PURETEC®
Industrial Water

DI Tank User Guide

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Table of Contents

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Introduction

All of us here at Puretec would like to thank you for trusting us with your high purity water needs. Ion exchange is a proven technology that has been around for many decades and we have nearly perfected the art of ion exchange regeneration at our facilities over the years. Quality is something that we are obsessed with and in today's world you should expect nothing less. However, we believe that the real value lies in how the ion exchange resins are delivered to our customers – without delay and by a delivery person who will not take any shortcuts.

Ion exchange can be used alone or in conjunction with other technologies such as reverse osmosis, UV and other technologies. Although this guide focuses only on ion exchange, we encourage you to reach out to us for more information on other water treatment technologies that we offer such as reverse osmosis, UV and all pre and post treatment equipment used in the production of high purity water for industrial and commercial use.

Thank you for choosing Puretec!

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The Basics of Ion Exchange

Ion exchange is a proven technology used to achieve ultra-pure water. It can be used alone or in conjunction with other technologies such as reverse osmosis. The extent of water treatment required depends on the end user's requirements and beginning feed water quality. Although this guide focuses only on ion exchange, we encourage you to reach out to us for more information and materials to further your water treatment education and understanding of other technologies available for high purity water production.

Background

Water is often called "the universal solvent" for a good reason. During the hydrological cycle, water encounters many substances and, to some extent, dissolves nearly everything that it encounters. For example, minerals are dissolved into water supplies through contact with the earth's layer. Gases such as C02 are absorbed into water from the atmosphere. A large assortment of bacteria thrives in water under almost any condition.

The tap water that we drink and bathe in is filtered to an acceptable level for human consumption, but dissolved minerals remain, and this is considered good for our health. However, when water is used as a rinse or ingredient in industrial applications, these dissolved minerals (and in some cases gases and living organisms) can be very detrimental and need to be removed or reduced from the water source before use. They can cause issues like scaling, corrosion, and product contamination.

There are different technologies available to reduce dissolved minerals in water. Reverse osmosis and distillation are other common methods. However, to produce highly deionized water, ion exchange has proven itself to be the most effective method.

What is an ion?

For simplicity sake, the minerals that water dissolves during the hydrological cycle are ions. These are extremely small atoms and molecules in water that have either a positive charge (cation) or a negative charge (anion). A mineral like calcium is a cation because it has a positive charge and conversely a mineral like carbonate is an anion because it has a negative charge. When calcium and carbonate combine, they form calcium carbonate which is a common scale. Ion exchange is used to prevent this from happening by exchanging calcium and carbonate for neutral ions that will not cause scaling.

Table of commonly found ions in a typical water supply	
Examples of Cations (+ charge)	**Examples of Anions (- charge)**
Calcium (Ca)	Bicarbonate (HCO3)
Magnesium (Mg)	Chloride (Cl)
Sodium (Na)	Sulfate (SO4)
Iron (Fe)	Nitrate (N)
Manganese (Mn)	Fluoride (F)
Potassium (K)	Silica (SiO2)

How does deionization work?

Deionization and demineralization mean the same thing and you will commonly hear them used interchangeably. We refer to our deionized tanks as "DI" tanks for short.

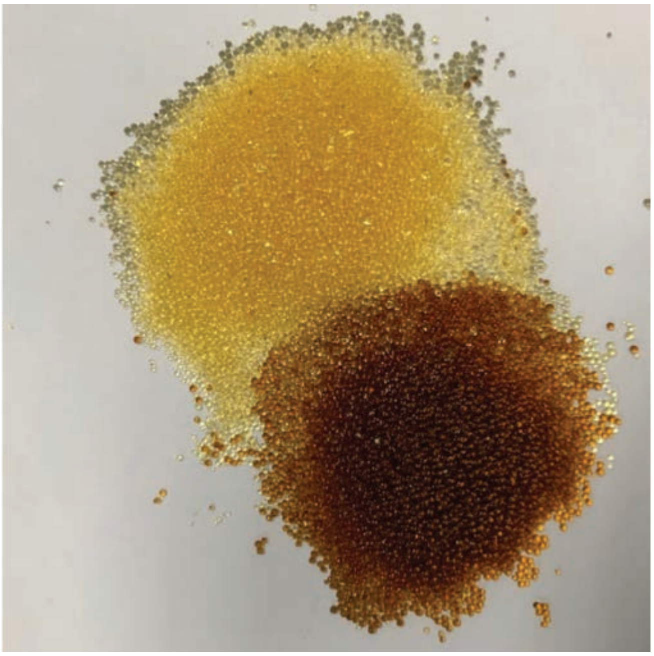
In simple terms, deionization is the removal of undesirable ions from water and works through a process called ion exchange. This process happens on small ion exchange resin beads pictured below.

Ion exchange is a chemical reaction in which unwanted ions are exchanged for harmless ions. For example, in a mixed bed tank, cations are exchanged for hydrogen (H+) and anions are exchanged for hydroxyl (OH-). These combine to form H20 that is free of undesired dissolved minerals. Ion exchange removes unwanted dissolved minerals based on their ionic charge rather than their size.

The ion exchange process is reversible, so when the ion exchange resin beads become saturated with undesired ions they can be regenerated and used again.

What types of ion exchange resins do we use?

There are five main classes of ion exchange resins: strong acid, weak acid, strong base (Type I), strong base (Type II), and weak base. There are other resin types for special applications for example chelating resins. At Puretec we use strong acid cation (both H+ and Na+ form), strong base anion (Type 1 in OH- form) and weak base anion resins (Free Base Form). Although not an ion exchange resin, we also use acid washed coconut shell granular activated carbon in some of our tanks.



Ion Exchange Resins: Ion exchange resins can be white, light yellow, tan, or dark amber in color. They vary from being odorless to an amine fish-like odor. The beads are very small, ranging in size from 0.3 to 1.2 mm in diameter.

What happens when water flows through a DI tank?

Water enters a DI tank and a screen helps distribute untreated water evenly over the ion exchange bed. As the water passes through the tank and encounters the ion exchange resin beads, the process of ion exchange takes place and the water becomes deionized. When the deionized water reaches the bottom of the DI tank it passes through a fine screen that allows the deionized water to pass but keeps the ion exchange resin beads behind.

Eventually the resin inside the tank is exhausted and sent back for regeneration. When to do this is determined by measuring the electrical conductivity (dissolved minerals conduct electricity) or other methods determined by the end user. We will discuss this more in detail later.

Fortunately, ion exchange is a reversible process. During regeneration, the ion exchange resins are 're-generated' using a process of chemical regeneration, cleaning and rinses before being reintroduced into the DI tanks and returned to our customers.

It's important to note that ion exchange does not remove everything from water. It will not remove bacteria, viruses, dissolved organic chemicals or particulates and for this reason there are other technologies that we offer such as activated carbon (GAC), reverse osmosis (RO) and ultraviolet irradiation (UV) that are often times used in conjunction with ion exchange depending on the end use quality requirements.

How are ions measured in water?

Ions conduct electricity. Electrical current passes through water using ions as stepping-stones to pass current from one conductive ion to another. As a result, by measuring the electrical conductance of water can tell us what the ionic content of the water is. Fewer 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.

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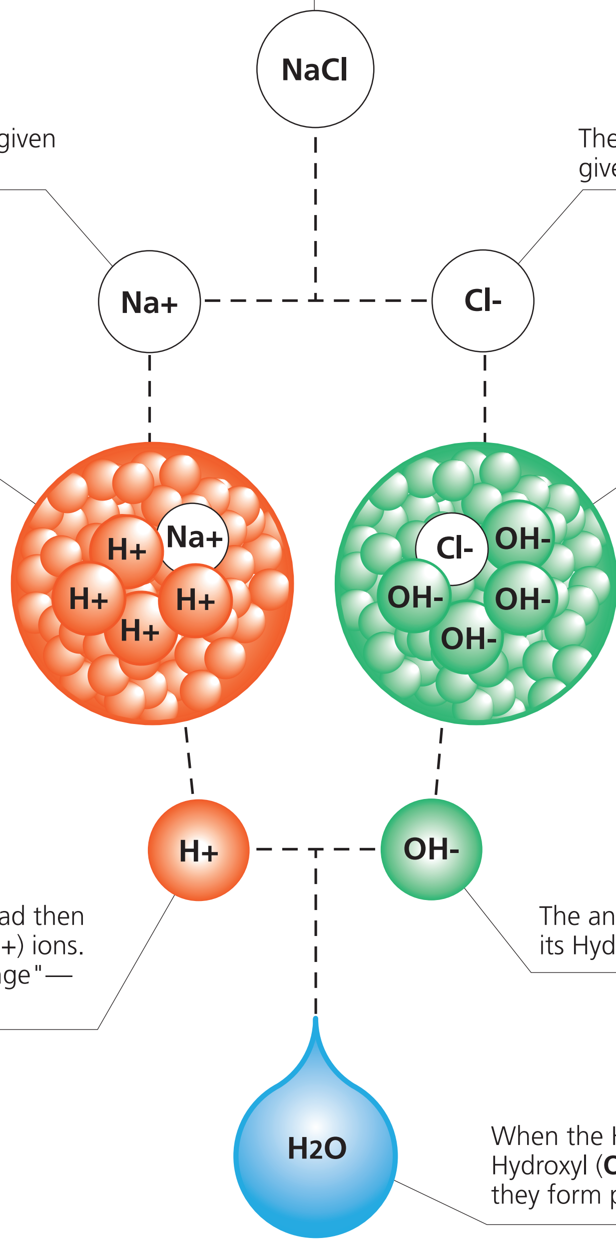
The Basics of Ion Exchange

NaCl or Sodium Chloride is a common salt. When dissolved in water, NaCl dissociates into its ion components, **Na+** (sodium) and **Cl-** (chloride).

The sodium ion represents any given ion that has a positive charge.

The chloride ion represents any given ion that has a negative charge.



Strong acid cation ion exchange bead in the Hydrogen form

Each small cation bead has millions of exchange sites. An exchange site has a fixed negative charge and a mobile positive charge (in this case Hydrogen, expressed as **H+**). When a positively charged ion, like sodium, encounters the cation resin bead, the sodium is attracted to the fixed negative charge (+ attracted to -) on the resin bead and sticks to it.

