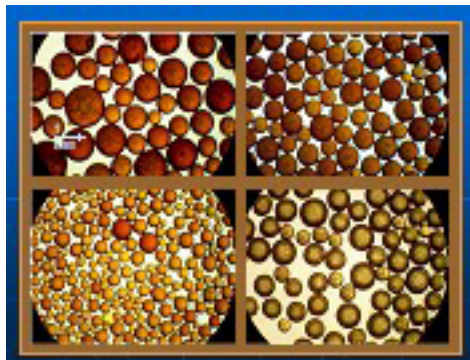


## Ask Tom! Column

### Everything You Wanted To Know About Water Softening

Guest article by Gary Schreiber, The Purolite Company



#### How Softening Works

During the softening process, water is passed through a column of ion exchange resin. The calcium and magnesium ions present in the water are exchanged on the resin beads for an equivalent amount of sodium ion. The softened water exiting the water softener is significantly higher in sodium than the raw water. This basically is the “Ion Exchange Process”.

The exchange of hardness for sodium is not perfect or complete and a small amount of “hardness” usually passes through the softener in the treated water. However, testing of the softened water discharging from a properly operating softener unit for hardness at this stage will usually not detect the trace amount of hardness. Eventually, more and more hardness will escape in the water and it can be detected with the normal water hardness test kit. At some stage, it will be necessary to rejuvenate or regenerate the resin so that the quality of softened water can be maintained at the required standard.

Regeneration of the resin is achieved by passing a solution of salt, (brine or sodium chloride), through the resin to displace the calcium and magnesium ions that have been taken up by the resin beads from the water. The sodium from the brine replaces the calcium and magnesium ions on the resin and when this process is complete the resin is ready to be used again for softening water.

Generally, the more brine that is used the more efficiently is the hardness displaced from the resin. So for more demanding applications, such as softening of boiler water, more brine is used to minimize the amount of hardness left on the resin when the softener is brought back into service. If insufficient brine is used “hardness leakage” from the softener will be higher.

#### Water Softening Resin Selection

A variety of ion exchange resins can be used for water softening. They are the heart of a Water Softener. When hard water, which contains calcium and magnesium (the primary hard water constituents), passes through a bed of resin calcium and magnesium are removed from the water. Together these two impurities are referred to as the total hardness (TH) of the water. The photo below is the general appearance of standard water softening ion exchange resin beads as they appear under a microscope.

Depending on the accuracy needed, water hardness can be tested by titration or by the simpler dropper-bottle test. The result for the total hardness test can be expressed as either “parts per million” (or ppm) of hardness or “grains per gallon” (or gpg), or even mg/l, and usually expressed as Calcium Carbonate (or CaCO<sub>3</sub>). (Grains per US Gallon x 17.118 = parts per million).

Household water containing less than about 1 grain per gallon, (or 17.1 ppm Total Hardness as CaCO<sub>3</sub>), is generally considered to be “soft water”. However, water for industrial or commercial use, (e.g. boiler feed water or other more demanding application), may require the water hardness to be reduced to less than 1 ppm total hardness.

However, in both cases similar softening processes can be used, but to achieve the lower level of total hardness required for the industrial application, the design for the industrial and commercial units is likely to be more stringent.

In addition to removing hardness from water ion exchange resins will also remove soluble Iron from the water. It is therefore important to test water for the presence and quantity of soluble Iron. Standard resins are generally limited to a maximum of 3 ppm of soluble Iron but can be applied to remove higher Iron levels provided steps are taken to prevent Iron fouling of the resin by either removing the Iron before feeding the water through the resin or by applying a resin cleaning chemical during the regeneration process.

## **Softening Basics**

Standard ion exchange resins for softening water are manufactured using an inert co-polymer of polystyrene and DVB, which gives the resin good mechanical strength. Functional groups, such as sodium, are added to the resin during the manufacturing process to give the resins their ability to soften the water.

Manufacturers typically produce a variety of grades of ion exchange resin. Resins to be used in potable water treatment are put through an additional manufacturing step to ensure compliance with FDA guidelines.

Polystyrenic gel resins, having an 8% DVB crosslinking, are the primary standard softening resins. These are produced as spherical beads varying in diameter from 0.3 millimeter to 1.2 millimeter. This is referred to as the standard Gaussian bead distribution, or "16 to 50 US mesh" beads. These beads provide the maximum surface area for the ion exchange process, while not being so small in diameter as to inhibit water flow through the resin. These resins are used for softening water in most residential and commercial/industrial applications.

