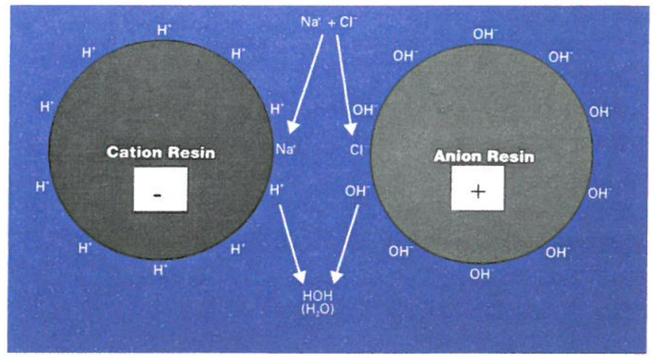
Dayton Water Systems

Advanced Solutions Since 1939

Deionization by Ion Exchange



Ion exchange is a chemical process by which ions, or ionic substances that are considered undesireable in water, are decreased or are removed from the water by use of properly designed ion exchangers, or resin.

Water supplied to homes and businesses, either through a municipal supply or a private well, has some water contaminants. When a water droplet develops in the clouds, it is pure. As water falls to the earth's surface as rain, sleet or snow, it begins to pick up contaminants from the air (sulfur dioxide, carbon monoxide, etc.) And as the rain runs across the ground, into rivers, and through the soil into underground streams, contaminants are dissolved into the water (iron, calcium, sodium, etc.).

Deionization of water by ion exchange process involves the exchange or substitution of all charged ions for hydrogen and hydroxyl ions. It is important to note that not all water contaminants are ionic and must be removed by other treatment processes (organic chemicals, bacteria, particulate, etc.).

Equipment using the deionization principle contains a bed of resin, a plastic bead-like material, through which the water flows. Deionizers utilize both cation and anion resins. Cation, derived from the word cathode, resin is negatively charged and attracts positively charged ions, i.e. calcium, magnesium, iron, sodium, etc. Anion, derived from the word anode, resin is positively charged and attracts negatively charged ions, i.e. bicarbonates, chlorides, nitrates, sulfates, phosphates, etc.

When the cation resin is at full capacity, hydrogen ions (H+) are attached to the resin beads. Similarly, when the anion resin is at full capacity, hydroxyl ions (OH-) are attached to the resin beads. The two resins are mixed together in one vessel (mixed bed) or are placed in two separate vessels (dual bed). This mixture of resins provides for a countless number of cation-anion "exchange sites" and as a result, high purity water can be produced.

As water with dissolved impurities passes through the resin, cations and anions are "exchanged" for hydrogen (H+) and hydroxyl ions (OH-). The dissolved ions in the water supply are more "attractive" to the resin allowing the hydrogen and hydroxyls ions to be released while the resin "captures" the other contaminants. The hydrogen (H+) and hydroxyl ions (OH-) combine to form pure water H_2O.

After a vast number of ions in the water have become affixed to the resin and most of the hydrogen and hydroxyl ions have been released, the deionizer can no longer deionize water and it becomes temporarily exhausted. Exhaustion is determined by a quality-indicating device.

Deionizer exchange tanks are swapped out or exchanged when they are exhausted with fresh tanks. Regeneration or recharging of the resin takes place in a central regeneration facility. The mixed-bed resin is backwashed separating the cation and anion resins. Each resin is transferred into individual vessels for regeneration.

The cation resin is regenerated with hydrochloric acid (HCl) and the anion resin is regenerated with sodium hydroxide (NaCl). The attraction or affinity of the resin for the other ions is overcome by the use of a relatively strong solution of acid or caustic. The cation resin will affix hydrogen ions to its exchange sites and anion resin with affix hydroxyl ions to its exchange site. The resins are rinsed, remixed, and rinsed again to produce quality deionized water.

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Water Quality

Specific Conductance (micromhos/cm*)	Specific Resistance (megohm/cm*)	Parts Per Million			Grains/Gallon as $CaCO_3$
		As Ion	As $CaCO_3$	As NaCl**	
0.055	18.240	none	none	none	none
0.056	18.000	0.036	0.028	0.022	0.002
0.063	16.000	0.041	0.031	0.025	0.002
0.071	14.000	0.046	0.036	0.029	0.002
0.083	12.000	0.054	0.042	0.033	0.002
0.100	10.000	0.065	0.050	0.040	0.003
0.125	8.000	0.081	0.063	0.050	0.004
0.167	6.000	0.108	0.083	0.067	0.005
0.250	4.000	0.163	0.125	0.100	0.007
0.500	2.000	0.325	0.250	0.200	0.015
1.000	1.000	0.650	0.500	0.400	0.029
1.250	0.800	0.813	0.625	0.500	0.037
1.667	0.600	1.083	0.833	0.667	0.049
2.500	0.400	1.625	1.250	1.000	0.073
5.000	0.200	3.250	2.500	2.000	0.146
10.000	0.100	6.500	5.000	4.000	0.292
20.000	0.050	13.000	10.000	8.000	0.585
40.000	0.025	26.000	20.000	16.000	1.170
80.000	0.0125	52.000	40.000	32.000	2.340
158.730	0.0063	103.175	79.635	63.492	4.641
312.500	0.0032	203.125	156.250	125.000	9.137
625.000	0.0016	406.250	312.500	250.000	18.273
1250.000	0.0008	812.500	625.000	500.000	36.550
2500.000	0.0004	1625.000	1250.000	1000.000	73.099
5000.000	0.0002	3250.000	2500.000	2000.000	146.199
10000.000	0.0001	6500.000	5000.000	4000.000	292.398