Strong base anion ion exchange bead in the Hydroxide form

Each small anion bead has millions of exchange sites (just like the cation bead). However, on an anion bead, the fixed exchange sites are positive and the mobile charge is negative (**OH-**, or Hydroxl). When a negatively charged ion, like chloride, encounters the anion resin bead, the chloride is attracted to the fixed negative charge on the resin bead and sticks to it.

Immediately the cation resin bead then gives up one of its Hydrogen (H+) ions. This is the basis for "ion exchange"— one ion is given up for another.

The anion bead then gives up one of its Hydroxy (OH-) ions.

When the Hydrogen (**H+**) and Hydroxyl (**OH-**) ions meet up, they form pure water, **H2O.**

Although this process is fairly simple in concept, its application is complicated by variables in raw water composition, treated water quality requirements, resin selection and condition, chemical dosages and control system requirements.

The Basics of Water Softening

What is "hard" water?

Water described as "hard" contains high levels of dissolved calcium and magnesium. Groundwater obtains these metals by dissolving them from surrounding soil and rock.

What problems are caused by hard water?

Hard water can cause costly breakdowns in boilers, cooling towers and plumbing. Hard water can also lessen the effectiveness of soap. When hard water is heated, the carbonates precipitate out of solution, forming a scale in pipes and surfaces. This scale is composed of mostly calcium carbonate, calcium sulfate, magnesium carbonate and magnesium sulfate. The resulting scale can end up completely plugging pipes and restricting flow. In boilers the scale prevents efficient heat transfer and will have to use a lot of energy to provide hot water and can cause metal boiler components to overheat. Soap is less effective in hard water because it reacts to form the calcium or magnesium salt of the organic acid of the soap.

How is hard water treated?

Water is made soft by the use of a water softener using ion exchange resin. The troublesome calcium and magnesium ions in hard water are exchanged for sodium, which is much more soluble and does not precipitate out to form scale or interfere with soap.

Ion exchange resins are very small porous round plastic beads. For water softening applications, the polymer structure of the resin bead contains a fixed negative ion that is permanently attached. This cannot be removed. In simple terms, the resin bead has a fixed negative charge. Each negatively charged exchange site can hold a positively charged ion. In this case, sodium (which has a positive charge) is attached to the exchange site (negative and positive charges attract – think of magnets)! In the end you have a mobile sodium ion attached to each of the fixed negative charges on the resin bead.

When hard water is passed through the resin bead, the calcium and magnesium ions have a stronger positive charge than sodium does. As a result, the calcium and magnesium have a stronger attraction to the negatively charged resin bead than sodium does. The sodium ion is then 'kicked off' the resin bead as the calcium and magnesium take its place (and remains attached to the bead). As a result, the less desirable calcium and magnesium ions are exchanged for more desirable sodium ions. It is important to note that the salinity of the water does not change; it is simply an exchange of one salt for another.

Eventually, the resin beads become saturated with hardness such as calcium and magnesium and there are no more exchange sites left to produce soft water. The resin beads have reached exhaustion and must be regenerated.

How does regeneration work?

In simple terms, the ion exchange resin is soaked in a strong solution of sodium chloride (brine) where the sheer volume of brine solution causes the calcium and magnesium ions in the resin beads to become dislodged. At the same time, the sodium in the brine solution again becomes affixed to the resin bead. After regeneration, the excess brine and hardness causing ions are rinsed to drain and the resin beads are ready for use again.

Exchange Tank Guide & Color Codes

Unit Designation	8″ Fiberglass	10″ Stainless	10″ Fiberglass	14″ Fiberglass	14″ Stainless	Flomax 37	Flomax 45
Volume	0.5 ft³	1.6 ft³	1.6 ft³	3.6 ft³	3.6 ft³	37 ft³	45 ft³
Weight	37 lbs	148 lbs	135 lbs	303 lbs	316 lbs	3120 lbs	3790 lbs
Footprint	8″	10″	10″	14″	14″	40″	43″
Height w/ Fittings	23″	42″	45″	50″	50″	96″	96″
Inlet Connection	1″ Fem Union	1″ Fem Union	1″ Fem Union	1″ Fem Union	1″ Fem Union	2″ Fem Camlock	3″ Fem Camlock
Outlet Connection	1″ Male Union	1″ Male Union	1″ Male Union	1″ Male Union	1″ Male Union	2″ Male Camlock	3″ Male Camlock
Operating Psi (max)	80 psi	80 psi	80 psi	80 psi	80 psi	80 psi	80 psi
Temperature Rating	80° F	180° F	80° F	80° F	180° F	80° F	80° F
Optimum Flow (GPM)*	1 to 2 GPM	2 to 8 GPM	2 to 8 GPM	3 to 20 GPM	3 to 20 GPM	35 to 120 GPM	45 to 200 GPM

*Lower flows can be achieved with a recirculation system and different flow rates will be suitable for medias other than ion exchange resins

Colored electrical tape is wrapped around the top neck or outlet fitting to designate what type of ion exchange resin is inside the tank.

Strong Acid Cation (H+ Form) | Strong Acid Cation (Na+ Form) | Strong Base Anion (OH- Form) | Weak Base Anion (Free Base Form) | Mixed Bed | Mixed Bed Polisher | Granular Activated Carbon

	Red	Black	Yellow	Green	Brown	Blue	Clear (no tape)
Resin Type	Strong Acid Cation (SAC) in Hydrogen Form	Strong Acid Cation (SAC) in Sodium Form	Strong Base Anion (SBA) in Hydroxide Form	Weak Base Anion (WBA) in Free Base Form	Mixed Bed Resin (contains both SAC and SBA)	Mixed Bed Resin (contains both SAC and SBA)	Granular Activated Carbon (GAC)
Commonly Referred to As	"C" or "Cation" Tank	"Sodium C" or "Softening Tank"	"S" or "Strong Base Tank"	"W" or "Weak Base Tank"	"M" or "Mixed Bed Tank"	"P" or "Polisher Tank"	"GAC" or "Carbon Tank"

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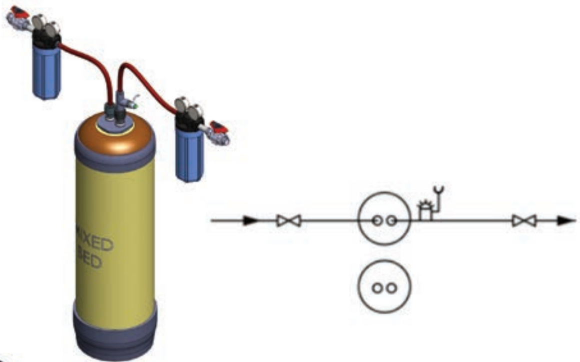
DI Tank Configurations

We will discuss common tank arrangements and configurations that you will see in the field. Tanks are chosen and set up in a way that optimizes the flow and quality requirements that the customer needs. There are 4 types of flow configurations that depend on what quality and flow requirements are required:

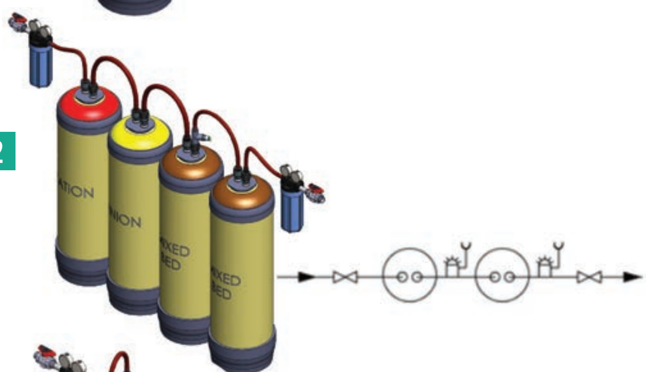
1



1. Single Tank with Standby

Water goes in one tank and out. This is used in applications where quality is not important, and the customer is not concerned about running out of water. Many times, there will be a standby tank in place as a backup for when the tank online exhausts.

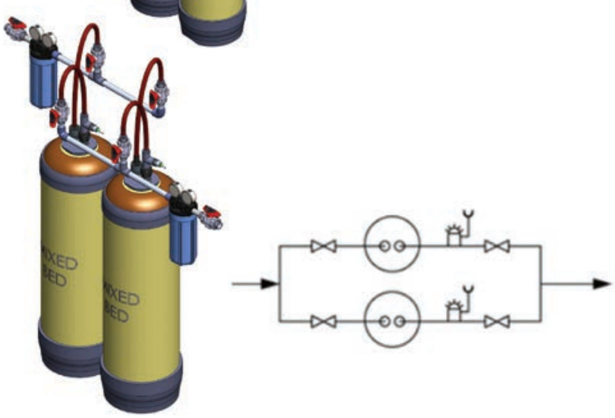
2



2. Series

Water goes in one tank and out to another tank. This configuration increases the water quality since each tank in series will "polish" and improve the quality of the water as it passes through. This setup adds redundancy as well because when the first tank in series exhausts you still have the second tank as backup. The first tank in series is called the "Lead" tank and the second tank in series is called the "Lag" tank. When the lead tank exhausts, you remove the lead tank and move the lag tank into the lead position. Then you put the fresh bottle in the lag position and make water again. For dual bed applications such as a SAC-WBA or SAC-SBA it is important to place the Strong Acid Cation (SAC) in the lead position otherwise the water created will be extremely acidic.

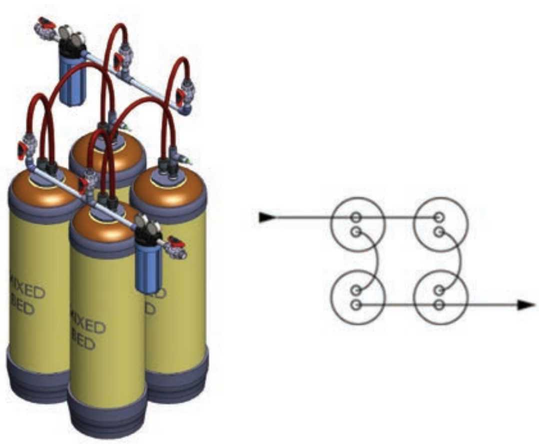
3



3. Parallel

The reason this configuration is to handle larger flow requirements. The flow can be distributed among additional tanks. For example, if the customer needs 30 gpm, this is too much flow for (1) 14" tank so you can split up the flow between (2) 14" tanks so each one will receive 15 gpm flow.

