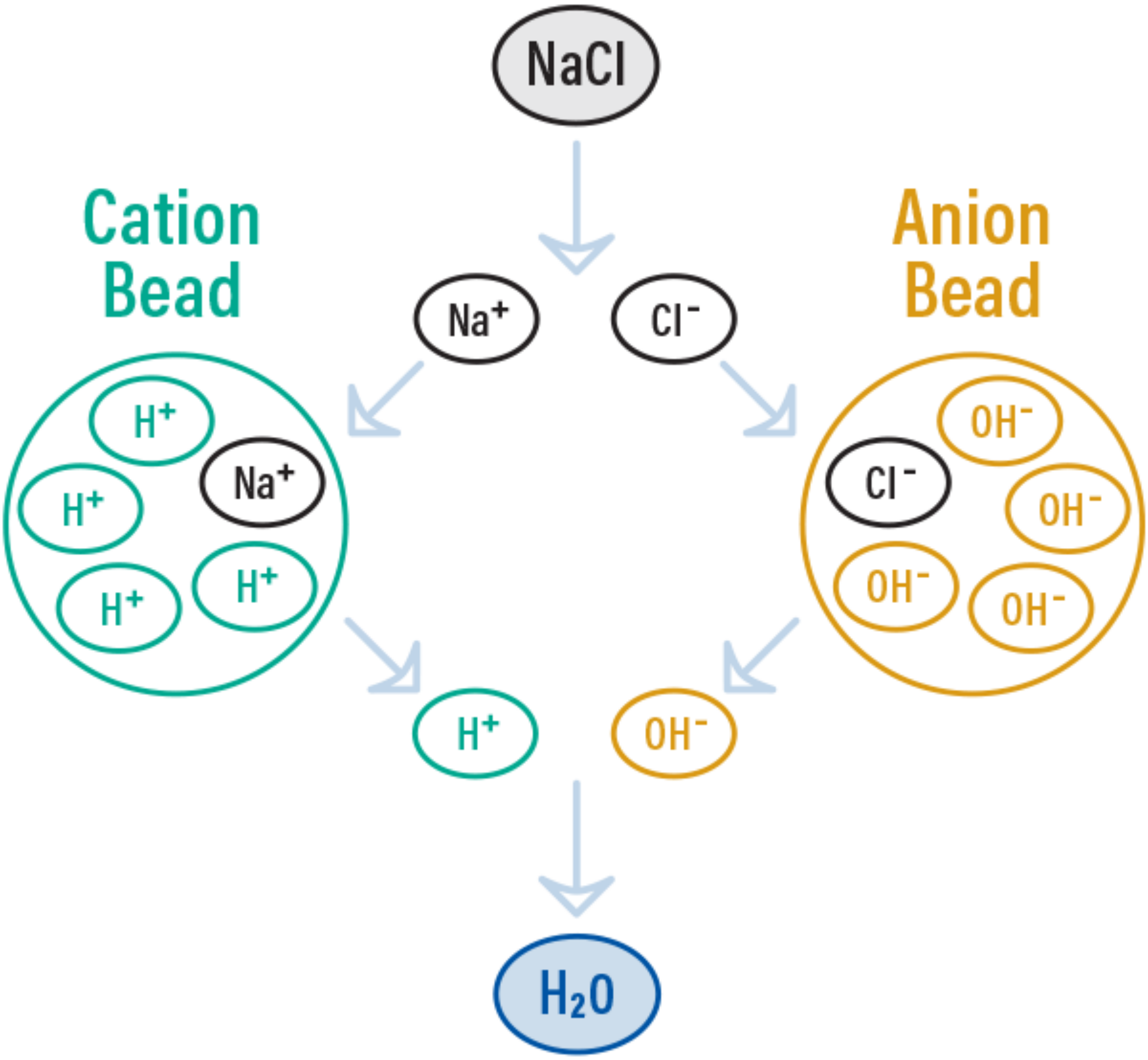
Basics of Ion Exchange/Demineralization



Deionization (also referred to as demineralization) is one of the most efficient processes for removing ionic dissolved salts and minerals from water. Ion exchange is a process where troublesome ions are exchanged for more desirable ions by using specially manufactured ion exchange resins. Ions are dissolved salts or minerals in water that can cause problems in high purity water systems when used as a rinse, coolant or a product ingredient. The purpose of ion exchange is to employ the correct type of ion exchange resins to remove the ionic contaminants that are unacceptable for the customer and replace them with ions that allow the customer to operate without problems. This process provides water that can remove nearly all dissolved salts and gases providing water that is high purity water that is similar to distilled water. The best ion exchange system for you depends on the quality of water entering the system and the quality of water that you require out of the system. By using the proper ion exchange resins it is possible to provide the optimal system for your applicatio

What is Deionized Water?

