ALABAMA A&M AND AUBURN UNIVERSITIES

Ion Exchange Units: Cation Exchange (Softeners) And Anion Exchange

Ion exchange units are known primarily as water softeners. But they can also remove nitrates, sulfates, and various toxic metals from water. Understanding how ion exchange works and what contaminants different units will remove can help you make informed decisions about water treatment by ion exchange.

How Ion Exchange Works

Ions are atoms, small particles that are the building blocks for molecules. Ions have a weak electrical charge. The charge may be positive (for cations) or negative (for anions). This positive and negative charge is similar to the north or south pole of a magnet or the positive or negative terminal of a car battery.

Positively charged sodium ions are commonly used to coat cation exchange resins. Negatively charged chloride or hydroxide ions are commonly used to coat anion exchange resins. Mixed bed resins combine both positive and negative ions.

Ion exchange units actually exchange ions from the resins with those in the water. When water to be treated passes through the ion exchange unit, ions in the water are attracted by either a positive or a negative charge to the ions in the resin bed. Since the ions from the water are usually held more tightly by the resins than they were held in the water, they are, in effect, removed from the water in the exchange process.

Cation Exchange Units (Softeners)

How Cation Exchange Works. Cation exchange resins are usually coated with positively charged sodium ions. When water containing dissolved cations contacts the resin, the cations are "exchanged" for or trade places with the loosely held sodium ions on the resin.

In this way the calcium and magnesium ions responsible for hardness are removed from the water and placed on the exchange resin, and the sodium ions from the resin are added to the water. This process makes the water "soft."

The calcium and magnesium, which cause hardness, are reported as grains per gallon (gpg), milligrams per liter (mg/L), or parts per million (ppm). Approximately 20 mg of sodium are added per gallon for each grain of hardness reduced.

Eventually a point is reached when very few sodium ions remain on the resin; thus, no more calcium or magnesium ions can be removed from the incoming water. The resin at this point is said to be "exhausted" or "spent" and cannot accomplish further water treatment until it is "recharged" or "regenerated." This can be done by backwashing with a sodium carbonate solution.

Most water in Alabama does not contain enough minerals to require softening.

What Cation Exchange Removes. Water softeners exchange calcium and magnesium with sodium. This exchange occurs as the hard water passes through a resin bed which attracts and holds calcium and magnesium in exchange for sodium. Calcium and magnesium cause hard water, and high levels can scale pipes, water heaters, boilers, and appliances, reducing water flow and efficiency.

Cation exchange resins also remove barium, cadmium, copper, iron, manganese, radium, zinc, and other metallic, positively-charged ions.

Factors To Consider Before Buying A Water Softener. Consider the following factors before buying a water softener.

Types Of Water Softeners. Softeners are either manual, semi-automatic, or automatic.

A manual water softener can be as simple as a tank to hold the exchange resin and appropriate piping for raw (inlet) and treated (outlet) water. Tanks must be constructed of corrosion-resistant material because of the concentrated salt solutions that are used.

More sophisticated systems may include a separate tank for mixing and containing the brine solution used for regenerating the resin, additional valves for backwashing the exchange resin, and switches for automatic or semi-automatic operation.

For semi-automatic operation, the homeowner sets the system switches when recharging is necessary. The system completes the process without need for further attention.

For automatic operation, all steps of the recharging process are controlled by a timing mechanism that the homeowner sets based upon water usage. Some models can measure water usage or remaining softening capacity and recharge themselves only when needed.

Maintenance. Maintenance of cation exchange units is largely confined to restocking the salt supply for the brine solution. With manual and semiautomatic models, the consumer will also have to start the regeneration cycle.

An exchange resin lasts many years. However, if it is not regenerated on a regular basis, it may become contaminated with slime or impurities from the raw water and become unusable. If this happens, the resin must be replaced with new material.

Resins can also become clogged with tiny particles of iron if the raw water contains much dissolved iron. Backwashing or reversing the normal flow of water through the treatment unit may be required to remove the iron. Special additives may be included in the brine regenerating solution to help minimize this condition.

Softened water is more corrosive than harder water, and the waste brines may be a disposal problem. Softening only the hot water tank lines or leaving the major cold water line for drinking water unsoftened can help overcome this problem. Water for outdoor taps does not need to be softened.

Cost. The cost of a water softener can be balanced against the savings of soft water. Softening hard water can reduce the quantity of cleaning products needed by as much as 50 percent. The life of the home's plumbing system and water-using appliances can be extended. Other benefits include the time saved in cleaning and removing scale and better results in laundry, dishwashing, and personal grooming.

Health Effects. The major disadvantage of water softeners is that they remove beneficial calcium and magnesium and substitute sodium. The sodium added to softened water is normally a relatively small fraction of the sodium intake from other dietary sources and is probably not a problem for healthy people. However, people on restricted salt diets should consult their physicians before using softened water from ion exchange units for drinking and cooking.

Anion Exchange

How Anion Exchange Works. Anion exchange units have a resin that exchanges chloride or hydroxide for the anions (the negatively charged atoms) that they remove. Most use chloride, which increases the chloride content of water and may cause a salty taste.

What Anion Exchange Removes. Anion exchange units can remove nitrate, sulfate, and other negatively charged atoms called anions. Researchers are developing resins to selectively remove nitrate more efficiently than can now be done.

Factors To Consider Before Buying An Anion Exchange Unit. Frequent monitoring is suggested if you use anion exchange for nitrate removal. As the anion exchange resin becomes "spent," the nitrate trapped in the resin may be exchanged with sulfate in the water if the water contains sulfate concentrations that are moderate to high. Under these circumstances, nitrate concentrations at times can be higher after water passes through the device than in the original water.

Mixed Bed Ion Exchange

Often called demineralizers, mixed bed ion exchange units combine resins for removal of both positive and negative ions. They do not remove organic chemicals and they produce water similar to distilled water.

Mixed bed units for industrial use are renewed with hydrogen ions from an acidic solution for cation exchange and with hydroxyl ions from an alkaline solution for anion exchange. These acidic and alkaline solutions are too dangerous for home use.

Mixed bed units for homes are usually not rechargeable. They must be discarded after a certain volume of water has passed through them. Therefore, they are expensive.

Water Softeners At A Glance

How Water Softeners Work: Remove minerals which cause hardness and replace them with sodium through cation exchange.

Pros/Cons: Can pay for itself in savings in soap, hot water. Not recommended for drinking water for individuals on a salt-free diet. Must buy salt regularly. Must dispose of brine solution.

Maintenance: Restock salt supply for brine solution used to regenerate the resin. Start regeneration cycle for manual and semi-automatic models. Backwash to remove iron or other particles that may clog system.

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