*At 25°C

1 grain / gallon = 17.1 ppm as $CaCO_3$

*At 25°C, given specific conductance values included in this table

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Considerations in Making Accurate pH Measurements in High Purity Water

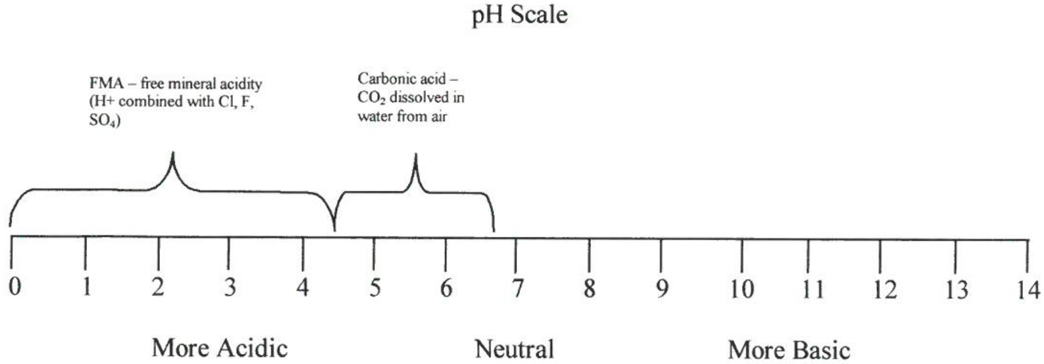
The acidity of alkalinity of water is measured by the relative concentration of positive hydrogen ions and negative hydroxyl ions. Water with equal concentrations of hydrogen and hydroxyl ions is considered neutral. When water has more hydrogen ions than hydroxyl ions, the water is considered acid. Conversely, when water is alkaline, there are more hydroxyl ions than hydrogen ions in water. pH is the expression of hydrogen ion concentration.

In order to verify the accuracy of any measurement, the expected results based on theoretical calculations must be known. This is especially true when evaluating a measuring instrument or device. Unfortunately, pH in high purity water is not well defined. A critical analysis of the physics of pure water shows that the true concentration of H+ in pure water at 25°C lies somewhere between 3.18×10^7 and 1.2×10^7 Mmol/l. The corresponds to a pH of 6.5 to 6.9, significantly less than the value of 7 usually assume for pure water.

Interferences can arise from a number of sources. The most common and well-known is CO_2 absorption from the environment (atmosphere). Other well known interferences include static charge build up resulting from the flow of the low conductivity water sample past the materials used to construct the sensor, the high impedances of the electrodes and sample, and the various temperature coefficients of the system's components. Others that are less understood or recognized are due to reference electrodes junction potential, contamination of the sample by the electrode's filling solution, and calibration errors.

The chief influence on low pH values in water is presence of carbon dioxide (CO_2) which when dissolved in water forms carbonic acid. CO_2 alone cannot make water more acidic than pH 4.5. If waters test below 4.5, a strong mineral acid is present. In nature, strong mineral acids typically occur as sulfuric acid originating from the oxidation of iron.

The best solution to measuring pH in high purity water is to experiment with settings that give the best consistent results. First, ask you probe supplier to provide his best unit for low ion/high purity water. Next, use your conductivity or resistivity meter to gauge in the pH meter. This can be done because water that is above 10,000,000 ohms-CM or 0.1 micromhos has to be between pH of 6.6 and 7.6 at 25°C.



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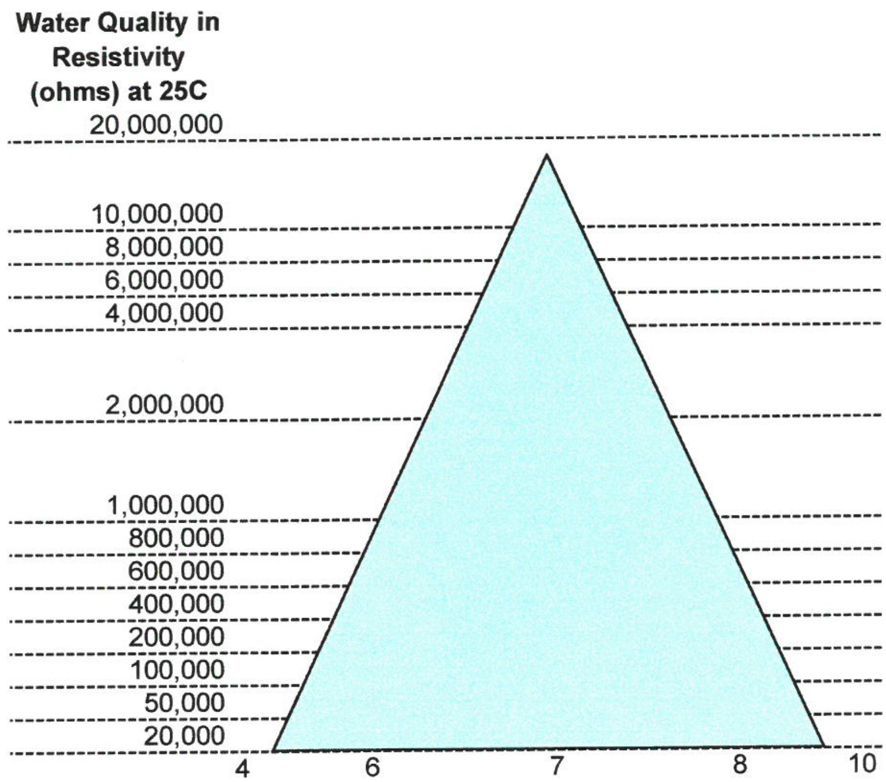
Limiting Theoretical pH Values



pH value of water at the given quality should fall into the shaded area.