Deionization ("DI Water" or "Demineralization") simply means the removal of ions.

Ions are electrically charged atoms or molecules found in water that have either a net negative or positive charge. For many applications that use water as a rinse or ingredient, these ions are considered impurities and must be removed from the water.

Ions with a positive charge are called "Cations" and ions with a negative charge are called "Anions". Ion exchange resins are used to exchange non desirable cations and anions with hydrogen and hydroxyl, respectively, forming pure water (H20), which is not an ion. Below is a list of ions commonly found in municipal water.

Cations (*Removed by Cation Resins*)	Anions (*Removed by Anion R*
Calcium (Ca++)	Chlorides (Cl-)
Magnesium (Mg++)	Sulfates (SO4--)
Iron (Fe+++)	Nitrates (NO3-)
Manganese (Mn++)	Carbonates (CO3--)
Sodium (Na+)	Silica (SiO2-)
Hydrogen (H+)	Hydroxyl (OH-)

How does ion exchange work?

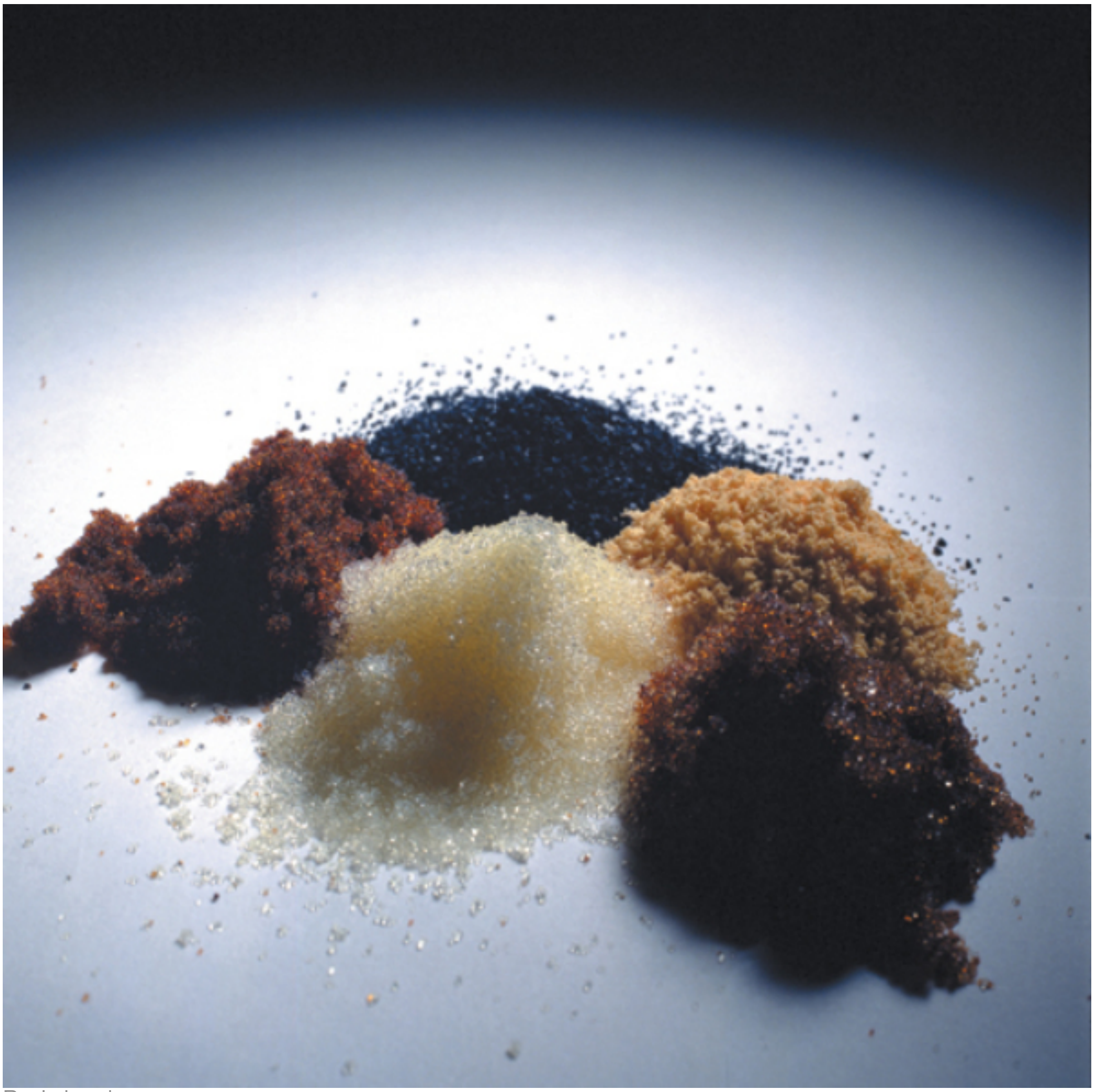
Ion exchange resins are used to produce **deionized water** (**demineralized water** or **"DI Water"**) . These resins are small plastic beads that are composed of organic polymer chains that have charged functional groups built into the resin bead. Each functional group has either a fixed positive or negative charge.