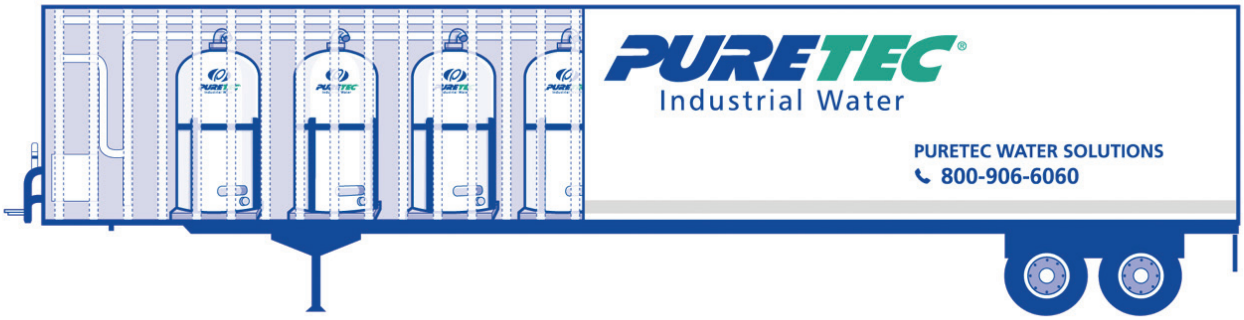
4



4. Series/Parallel

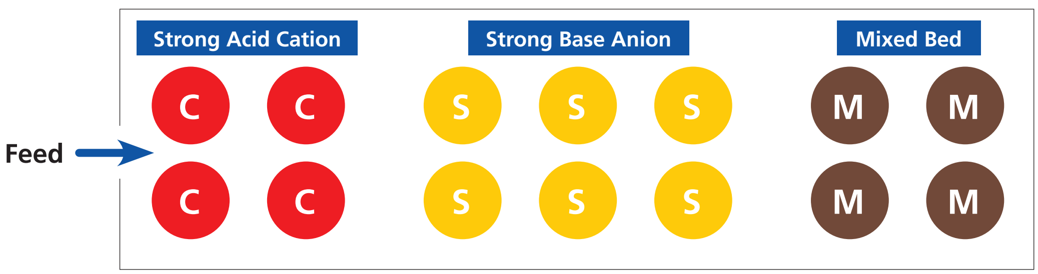
This configuration provides the benefits of series (better quality and redundancy) with parallel (able to handle more flow).

Mobile DI Trailers



A mobile DI trailer provides deionized water for large flow applications (up to 400 gpm per trailer) and has systems in place to protect against power failure, excess pressure and out of spec water conditions. Furthermore, each trailer can be remotely monitored for quality and location and an internal heater can be provided for cold weather operation.

Each mobile DI trailer has (14) 45 cft3 Flomax DI tanks inside which provides 630 cft3 of ion exchange capacity. The tank type and arrangement are shown below. Each bank contains (2) Strong Acid Cation Flomax, (3) Strong Base Anion Flomax and (2) Mixed Bed Flomax. Each bank can be ran separately or both together at the same time.



Mobile DI Trailer Capacity	
Feedwater Conductivity µs	**Estimated Mobile DI Capacity (gallons) with 1µs endpoint**
10	16,758,000
50	3,351,600
100	1,675,800
200	837,900
300	558,600
400	418,950
500	335,160
600	279,300
700	239,400
800	209,475
900	186,200
1,000	167,580
1,100	152,345
1,200	139,650
1,300	128,908
1,400	119,700
1,500	111,720

Specifications	
Nominal Exchange Capacity (kgr)	8,000+
Flow Rate (gpm) min/max	50/400
Inlet Pressure (psig) min/max	40/80
Inlet /Outlet Connections	2-1/2” Minimum
Weight (lbs) shipping/operating	60,845/82,302
Dimensions—L x W x H	53’ x 8.5’ x 13.5’
Trailer Electrical Requirements	(2) 115 V, single phase, 60 hz, 10 amps
Instrumentation	Conductivity on feed and effluent; flow indicator and flow totalizer; pressure gauges and quality sample ports
Typical Water Service Quality	Conductivity 0.056µs Silica Leakage <10ppb

*Based on 1µs/cm end point

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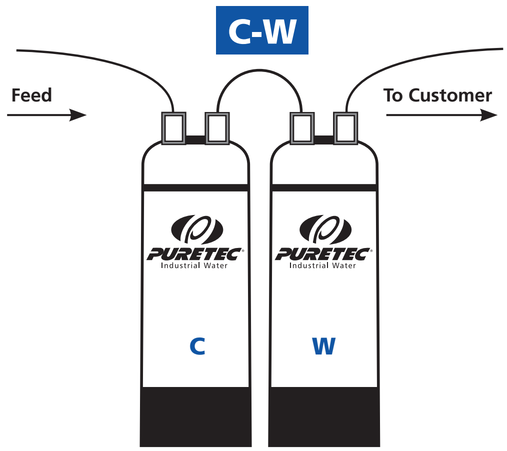
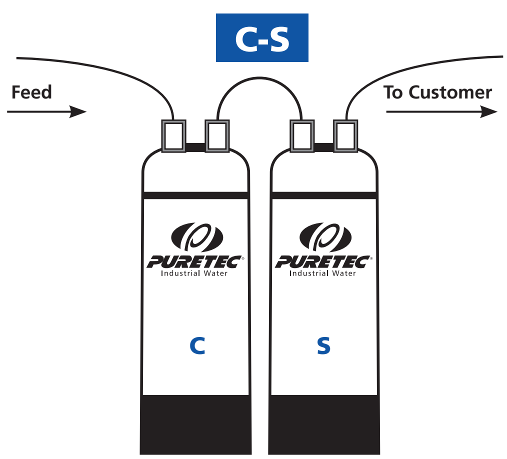
Quality Configurations

Below are common tank arrangements to meet different quality criteria. We'll also explore examples of installations and explain the purpose of each type of equipment.



C-W	
Typical Quality	
Resistivity	50K Ohms-cm^3
Conductivity	20 Microseimens
TDS (Total Dissolved Solids)	10 parts per million
Grains per Gallon	0.6 GPG
pH	5.5
Quality Light	20K
No Silica or CO2 removal.	



C-S	
Typical Quality	
Resistivity	125K Ohms-cm^3
Conductivity	8 Microseimens
TDS (Total Dissolved Solids)	4 parts per million
Grains per Gallon	0.2 GPG
pH	8.5
Quality Light	20K
CS will significantly reduce or remove Silica and CO2.	

C-W

A C-W set consists of a "C" which is a tank filled with Strong Acid Cation resin (H+ form) followed by a "W" which is a tank filled with Weak Base Anion (Free Base form). A C-W set produces an average water quality of 50K resistivity or 20 micromhos conductivity or 10ppm TDS depending on which unit of measure you choose. The pH will be slightly lower than average (around 5.5) due to the fact that a C-W set does not remove the weak acids produced by the C tank. Also, a C-W does not remove silica or CO_2.

A C-W is a good choice for a customer who needs a large volume of water at resistivity levels much lower than a mixed bed and can operate with lower pH values and unchanged silica and CO2 in the product water. Furthermore, a C-W is ideal for feed waters with low alkalinity (low acid absorbing capacity) or when the Free Mineral Acidity (the sum of the chloride, sulfate, nitrate which are in the acid form, i.e. HCl, H2SO4, HNO3, respectively) is greater than 60% of the total anions.

C-S

A C-S set consists of a "C" which is a tank filled with Strong Acid Cation resin (H^+ form) followed by a "S" which is a tank filled with Strong Base Anion (OH^- form). A C-S set produces an average water quality of 125K resistivity or 8 micromhos conductivity or 4ppm TDS depending on which unit of measure you choose. The pH will be slightly higher than average (around 8.5) due to the fact that a C tank will inevitably have a small amount of sodium leakage. Sodium leakage occurs when the sodium (Na^+) ion is unable to exchange for the hydrogen (H+) ion on the cation resin in the C tank. The sodium then passes through to the S tank where the sodium combines with hydrxoide (OH-) and produces sodium hydroxide (NaOH) which is a caustic base. This results in a higher than average pH and lower resistivity (compared to a mixed bed). However, a C-S produces higher resistivity water than a C-W set since a C-S set removes silica and CO2, whereas a C-W set does not.

A C-S is a good choice for a customer who needs a large volume of water at resistivity levels higher than a C-W set and can operate with the higher pH values. Furthermore, a C-S is often used before a mixed bed to remove a large portion of dissolved solids and then let

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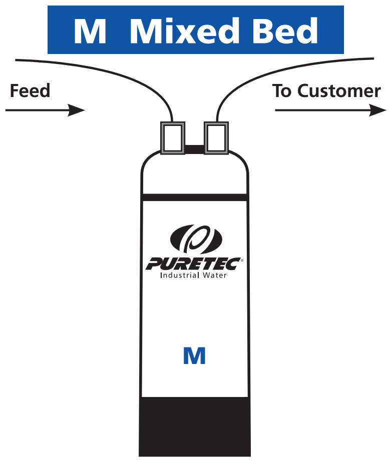
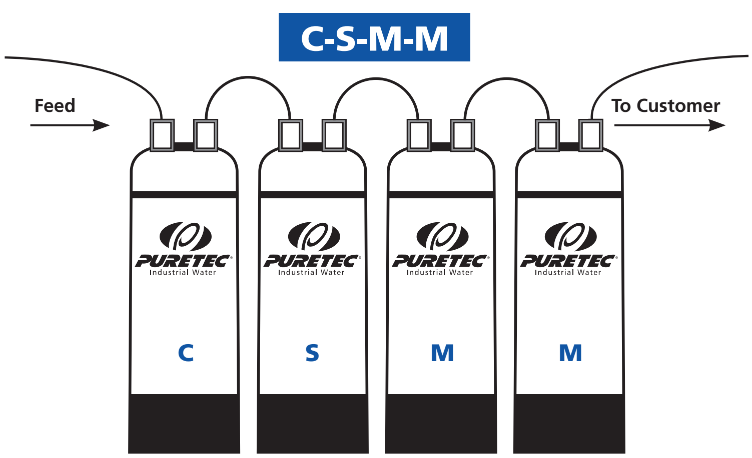


M Mixed Bed	
Typical Quality (Depends on Feedwater)	
Resistivity	Up to 18.2 Ohms-cm^3
Conductivity	Down to 0.056 Microseimens
TDS (Total Dissolved Solids)	Down to 0.028 parts per million
pH	Neutral at 18.2 Ohms-cm^2
Quality Light	200K or 1 Meg or Inline Meter
A Mixed Bed consists of 60% strong base anion and 40% strong acid cation.	



