion exchange resin with sodium. This process is commonly known as positive ion or cation exchange. Negatively charged ions from the source water remain. Softening does not reduce total dissolved solids; it exchanges the "troublesome" hardness ions for sodium ions.

To avoid potentially coating the ion exchange resin with colloidal or suspended material, clear water should be applied to the softener. Water supplies containing very high amounts of other ions or contaminants may need to be pretreated before being applied to a softener.



Culligan

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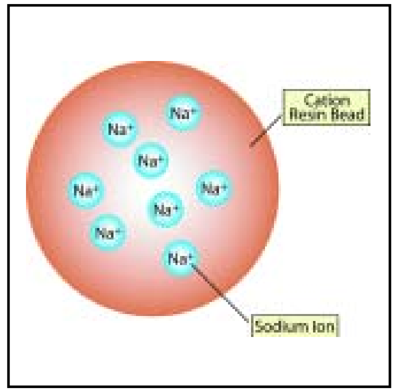
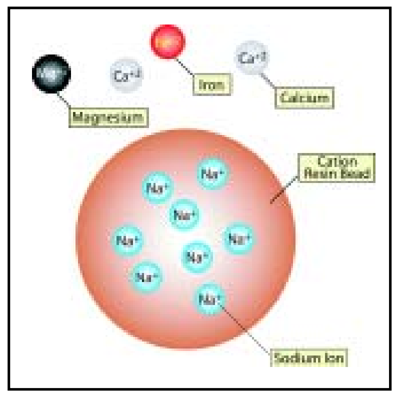
"How it works"

Cullex® cation resin beads, less than 1/32 of an inch in diameter, are insoluble in water and have a negative electrical charge. The resin beads are where the exchange of ions actually occurs. Cation resin beads attract positively charged ions like a magnet. It holds them until the beads are exposed to another cation for which it has a greater attraction. Generally, an exchange site on the resin will have a naturally greater affinity for a cation with a larger or denser charge.

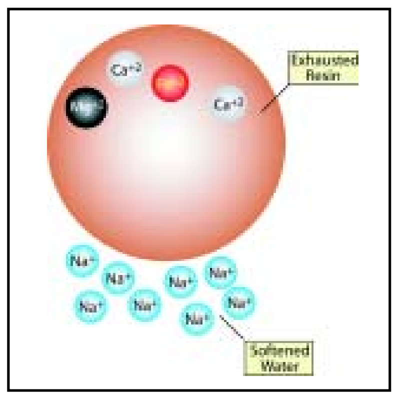


At the beginning of the water softening cycle, the resin beads are covered with single charged sodium (Na+) ions. This is done by rinsing them in a sodium chloride (brine) solution. These resin beads are typically contained in a pressurized vessel called a water-softening resin tank. The untreated hard water enters the resin tank, passes through the bed of resin and flows out to meet service demands.



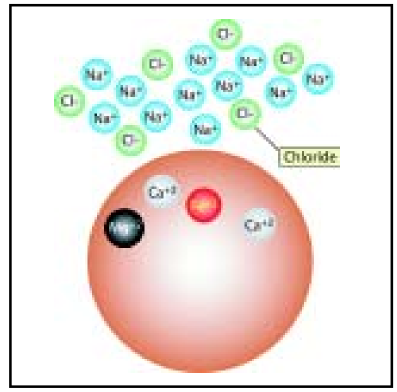
The negatively charged resin beads have a greater attraction for the two positive charges in each ion of calcium (Ca++) and magnesium (Mg++) than they do for the single positive charge of the sodium (Na+) ion. Therefore, sodium ions on the resin beads will be displaced by the calcium and magnesium ions. In effect the resin beads "exchange" the sodium ions for the "hard water" ions, allowing "soft" water to flow from the resin tank.