- Cation resin has a negative functional group and therefore attracts positively charged ions. There are two types of cation resins, weak acid cation (WAC) and strong acid cation (SAC). Weak acid cation resin is used mainly in dealkalization and other unique applications. For this reason we will focus on explaining the role of strong acid cation resins used for producing deionized water:

- Anion resin has a positive functional group and therefore attracts negatively charged ions. There are two types of anion resins, weak base anion (WBA) and strong base anion (SBA). Both types of anion resins are used to produce deionized water, however, they have different characteristics listed below:
- WBA resins do not remove silica, C02 or have the ability to neutralize weak acids and has a lower than neutral pH when used in a dual separate bed system.
- SBA resins remove all anions in the above table, including C02, and has a higher than neutral pH when used in a dual separate bed system due to sodium leakage.

- Mixed bed resins use SAC and SBA resins combined together.

In order to produce deionized water, cation resin is regenerated with Hydrochloric Acid (HCl). The Hydrogen (H+) is positively charged and therefore attaches itself to the negatively charged cation resin bead. The anion resin is regenerated with sodium hydroxide (NaOH). Hydroxyl (OH-) is negatively charged and attaches itself to the positively charged anion resin bead.



Resin beads

Different ions are attracted to a resin bead with different strengths. For example, calcium is more strongly attracted to a cation resin bead than sodium is. The hydrogen on the cation resin bead and the hydroxyl on the anion resin bead do not have a strong attraction to the bead. This is what allows ion exchange to take place. As positively charged cations flow across cation resin beads, the cations are exchanged for hydrogen (H+). Likewise, as negatively charged anions flow across anion resin beads, the anions are exchanged for hydroxyl (OH-). When you combine hydrogen (H+) and hydroxyl (OH-) you form pure H20.

Eventually all of the exchange sites on the cation and anion resin beads are used up and the tank no longer produces deionized water. At this point, the resin beads require regeneration to prepare them for use again.

Separate bed vs. mixed bed

Demineralization therefore requires using at least two types of ion exchange resins to produce deionized water. One resin will remove positively charged ions and the other will remove negatively charged ions.

In a dual bed system, the cation resin is always first in line. As city water enters the tank filled with cation resin, all positively charged cations are attracted to the cation resin bead and exchanged for hydrogen. The negatively charged anions are not attracted to the cation resin bead and pass through. For example, let’s examine calcium chloride in the feed water. In solution, the calcium ion is positively charged and will attach itself to the cation bead and will release a hydrogen ion. The chloride has a negative charge and therefore will not attach itself to the cation resin bead. The hydrogen, which has a positive charge, will attach itself to the chloride ion, forming hydrochloric acid (HCl). The resulting effluent from a SAC exchanger will have a very low pH and a much higher conductivity than the incoming feed water.

The effluent from the cation resin will consist of strong and weak acids. This acidic water will then enter a tank filled with anion resin. The anion resin will attract negatively charged anions such as chloride and exchange them for hydroxyl. The result is hydrogen (H+) and hydroxyl (OH-), which forms H20.

In reality, a dual bed system does not produce true H20 due to "sodium leakage". If sodium leaks past the cation exchange tank, then it combines with hydroxyl to form sodium hydroxide which has a high conductivity. Sodium leakage occurs because sodium and hydrogen have a very similar attraction to the cation resin bead and sometimes the sodium ion does not exchange itself for a hydrogen ion.

In a mixed bed system, the strong acid cation and strong base anion resin are intermixed. This effectively makes the mixed bed tank act like thousands of dual bed units in one tank. The cation/anion exchange is taking place over and over within the resin bed. Sodium leakage is addressed because of the sheer number of repeated cation/anion exchanges taking place. By using a mixed bed you can produce the highest quality of deionized water possible.

How are ions measured?

Ions conduct electricity. Electrical current passes through water using ions as stepping stones. As a result, by measuring the electrical conductance of water can tell us what the ionic content of the water is. Less ions in the water will make the passage of electricity more difficult. Therefore, water with a lower conductivity value is considered more "deionized" than water with a high conductivity value