C-S-M-M	
Typical Quality	
Resistivity	Up to 18.2 Ohms-cm^3
Conductivity	Down to 0.056 Microseimens
TDS (Total Dissolved Solids)	Down to 0.028 parts per million
pH	7
Quality Light	A 20K after the C-S, and a 1Meg light after the 1st Mixed Bed (M). Inline Resistivity Meter after 2nd Mixed Bed.
The first M in this set is the lead and the second is the lag.	

the final mixed bed polish the water to a much higher resistivity by removing whatever small amount of dissolved solids remain.

Mixed Bed

A mixed bed combines both strong acid cation resin (H+ form) and strong base anion resin (OH- form) into one tank. By combining C and S resin together, the feed water going through the tank will exchange cations and anions many times over and over, whereas with a C-S set the exchange only happens once. This solves the sodium leakage issue that C-S sets have and results in a much higher resistivity value.

When a RO or C-S set is placed before a mixed bed it will produce extremely pure water up to 18.2 megohm resistivity or 0.055 micromhos conductivity or 0.03 TDS ppm depending on which unit of measure you choose. The pH will be neutral at this level of purity although it will can be challenging to measure and verify pH at higher resistivity levels due to atmospheric contamination. When exposed to air, deionized water will absorb carbon dioxide (CO_2) in the atmosphere and it is quickly converted to carbonic acid (H_2CO_3) which will result in a lower than average pH reading.

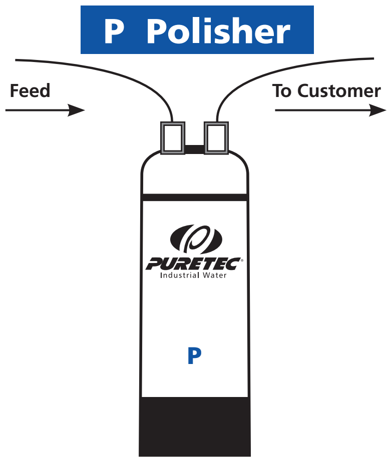
When a mixed bed is used alone and does not have any partial demineralization before the tank, the resulting quality is higher than a C-S set but various depending on the incoming water quality to the mixed bed. Like any ion exchange tank configuration, the amount of water and the quality of the water that a mixed bed produces will all depend on the feed water entering the tank

A Mixed bed tank is a good choice for a customer who needs a consistent, dependable supply of ultra-pure deionized water.

C-S-M-M

A C-S-M-M set produces an excellent water quality of up to 18.2 Megohm resistivity (0.055 micromhos conductivity or 0.03 ppm TDS) depending on which unit of measurement you choose. The pH will be neutral at a high resistivity. The C-S portion of the system removes the bulk of dissolved solids including silica and CO_2 and the two mixed beds on the end provide a final polish while also maintaining a certain level of redundancy to make sure you don't run out of deionized water.

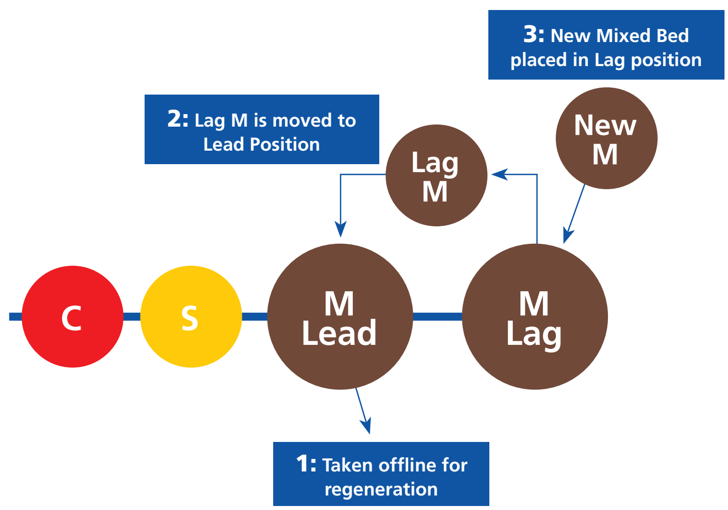
A C-S-M-M set must be carefully monitored for optimal performance and output. Quality lights are placed after the C-S and the first mixed bed to determine when they should be taken offline. Typically, an inline resistivity probe is placed after the final mixed bed to obtain a high value resistivity reading and likewise determine when the final mixed bed should be removed. The two mixed beds



P Polisher	
Typical Quality (Depends on Feedwater)	
Resistivity	Up to 18.2 Ohms-cm³
Conductivity	Down to 0.056 Microseimens
TDS (Total Dissolved Solids)	Down to 0.028 parts per million
pH	Neutral at 18.2 Ohms-cm²
Quality Light	Usually 200K or 1 Meg
A Polisher is a Mixed Bed that always goes after dual or triple layers of demineralization.	

after the C-S tanks are rotated in a lead-lag arrangement. The lead is the first mixed bed after the C-S and the lag is the final mixed bed tank in the series. When the lag mixed bed is taken offline it is usually done so at a high resistivity value (17.5 megohm for example). However, the lead mixed bed in the series (immediately after the C-S) is taken offline once the tank drops below 1 megohm resistivity. Since the lag mixed bed still has a relatively high resistivity value and has the capacity to remove more dissolved solids, it will be rotated to the lead position and the mixed bed that was previously in the lead position will be taken offline and regenerated. A new mixed bed tank will be placed in the lag position and then the system is put back online. Sometimes the lead tank will also be called the worker tank and the lag tank will be referred to as the polisher.

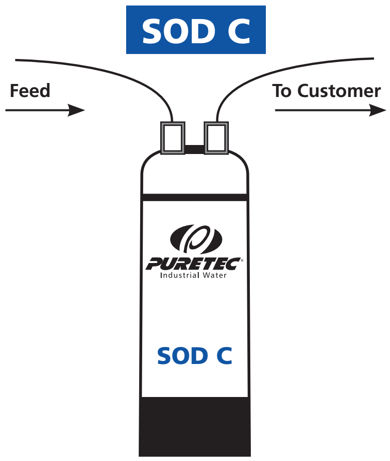
A C-S-M-M is a good choice for a customer who needs a very reliable source of ultra-high purity deionized water with redundancy to handle significant changes in demand and feed water chemistry.



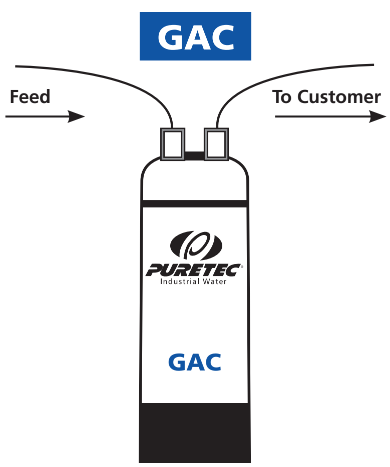
POLISHER

A polisher is a mixed bed that goes through additional regeneration steps to ensure the highest possible quality and capacity as well as resin isolation, dedication and traceability. A polisher is always placed after two or more layers of demineralization such as reverse osmosis followed by mixed beds. The polisher will pick up any remaining dissolved solids that the RO and mixed beds failed to exchange. As a result a polisher can often last for a very long time at 18.2 megohm resistivity before requiring an exchange.

A polisher tank is a good choice for a customer who demands ultra-pure deionized water for critical applications (such as biotech and pharmaceutical) and the isolation, dedication and traceability from a cGMP regeneration facility.



SOD C	
Typical Quality (Depends on Feedwater)	
Grains per Gallon	0 GPG
Parts per Million Hardness	Less than 2
A SOD C tank is good for removing Calcium and other "Hardness" causing minerals from feed water.	



GAC
Typical Quality (Depends on Feedwater)
Removes organics, chloramine and chloramines
A pound of GAC has more than 35 acres of surface—nearly 100 football fields.

SODIUM C

A sodium C, or SOD C, tank is a softening tank and is filled with strong acid cation resin in the sodium (Na^+) form. A softener only removes hardness causing dissolved solids such as calcium and magnesium and exchanges these ions for sodium. A softener produces water less than 2 ppm hardness. A Sodium C will not change resistivity, conductivity or TDS values and actually might increase them since sodium is a very conductive ion.

Any customer who requires soft water, from boiler feed water applications to large laundry facilities, is a perfect candidate for soft water. Many times a SOD C tank will also be placed before an RO to prevent scaling on the RO membrane.

Granular Activated Carbon (GAC)

GAC is not a type of ion exchange resin but rather a media that is used for chlorine/chloramine and organic removal. A GAC is sometimes placed before an ion exchange system to reduce organics and/or chlorine/chloramines before the ion exchange tanks. GAC is also used before a RO system to remove chorine/chloramines since these oxidizers can damage RO membranes.