## **Other Water Softening Resins Include**

a) Fine Mesh Resin: Resins that have a range of bead sizes that are generally smaller in diameter (40 to 70 mesh) than standard resin. Fine Mesh resins offer the advantage of lower salt usage, less rinse water requirement and faster kinetics (the rate at which calcium and magnesium hardness is exchanged onto the resin in place of sodium). Fine Mesh resins are generally not used in commercial or industrial applications, but are typically used only in residential applications.

b) UPS Resin: A resin with Uniform Particle Size, (bead size generally 30 to 40 mesh), designed to provide a higher operating capacity. They can be used in any softening application but are primarily designed for commercial/industrial applications. They offer higher operating capacity than standard resins, require lower salt doses, have lower hardness leakage and lower service pressure loss. The exact difference in capacity will depend on the actual water quality and operating conditions.

c) High-Velocity or High-Flow Resin: This is a coarser grade of resin beads (16 to 35 mesh) that are designed to allow higher flow rates without the disadvantage of the higher pressure drop that would occur with the standard resin. This allows for smaller vessels. The kinetics of these bead sizes are not as good as Standard, Fine Mesh or UPS resins. Therefore they are usually limited to low hardness waters with no soluble Iron content.

d) 10% DVB Crosslinked Resin: Referred to as a 10% crosslinked product, emphasizing the higher 10% DVB content (as compared to 8% DVB in standard softening resins). The higher DVB content makes the product more resistant to chlorine or similar oxidizing chemicals (such as Hypochlorite, ozone, hydrogen peroxide or permanganate). So in situations where chlorine concentrations are difficult to control, 10% DVB crosslinked resin may be a better option, although it too will eventually be attacked by the chlorine.

e) Macroporous Resin: Manufactured differently from the standard softening resins that are referred to as gel resins. Gel resins have no porosity. Macro resins are manufactured to have large pores and higher DVB concentrations. These 2 features make them more resistant to high temperature and to DVB de-crosslinking. When chlorine or other oxidizing chemicals are present in significant concentrations in the water to be treated, these oxidizing agents dissolve the DVB from the resin. Macro resins having more DVB will have longer life than standard resins, particularly in situations where the oxidizing agents in the water to be softened are in excess of 1 ppm.

A new softening resin technology, representing a revolutionary way of manufacturing resin, with a shell and inner core sections of the beads is now available. The process is known as Shallow Shell Technology or Salt Saving Technology. The core of the resin beads is inert and does not take part in the ion exchange process. All softening occurs in the outer shell area that is closer to the surface of the beads. It is ideally suited for co-flow softening designs (the most popular in North America) in which the water to be treated and the brine used afterward for regeneration enters and leaves the ion exchange resin bed in the same direction (usually from top to bottom).

During regeneration, it is easier and faster for the brine to reach all of the hardness inside the shell of the bead. Because of this, considerably less salt is required compared to standard softener resins, and the resin will still achieve the same or lower hardness leakage during the next service cycle. Less rinse water is needed for the same reason. From an environmental standpoint, the reduced salt usage and the lower rinse water requirement makes it quite attractive compared to standard resin. The extremely low hardness leakage allows it to excel in industrial applications, such as softening feed water for use in low and medium pressure boilers, feed water for use in Reverse Osmosis systems, and softening of oil field type (high total dissolved solids) water.

Even though Shallow Shell Technology resin sells at a premium over standard softening resins, it is usually possible in most cases to recover this premium in just a few months from the savings in both salt and water used for regeneration. The lower hardness leakage translates to higher efficiency and greater reliability of the equipment being served.

Your resin manufacturer of choice can help you to select the right grade of ion exchange resins for water softening.

## Summary

Water softening using ion exchange is very flexible, cost effective and can be applied anywhere there is the need to solve a water hardness related problem.

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**Welcome to Ask Tom!**, a monthly column by our resident water treatment guru, Tom Keenan of National Environmental Services Agency (NESA). Tom addresses the issues that bug you the most. And Tom knows!! With 35 years experience in providing environmental support services to public and private sector clients on a wide range of environmental issues.

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