There is an area within the resin bed where hard water is in the process of becoming softened, because ion exchange requires time to occur. This is called the reaction zone. The size of the reaction zone depends on factors such as hardness, flow rate, other total dissolved solids, and resin particle size. When the resin bed has no more sodium ions for calcium or magnesium ions to exchange with, it is considered exhausted. To replenish the desired exchange capability, the water softener must be regenerated.



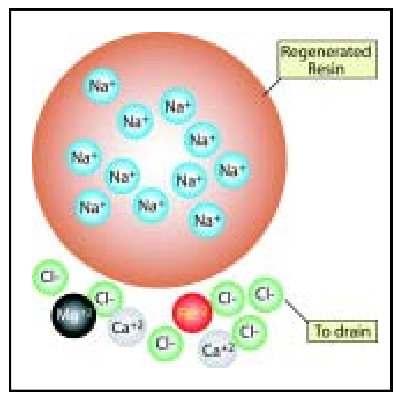
The resin bed is backwashed before the regeneration cycle begins. Water is passed through the resin bed in the opposite direction of normal flow. Backwashing flushes suspended matter from the ion exchange resin out of the tank to a drain. Backwashing also loosens the resin bed which can become compacted during the softening cycle. The backwash cycle typically lasts for 10 minutes.

Next, the resin beads are flushed with a sodium chloride solution commonly known as brine. Concentrated brine is drawn from the brine tank and blended with fresh water as it is delivered to the resin tank. Although the resin beads prefer calcium and magnesium ions, the overwhelming concentration of sodium ions overcomes this affinity. The sodium ions in the brine solution force the calcium and magnesium ions off the beads and they are discharged to a drain. This brine flushing process requires about 10 to 30 minutes, depending upon the amount of brine required to replenish the exchange capability.



Next, fresh water continues to slowly flush through the resin bed. This helps extend the resin and brine contact time while rinsing out the brine solution. The slow rinse cycle lasts about 30 minutes.

The last portion of the regeneration cycle is a fast rinse or purge cycle. Rinsing at a higher flow rate ensures no brine solution remains in the tank before returning the softener to service. The fast rinse cycle lasts about 5 minutes.



The entire regeneration cycle requires about 1½ hours. The actual frequency of this regeneration process is mainly determined by the amount of ion exchange resin in the softener, the amount of brine used in the regeneration, the hardness of the water, and the water usage

"Soft water quality"

"Soft water" is generally defined as having less than one grain per gallon (17.1mg/l) of dissolved calcium and magnesium ions. The quality of the softened water refers to the amount of hardness still remaining after passage through the ion exchange resin.

The amount of salt used to regenerate the exchange material governs both its hardness removal capacity and the water quality. Each cubic foot of *Cullex* resin has an ion-exchange capacity of 30,000 grains of hardness when regenerated with 15 pounds of salt. A lower salt dosage of 6 pounds will yield a softening capacity of 20,000 grains per cubic foot. The lower salt dosage is more efficient, but requires more frequent regenerations.

The total dissolved salts (TDS) content of the water also influences the effective softening capacity of a water softener. TDS content is the sum of all the ions present in the water. It varies for each water supply. Highly mineralized waters tend to reduce the efficiency of a softener and therefore should be considered when selecting the salt setting. If the TDS limitations are not observed, some passage of hardness into the product water can occur.

In situations where the conditioned water is used for general purposes, soft water quality is not critical. Slight traces of hardness don't influence the overall operation and are ignored. When the TDS level is low, lower salt dosages are recommended for general use to provide the greatest operating economy. Although more frequent regenerations would be required, the operation is normally fully automatic.

“Typical uses for softening”

Reduction of scale build-up from hard water (4 gpg – ASPE Handbook) for: boiler and cooling tower pretreatment, laundry operations, warewashing in foodservice, vehicle wash, manufacturing processes, and pretreatment for other water treatment applications such as reverse osmosis and deionization.

Untreated water can cause: increased utility bills, higher operating costs, decreased equipment efficiency and life; increased use of detergents and chemicals, reduction in linen life, dingy laundry, and increased boiler blow-downs and downtime.

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