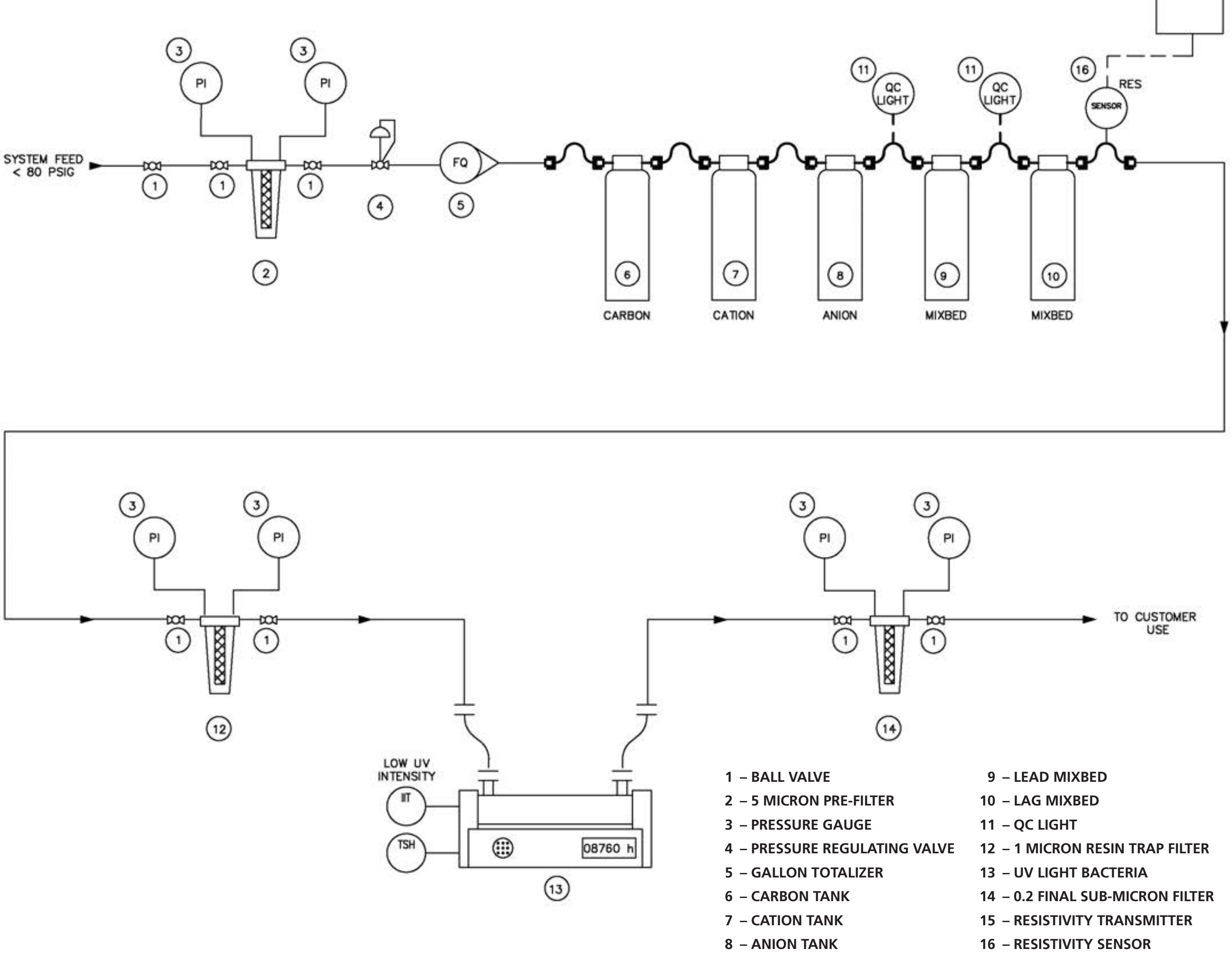
GAC reacts very quickly with chlorine and converts it to CO2. A GAC also removes organics, but not as quickly. A gram of carbon contains a huge surface area which allows molecules in the feed water to diffuse into the GAC and stay. Organic molecules with a molecular similarity to the aromatic rings of the carbon walls will literally stick to them. For this to happen, the water must have enough contact time with the GAC to remove organics, so the feed rate must be slow for organic removal to take place. For chlorine removal, GAC does not require much contact time as it is almost instantaneous. However, for chloramine removal, this process takes more contact time.

GAC is either steam cleaned or replaced when no longer suitable for use. It is important to use a high-quality pre-acid washed carbon from a reputable supplier. Coconut shell carbon is plant based and tends to be cleaner than other types of GAC. This is important since dirty GAC can bleed carbon dust that will foul RO membranes and other downstream equipment. It is a good idea to rinse a GAC to drain after transport to a customer's facility since the carbon dust will shake loose during the drive.

GAC will remove chlorine/chloramines at the top layer of the bed and the remainder of the GAC bed will capture organics. This can pose a problem since the bottom part of the bed will be saturated with organics and no oxidizer such as chlorine will be available to prevent their growth. If GAC is used before a RO system, it is a good idea to monitor organic levels after the GAC to prevent biofouling on the RO membranes.

Process Diagram for Typical DI System

The following PI&D shows an example of a DI system and their respective components. Not all systems are designed the same way and numerous different design layouts are possible. This is just an example to walk through step by step and understand the purpose of each component in the system.



1: Feed water goes through a ball valve. A ball valve is needed to turn off water to the system for tank exchanges or other purposes.

2: A 5 micron filter helps remove any debris in the feedwater.

3: Pressure gauges on the inlet and outlet of the 5 micron filter housing help determine when the filter is plugged and should be replaced.

4: A pressure regulator is placed before the DI tanks to make sure the pressure does not exceed 80 psi.

5: A gallonage totalizer is an optional component to track how many gallons of water goes through the DI system.

6: Ideally a carbon tank (GAC) is placed before the DI tanks to remove organics and any oxidizers.

7: The cation tank exchanges cations for hydrogen.

8: The anion tank exchanges anions for hydroxide. At this point you have deionized water that is less than 1 megohm.

9: The lead mixed bed removes any remaining dissolved solids that the cation/anion tanks could not. At this point you have deionized water greater than 1 megohm.

10: The lag mixed bed further removes any remaining dissolved solids that the lead mixed bed could not. At this point you have high quality deionized water in the range of 15-18.2 megohm.

11: Quality lights are placed after the anion tank to measure water quality. Typically the light is green (or lit) to indicate the water is above a set resistivity point. Oftentimes a 20K resistivity light is placed after the anion tank. Once the quality light turns red (or off) this indicates that the cation-anion tanks need to be replaced with fresh tanks. A 1 megohm quality light is usually placed after the lead mixed bed to determine when the lead mixed bed should be taken offline and replaced.

12: The 1 micron post filter resin trap is important to have in place to catch any resin fines that might escape the DI tanks and end up in downstream equipment.

13: A UV Light is used in systems that need to reduce microorganisms in their DI water. A UV system does not remove microorganisms, but rather alters their DNA making them unable to reproduce.

14: The 0.2 Final sub-micron filter captures these inert microorganisms from the UV system.

15: The Resistivity transmitter displays the actual resistivity reading of the water after the lag mixed bed.

16: The Resistivity sensor is placed inside the pipe and accurately measures the resistivity of the water after the lag mixed bed. The resistivity sensor is connected to the resistivity transmitter.

Measuring Water Quality

For the sake of simplicity, water contaminants can be simplified into two groups: suspended solids and dissolved solids. Ion exchange is intended to treat dissolved solids so we will focus on that in this section.

Conductivity

The most efficient way to measure dissolved solids in water is by measuring the electrical conductivity since dissolved solids (cations and anions) are very conductive. If water has very little dissolved solids, then the electrical conductivity will also be low.

Conductivity meters for measuring water quality compensate for temperature variations and come in a variety of models from portable handheld units to units that are plumbed into a system. The unit of measurement for conductivity is microsiemens (μS) and the lowest possible conductivity reading for water is 0.055 μS.

For example, a water sample that measures 500 μS contains more dissolved solids than a water sample that contains 200 μS.

Measuring the electrical conductivity of water will not tell you what type of ions are present in the water; it will only provide the total sum of their electrical conductivity. Some ions are more conductive than others and TDS can't distinguish which ions are in the water. There are specific ion analyzers available that can measure individual ions if that is needed. For example, the power industry will have separate analyzers that measure silica as an individual ion.

Resistivity

Not everyone prefers to use conductivity as a water quality measurement. Other prefer to measure water quality in resistivity or TDS (Total Dissolved Solids).

Resistivity is simply the inverse of conductivity and is measured in ohms. Dissolved solids in water are good at conducting electricity and likewise they provide little resistance to electricity. This means that a high resistivity value would translate into a low conductivity value. Therefore, as water purity increases then it will have lower conductivity and higher resistivity values.

The unit of measurement for resistivity is ohms (Ω). For example, water that has a resistivity of 10,000,000 ohms is purer (has less dissolved solids) than a water sample that is 8,000,000 ohms. We often remove the zeros and report "Megohms" or "Kohms".

TDS

Some instruments report values in TDS (Total Dissolved Solids). A lower TDS value translates into water with less dissolved solids.

The TDS meter is first measuring conductivity and then converting that into TDS. This is a shortcut that has its flaws. TDS should really be determined by gravimetric testing which involves evaporating the water sample in a laboratory and measuring the residual mass that is left behind. That method is inconvenient though, so we correlate conductivity values to TDS.

The unit of measurement for TDS is parts per million (ppm) or milligrams per liter (mg/L). When measuring very small amounts of dissolved solids they can be expressed in parts per billion (ppb) and micrograms per liter (μg/L).

Measuring hardness for water softening applications

Hardness in water refers to certain dissolved solids like calcium and magnesium that consume soap and cause scaling in low pressure boilers and water heaters. Hardness is removed through a water softener.

Water hardness is expressed in either parts per million (ppm) or grains per gallon (gpg). There is 17.1 ppm for every grain of hardness. So if the water sample has 2 grains of hardness then that equals 2 x 17.1 = 34.2 ppm of hardness.

The more hard water is, the higher the hardness grains or ppm will be. For example, a water sample with 2 grains of hardness is harder than a water sample with 1 grain of hardness.

Note: A water softener reduces hardness but does not reduce total dissolved solids (TDS) or conductivity or resistivity!

Water hardness can be measured in several ways. The most common methods we see are a simple drop-count titration test or a continuous hardness analyzer that samples continuously.

There is no universal agreement on what exact hardness value is considered "soft", however the Water Quality Association has the following guidelines.

Water hardness for water softening application guidelines

Classification of Hardness	Mg/L	gpg
Soft	0-17	0-1
Slightly Hard	17-60	1-3.5
Hard	120 – 180	7 – 10

pH and deionized water

The pH of a typical water solution can be measured in many ways. The most common method involves a pH sensitive glass electrode, a reference electrode and a pH meter. This is the best method for precise and continuous measuring. Other methods include color changing pH paper, pH handheld meters and colorimeters that use a reagent mixed with the water sample to produce a color that is then compared to a color wheel to determine the pH value.

Measuring the pH of deionized water is very problematic. Using a handheld or bench unit can lead to skewed values due to changes in ionic strength and buffer capacity. It is best to infer the pH value of water by referencing the resistivity measurement of the deionized water. A water resistivity value of 18.2 Megohm will translate into a neutral pH of 7.

Bacteria

Ion exchange tanks are a perfect breeding ground for bacteria and other biological growth. If biocontamination is a concern then additional tools such as ultraviolet irradiation (UV), piping materials of construction, final filtration, elimination of dead legs and flow design considerations should be considered to help keep bio growth to a minimum.

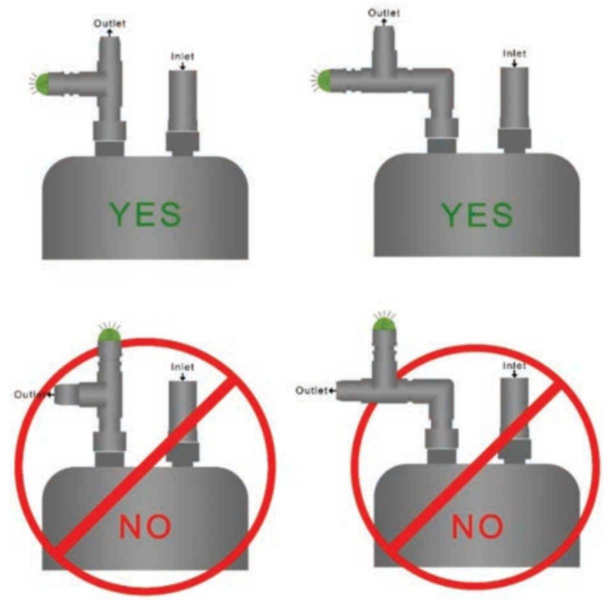
The most common method for measuring bacteria in water is using the Heterotrophic (Standard) Plate Count (HPC) method.

The heterotrophic plate count is a procedure for estimating the number of live bacteria in water and is expressed as colony forming units per milliliter (cfu/ml). It is an indicator for the effectiveness of any treatment/disinfection system in place.

Total Organic Carbon

Measuring TOC (Total Organic Carbon) involves determining the number of carbon-based contaminants found in a water sample. TOC may come from a large number of sources such as plastic based derivates, PVC glue, alcohol, decaying plant matter and sugars to name a few. The presence of TOC's indicates that organics may exist in water and these organics are a food source for bacteria. Organics may also result from the formation of biofilms in the water system. Therefore, TOC is often used as a non-specific indicator of water quality or cleanliness. Ion exchange tanks do not reduce TOC and likely contribute to higher TOC values.

Ion exchange tanks do not remove uncharged organic compounds and Granular Activated Carbon (GAC) tanks collect and eventually can throw off high TOC values. TOC values are reduced by using a UV system with a 185 nm lamp that decomposes organic molecules into carbon dioxide and water. A granular activated carbon (GAC) tank also reduces TOC levels but is not as effective as a UV 185 nm unit.



This diagram shows the proper installation method for quality lights.

Quality Lights

Most DI tank installations use quality lights to determine water quality and come in different end points including 20 Kohm, 50 Kohm, 200 Kohm, 500 Kohm, 1 Megohm, 2 Megohm and 5 Megohm resistivity. Monitoring a quality light is simple – if the quality light is on (or green) this indicates that the resistivity of the water is above the threshold value (endpoint) listed on the quality light. For example, if you have a 1 Megohm quality light after a DI tank and the light is on (or green on some models) then that means the water is greater than or equal to 1 Megohm but does not give a specific value.

Some quality lights have a light on (good) or light off (bad) function and others have a green (good) or red (bad) function.

Important notes on quality lights

A quality light requires water to be flowing across the unit to operate effectively.

A quality light is prone to failure and should not be used a primary indicator for critical DI water applications. Redundant meters should be used in conjunction with a quality light such as an inline resistivity monitor and/or confirmed with handheld resistivity meters to confirm accuracy.

Quality lights can malfunction. Some common problems include electrodes that corrode from water exposure and burned out bulbs. See troubleshooting section in this manual for more details.

The diagram to the left shows the proper installation method for quality lights. This will help prevent air pockets to form around the quality light's electrodes which will result in false positives.

Preventing water leaks and resin spillage

Water treatment equipment is prone to leaks. The following guidelines will help to prevent water related damages in the event of a leak.

- Municipal water pressure often increases significantly at night when there is little water usage. This can put excessive strain on DI tanks and connecting hoses. The DI systems are not intended for water pressure to exceed 80 psi. If possible, shutting off the water supply to DI tanks at night is a good safeguard to prevent water leaks.
- It is also highly recommended that a pressure regulator (set below 80psi) is installed prior to the DI tank system. Pressure regulators are prone to failure and need to be maintained on a frequent basis.
- It is a good idea to have a floor drain and wall protectors installed in the same room as the DI tanks.
- If the tanks will be exposed to freezing conditions or feed water above 80 F then this can likely lead to water leaks.
- If any vacuum occurs in the DI system, then the DI tanks will likely rupture and leak. A vacuum breaker should be installed prior to the DI tanks to be safe. Some examples of when a vacuum may occur are when DI tanks are elevated from their point of use, a fire hydrant was exercised on the street or the DI water is re-pressurized after the DI tanks.
- When a softener is used before a water heater, the pop off relief valve should be in working order on the water heater.
- If the DI water is going to a storage tank, the float level switches need frequent maintenance to prevent overfilling.
- There should always be a post-filter placed after DI tanks in the event of a lateral failure inside the tank which will cause resin to leak into the water supply. A post filter (1 micron pore size) will capture any lost resin beads and prevent any further contamination.
- If possible, placing the DI tanks outside is another safeguard to prevent water damage from leaks.
- Water backflow into the outlet of the DI tank will cause resin leakage from the inlet of the tank.

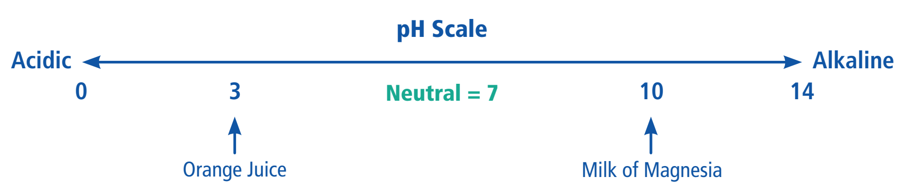
A note on leak detectors

Leak detectors are not reliable, and you should not rely on them as a foolproof method to prevent water related damages. Furthermore, if the leak occurs after the DI tanks, then the deionized water often doesn't activate the leak detector since deionized water is not very conductive.

Water Quality Conversion Chart

Less Dissolved Solids → Quality

Resistivity	Conductivity	Dissolved Solids	Grains Per Gallon	Estimated pH	
Ω = ohms	μS = Microseimens mS = Miliseimens	TDS (ppm or mg/l as CaCo3)	GPG 1 Grain = 17.1 ppm	Max	Min
18 M Ω	0.056 μS	0.028	0.000	7.8	6.2
17 M Ω	0.058 μS	0.029	0.002	7.8	6.2
16 M Ω	0.063 μS	0.031	0.002	7.9	6.1
15 M Ω	0.066 μS	0.033	0.002	7.9	6.1
14 M Ω	0.071 μS	0.036	0.002	7.9	6.1
13 M Ω	0.077 μS	0.038	0.002	7.9	6.1
12 M Ω	0.083 μS	0.042	0.002	8.0	6.0
11 M Ω	0.091 μS	0.045	0.003	8.0	6.0
10 M Ω	0.1 μS	0.05	0.003	8.1	5.9
9 M Ω	0.11 μS	0.055	0.003	8.1	5.9
8 M Ω	0.125 μS	0.063	0.004	8.2	5.8
7 M Ω	0.143 μS	0.0715	0.004	8.3	5.7
6 M Ω	0.167 μS	0.0835	0.005	8.3	5.7
5 M Ω	0.2 μS	0.1	0.006	8.4	5.6
4 M Ω	0.250 μS	0.125	0.007	8.5	5.5
3 M Ω	0.333 μS	0.1665	0.010	8.6	5.4
2 M Ω	0.5 μS	0.25	0.015	8.8	5.2
1 M Ω QC Light	1 μS	0.5	0.029	9.1	4.9
900 K Ω	1.11 μS	0.55	0.032	9.2	4.8
800 K Ω	1.25 μS	0.625	0.037	9.2	4.7
700 K Ω	1.43 μS	0.715	0.042	9.3	4.6
600 K Ω	1.67 μS	0.835	0.049	9.4	4.5
500 K Ω	2 μS	1	0.058	9.5	4.4
400 K Ω	2.5 μS	1.25	0.073	9.6	4.4
300 K Ω	3.3 μS	1.65	0.096	9.7	4.3
200 K Ω QC Light	5 μS	2.5	0.146	9.7	4.3
100 K Ω	10 μS	5	0.292	10.1	3.9
50 K Ω	20 μS	10	0.585	10.4	3.6
40 K Ω	25 μS	12.5	0.731	10.5	3.5
30 K Ω	33.3 μS	16.65	0.974	10.6	3.4
20 K Ω QC Light	50 μS	25	1.462	10.8	3.2
10 K Ω	100 μS	50	2.974	11.1	2.9
5 K Ω	200 μS	100	5.848	11.4	2.6
1 K Ω	1 mS	500	29.240	12.1	1.9



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How many gallons will the tank produce?

This is a common question with no exact answer. We can only provide ballpark estimates due to the complex always changing nature of water chemistry. However, one thing is certain – water that has higher total dissolved solids (TDS) will produce fewer gallons and water that has lower TDS will produce more gallons of deionized water. Other water quality characteristics such as turbidity and organics also affect the number of gallons produced.

Estimated Run Length = Total operating removal capacity of the resin in grains[1] / Total grains of dissolved solids in the feedwater

Below is a table that shows estimated yields from different types and sizes of tanks. It's important to note what endpoint is specified for each type of tank. This is the quality endpoint when the DI tank is taken offline. An endpoint of 200K resistivity is far different than an endpoint of 10 ppb Silica and you will receive drastically different results.

Other factors that affect DI run length might include flow rates that are too high or low, intermittent starting and stopping of DI system, bacterial growth, leaking bypass valves, downstream copper piping, extreme temperatures, air in system, upstream equipment problems and/or placement of a 185nm UV system after a mixed bed. Also, don't forget to confirm that the instruments used to measure deionzed water quality are calibrated and functioning properly.

For more information on troubleshooting DI systems, please visit puretecwater.com/resouces and click on DI User Manual.

Estimated DI Tank Run Lengths															
	Endpoint of 200K					Endpoint of 20K					Endpoint of 20K				
Feedwater Conductivity µs	8" M	10" M	14" M	Flomax 37	Flomax 45 M	8" C-S	10" C-S	14" C-S	Flomax 37 C-S	Flomax 45 C-S	8" C-W	10" C-W	14" C-W	Flomax 37 C-W	Flomax 45 C-W
200	599	2128	4788	47880	59850	998	3547	7980	79800	99750	1385	4925	11081	110808	138510
300	399	1419	3192	31920	39900	665	2364	5320	53200	66500	923	3283	7387	73872	92340
400	299	1064	2394	23940	29925	499	1773	3990	39900	49875	693	2462	5540	55404	69255
500	239	851	1915	19152	23940	399	1419	3192	31920	39900	554	1970	4432	44323	55404
600	200	709	1596	15960	19950	333	1182	2660	26600	33250	462	1642	3694	36936	46170
700	171	608	1368	13680	17100	285	1013	2280	22800	28500	396	1407	3166	31659	39574
800	150	532	1197	11970	14963	249	887	1995	19950	24938	346	1231	2770	27702	34628
900	133	473	1064	10640	13300	222	788	1773	17733	22167	308	1094	2462	24624	30780
1000	119.7	426	958	9576	11970	200	709	1596	15960	19950	277	985	2216	22161.6	27702
1100	109	387	871	8705	10882	181	645	1451	14509	18136	252	895	2015	20147	25184
1200	100	355	798	7980	9975	166	591	1330	13300	16625	231	821	1847	18468	23085
1300	92	327	737	7366	9208	153	546	1228	12277	15346	213	758	1705	17047	21309
1400	86	304	684	6840	8550	143	507	1140	11400	14250	198	704	1583	15830	19787
1500	80	284	638	6384	7980	133	473	1064	10640	13300	185	657	1477	14774	18468

Estimated Gallons with endpoint of 2 ppm hardness (mg/l)					
	Soft Water				
Feedwater Grains per gallon (gpg) Hardness	8"	10"	14"	37 Flmx	45 Flmx
5	2610	9280	20880	208800	261000
10	1305	4640	10440	104400	130500
15	870	3093	6960	69600	87000
20	653	2320	5220	52200	65250
25	522	1856	4176	41760	52200
30	435	1547	3480	34800	43500

[1]It is important to use operating capacity vs total capacity (which is often advertised by resin manufacturers). Operating capacity refers to the realistic resin capacity that you can expect before the resin exhausts to a point where the water is still deionized but to a lower level that requires you to take the tank offline. Total capacity refers to the level of exhaustion where the feedwater entering the tank equals the quality of water leaving the tank. That level of exhaustion is far beyond what most applications would deem acceptable.

Water Quality Standards

ASTM STANDARDS FOR LABORATORY REAGENT WATER (ASTM D1193-91)

Measurement (unit)	Type I	Type II	Type III	Type IV
Resistivity (MΩ-cm)	> 18	> 1	> 4	> 0.2 (200KΩ)
Conductivity (µS/cm)	< 0.056	< 1	< 0.25	< 5.0
pH at 25°C	N/A	N/A	N/A	5.0 – 8.0
Total Organic Carbon (TOC) ppb or µg/L	<50	<50	<200	N/A
Sodium (ppb or µg/L)	< 1	< 5	< 10	< 50
Chloride (ppb or µg/L)	< 1	< 5	< 10	< 50
Silica (ppb or µg/L)	< 3	< 3	< 500	N/A

ADDITIONAL ASTM SUB-STANDARDS FOR LABORATORY REAGENT WATER

Measurement (unit)	A	B	C
Heterotrophic Bacteria Count (CFU/ml)	< 1	< 10	< 1000
Endotoxin (units per ml)	< 0.03	< 0.25	N/A

ISO 3696 STANDARD

Parameter	Grade 1	Grade 2	Grade 3
Conductivity µS/cm (Temp Corrected)	< 0.1	< 0.1	< 5.0
pH at 25˚C	N/A	N/A	5.0 – 7.0
Oxidizable matter Oxygen (O2) content mg/L	N/A	< 0.08	< 0.4
Absorbance at 254 nm and 1 cm optical path length, absorbance units	< 0.001	< 0.01	N/A
Residue after evaporation on heating at 110˚C mg/kg	N/A	< 1	< 2
Silica (Si02) mg/L	< 0.01	< 0.02	N/A

CLSI[1]-CLRW GUIDELINES

Contaminant	Parameter and Unit	Type 3	Type2	Type1	CLRW
Ions	Resistivity (MΩ-cm)	> 0.05 (50 KΩ)	> 1	> 18	> 10
Organics	Total Organic Carbon (TOC) ppb	< 200	< 50	< 10	< 500
Pyrogens	(Eu/ML)	N/A	N/A	<0.03	——
Particles	Particles >0.2 µm (units/mL)	N/A	N/A	< 1 (0.22µ filtration required)	Include 0.22µ filtration
Colloids	Silica (ppb)	< 1000	< 100	< 10	——
Bacteria	Bacteria (cfu/ml)	< 1000	< 100	< 1	< 10

LABORATORY WATER PURITY SPECIFICATIONS CONSOLIDATED GUIDELINES

Contaminant	Parameter and Unit	Type 1	Type 2	Type 3
Ions	Resistivity (MΩ-cm)	> 0.05 (50 KΩ)	> 1	> 0.05 (50 KΩ)
	Silica (ppb)	< 10	<100	<1000
Organics	Total Organic Carbon (TOC) ppb	< 20	< 50	< 200
Particles	Particles > 0.2 µm (#/ml)	< 1	N/A	N/A
Bacteria	Bacteria (cfu/ml)	< 1	< 100	< 1000
	Endotoxin (EU/mL)	< 0.001	N/A	N/A

USP STANDARDS

Properties	USP Purified Water	USP Water for Injection & Highly Purified Water
Conductivity (µS/cm @ 25˚C)	< 1.3	< 1.3
Total Organic Carbon (TOC) ppb or µg/L	< 500	< 500
Bacteria (guideline)	< 100 cfu/ml	< 10 cfu/ml
Endotoxin (EU/ml)	N/A	< 0.25 EU/ml

Troubleshooting DI Tanks

Problem	Cause	Solution
DI tanks are exhausting earlier than expected or the DI tank does not rinse up to quality	Changes in feedwater quality	Test feedwater and compare results to earlier values when tanks performed as expected. If feedwater TDS has increased, then the DI tanks will not last as long. There are also other frequently changing factors such as CO2, organics and turbidity that can impact DI run length as well.
	Changes in feedwater flow rates	Each size of DI tank is designed to handle a certain range of flow rates. If the flow is too low or too high, then the proper kinetics on the resin bead will not happen. Make sure the flow rate is set for the size of DI tank that you have or upgrade/downgrade the size of DI tank to accommodate the required flow. See page 8 for recommended flows.
	Is operation of DI tank continuous?	Intermittent operation will result in higher than normal mineral leakage and lower quality output.
	Quality instrumentation needs calibration	1 Confirm that the conductivity/resistivity/TDS instrument is calibrated and working properly. Make sure that the sensor probe is not damaged or covered in Teflon tape. 2 If you have a handheld resistivity meter, take resistivity reading of DI tank effluent. If the customer's meter agrees with your handheld meter reading, then the customer's meter is probably working properly. If the two readings don't agree, the customer's quality meter may not be working properly. 3 However, keep in mind that at higher resistivities, a handheld meter will not be reliable due to atmospheric contamination of the water sample (CO2 is absorbed into highly deionized water and converts to carbonic acid and lowers the resistivity reading).
	Quality light is not working properly	1 Make sure that there is power to the outlet that the quality light is plugged into. 2 Make sure that there is water flowing by the quality light. Many gallons might need to flow before the quality light turns on or green. If there is no flow for a period of time, then typically the quality light will turn off or turn red. 3 Double check the resistivity value with a handheld resistivity meter. If the resistivity reading on the handheld shows that the quality light should be lit but it is not, then replace the quality light. 4 If a handheld meter is not available, turn off water system and relieve pressure to the DI tank. Unplug the quality light and unscrew the quality light. Inspect the electrodes for dirt and corrosion. Then expose the electrodes on the quality light to air and then plug the light back in (do not touch the electrodes when doing this). If the light turns on (or turns green with some models) then the quality light is working properly. Likewise, the quality light should turn off (or red) when you dip the electrodes in city water. If not, then the quality light needs to be replaced. 5 Make sure that the quality light is mounted correctly on the DI system to prevent air gaps across the electrodes and false alarms.

Problem	Cause	Solution
DI tanks are exhausting earlier than expected or the DI tank does not rinse up to quality, continued . . .	UV system is in the wrong place	If a mixed bed is followed by a UV unit with 185 nm lamps, the organic material will be oxidized to form water and carbon dioxide. Carbon dioxide will convert to carbonic acid and further reduce resistivity. In a well-designed system, a 185 nm UV will be placed before the mixed bed polisher and a 254 nm UV will be placed after the mixed bed polisher.
	Bacteria growth	If the DI tank has not been used in a while then bacteria can grow in the resin bed, especially if the DI tank is placed outside. Microorganisms growing in the resin bed will affect the ability of ion exchange resin to function and eventually affect flow rates and pressure drop across the DI tank. Many times, a mixed bed tank with high bacteria growth will have a high pH effluent. The DI tank should be replaced, and the system sanitized.
	Bypass valve is not working or seated properly	Improperly seated valves can introduce contaminants into the treated water stream.
	Is there copper pipe after DI tank?	The deionized water is very aggressive and will partially dissolve the copper pipe. Copper is very conductive and will increase the conductivity of the water. Replace copper piping with PVC or other suitable piping material.
	Did the tanks lay horizontally during transport?	If a mixed bed or polisher tank is laid on its side, the cation and anion resin may separate resulting in poor quality effluent. The mixed bed or polisher should be replaced with a tank that was not stored on its side.
	Is the ion exchange resin dry? Air in system?	If the water has been removed from the tank and the resin is dry, it will take time to rinse up to quality as the air is replaced with water inside the tank and throughout the system.
	Feed line hooked up to system outlet instead of inlet, resulting in reverse flow	If there was reverse flow across a mixed bed or polisher tank, the resin might separate, resulting in poor quality effluent. Tanks should be replaced.
	Is the cation "C" tank (red tape) placed after anion tank (W or S)?	If the anion tank was mistakenly placed before the cation tank, then the DI system will produce acidic water that can be damaging to the end user. The tanks should be exchanged. If you place the cation tank back online in the correct position, then the anion tank would become fouled with calcium hydroxide and magnesium hydroxide.
	Reverse Osmosis (RO) has lower rejection rate	As the RO system rejection rate drops it significantly reduces DI run lengths. RO membranes should be cleaned or replaced if necessary.
	Degasifier, if present, is not working properly	If a degasifier is used in the DI system to remove C02, make sure that it is operating properly. CO2 uses up anion resin capacity.
	High organics or turbidity in feedwater	Organics in feedwater can foul anion resin by coating the surface of the resin and reduces the ion exchange removal capacity. When the source water is from a shallow lake, they often experience turnover in the spring and fall which increase organic levels.
Quality light on DI tank goes out immediately after DI tanks are re-started after sitting for a long period of time	Water has not yet rinsed up to quality	Run several gallons of water through the DI tank(s). If the quality light remains off, then double check resistivity value with handheld meter. If the handheld meter shows that the quality light should be on, then replace the quality light.

Problem	Cause	Solution
Poor water quality from C-S system during rinse up	Problem with cation "C" tank	Check total hardness and pH coming from cation "C" tank with the red band. Hardness should be zero and pH should be low. If hardness is not 0, this could indicate an internal bypass inside the tank or that the cation resin was not regenerated well enough.
	Problem with anion "S" tank	Check total hardness and pH coming from anion "S" tank with the yellow band. Hardness should be zero and the pH should be high. If hardness is 0 but the pH is low, the anion resins could be fouled with organics or C02 could be leaking from anion tank into effluent. If hardness is not zero, then anion resins could be hardness fouled.
Low flow rate coming out of DI tank	Interconnecting hoses, inlet screen or top of resin bed could be fouled with debris, algae, bacteria, or scale	Turn off feedwater. Disconnect inlet hose from DI system. Check inside of inlet hose, and clean if it is slimy. Hold inlet hose over bucket and run water through it, if you have good flow, reconnect inlet hose to system. Turn feedwater back on and check effluent flow, if still low, pluggage is somewhere inside tank or outlet hose. Troubleshoot outlet hose in the same manner as above. If outlet hose is not the problem, pluggage is either at top of resin bed or inside inlet screen.
	Inlet screen and interconnecting hoses could be plugged with resin, caused by broken bottom lateral screen in the tank before it	Turn off feedwater, disconnect interconnecting hose on last DI tank in the series. Inspect hose and inlet screen for presence of resin. Inspect each successive tank in this manner, and if resin is discovered, replace the tank in front of it. This tank will likely have a broken internal lateral.
	Pre-filter or final filter after DI tanks could be plugged or sized incorrectly	A pre or post filter should be replaced when the psi drop is greater than 10 psi. If a pressure gauge is not installed, then remove post-filter and re-check the flow. If it increases, the filter was plugged, and should be replaced. Also, make sure you have the correct micron rated filter. For pre-filters to a DI system they should be 5 microns. After a DI system, a post-filter should be 1 micron. If you have a smaller micron sized filter in these positions, then pluggage will occur very rapidly and produce a high pressure drop across the filter and corresponding flow loss.
	Flow controller may be malfunctioning	Check flow controller and paddle wheels.
	Inlet or outlet valves not fully open or malfunctioning?	Inspect valves.
	City water feed flow may be inadequate	Double check city water flow rate and make sure it is adequate. See page 8 for required flow rates.
	Pressure regulator needs adjustment	If the pressure drop across the pressure regulator is greater than 15 psi then adjust the pressure regulator to increase outlet pressure. Clean the pressure regulator screen. If the pressure difference is greater than 25 psi across the pressure regulator then replace the regulator. Do not exceed 80 psi.
The water coming from DI tank has an odor	Chemical or solvent odor	These could be from hydrocarbons in a non-potable water supply. The DI tank should be removed from use and isolated, so it is not emptied into the regeneration system.
	Rotten egg odor	This is due to bacteria growth inside the DI tank. Anaerobic bacteria release a gas called hydrogen sulfide which causes the rotten egg odor. Flushing the DI tank with water will help to remove the odor.
	Fish smelling odor	Anion resin in a separate bed system can give off a fishy odor —especially with new resins. Flushing tank will help with odor.

Frequently Asked Questions (FAQ)

How many gallons will I get from a DI tank?

This is a common question with no exact answer. We can only provide ballpark estimates due to the complex always changing nature of water chemistry. However, one thing is certain – water that has higher total dissolved solids (TDS) will produce fewer gallons and water that has lower TDS will produce more gallons of deionized water. Other water quality characteristics such as turbidity and organics also affect the number of gallons produced.

Other factors that affect DI run length might include flow rates that are too high or low, intermittent starting and stopping of DI system, bacterial growth, leaking bypass valves, downstream copper piping, extreme temperatures, air in system, upstream equipment problems and/or placement of a 185nm UV system after a mixed bed. Also, don't forget to confirm that the instruments used to measure deionzed water quality are calibrated and functioning properly.

How does the Quality Light work?

A quality light measures the conductivity between two electrodes that are submerged in the water stream. Some quality lights have a light on/light off feature. When the light on, that means the water is deionized and if the light off, that means the water is no longer suitable for use. Newer quality lights work with a green light/ red light feature that are more intuitive – green is good and red is bad.

It is important to remember that water must be flowing across the quality light for it to work properly. Page x shows correct ways to install a quality light.

What is the difference between a mixed bed and a softener (SOD C)?

Water softeners (SOD C's) remove hardness minerals from the water, mainly calcium and magnesium, and replace them with sodium to reduce the potential to form hardness scale. The total conductivity of soft water will remain unchanged and often increases since sodium is very conductive. On the other hand, a mixed bed removes nearly all dissolved solids from the water and reduces the conductivity to extremely low levels.

Are DI tanks able to remove all the contaminants in water?

No, DI tanks are very good at removing dissolved minerals, but they do not remove organics or bacteria and other pathogens. They do remove some particulates through entrapment in the resin beads, but this reduces the DI tanks ability to remove dissolved minerals.

Why is the pH of my mixed bed not neutral (pH 7)?

Placing the electrodes of a pH meter into a beaker full of mixed bed effluent (deionized water) will result in a somewhat meaningless value. This is because deionized water has a very low ionic strength (most if not all the dissolved ions have been removed) and it is an extremely aggressive solvent when in this state. As a result, when using a pH meter, large differences in the ionic strength of the sample and the buffer solution of the pH electrode can cause unreliable readings. The required electron transport between the measuring and reference sides of the pH electrode is difficult to achieve in these conditions. Furthermore, the quick adsorption of contaminants into the pure water sample can compromise a pH reading because it has little, if any, buffering capacity. For example, a sample of deionized water exposed to air can quickly adsorb C02 and form carbonic acid (H2CO3) which can alter the pH of neutral water at 7.0 to drop as low as 5.6.

High purity water with a Resistivity of 18.2 Megohm (or a conductivity value 0.055 µS) will have a neutral pH but proving that with a pH meter will be difficult for the reasons above.

The pH of the water coming from my C-S set is high. Why?

The pH of the strong base anion (S) effluent is supposed to be above 7, because during ion exchange, the hydroxide ions in the anion tank combine with any sodium ions that might have leaked out of the cation tank , and form sodium hydroxide, a base, that increases the pH.

The pH of the water coming from my C-W set is low. Why?

The pH of the weak base anion (W) effluent is supposed to be below 7, because the weak base anion (W) does not remove weak acids (or C02) which contribute to a lower acidic pH.

Can I drink deionized water?

We recommend against drinking deionized water unless it has been disinfected and re-mineralized.

What is the difference between deionized water and distilled water?

Deionization removes all dissolved minerals whereas distillation removes most dissolved minerals in addition to many more impurities such as chemicals and pathogens.

Can DI tanks remove bacteria?

No, they are not intended or designed for that purpose.

Does a water softener (SOD C) lower conductivity values?

No, a water softener exchanges hardness causing minerals like calcium for sodium which is conductive. Sometimes the conductivity reading after a softener will be higher than before a softener due to this reason. A water softness test kit is used to measure the performance of a water softener versus conductivity which is used to measure other ion exchange tanks.

What is the difference between Polisher and Mixed Bed?

The difference between a mixed bed tank and a polisher tank is its intended use and how it is handled during regeneration. A mixed bed tank can have city water as its feed source. A polisher must have water that is already deionized as the feed source and polishers tend to be used in more critical applications. The regeneration process is different as well. The polisher resins are newer, receive more chemical regenerant and are isolated, dedicated and identified in a different manner.

How long is shelf life on an unused DI tank before it should be either used or returned for regeneration?

6 months.

What are ion exchange resins made of?

Ion exchange resins are copolymers made of DVB (divinyl benzene) and styrene. The more DVB means the resin will be stronger and able to resist higher temperatures and less susceptible to oxidation.

What kind of pressure drop can I expect through a DI tank?

The pressure drop across a resin bed can vary depending on several factors. These include resin type, bead size and distribution, interstitial space (bed void space), flow rate and temperature. The total head loss of a unit in operation will also depend on its design. It is also substantially affected by the contribution of the strainers surrounded by the resin.

What are the DI tanks made from?

The tanks have an inner shell made from polyethylene that is double wrapped in a fiberglass and epoxy resin and oven cured.

Where can I find SDS forms for ion exchange resins

We have ion exchange resin Safety Data Sheets available for download on our website at puretecwater.com/resources.

Can you determine TOC from conductivity?

No, a conductivity meter does not read uncharged organic compounds.

Why does a handheld conductivity meter provide different readings than an in-place unit?

A handheld conductivity meter is less accurate than an inline unit because it is susceptible to atmospheric contamination. This is especially true for higher purity water samples. For example, CO_2 in the atmosphere will quickly absorb into the handheld unit's water sample and convert to carbonic acid. This will increase the conductivity value and make the conductivity reading inaccurate.