associates

# Lab DI Water Systems

***Precision Cleaning Systems***

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## DI Water

DI or de-ionized water is simply water that has had most of the mineral content and dissolved ion content removed. It is pure water. The cleanliness of the water is rated as its resistance value. [Pure water will not conduct electricity][The rating is in Meg Ohms.] Microsiemmens or Conductivity is also used as a measurement of DI water

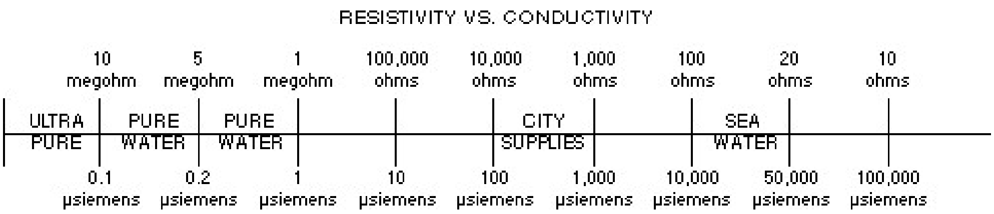
Standard tap water is brought to a temperature of about 72 degrees f and run though a pre filter system consisting of a 25 micron sediment filter, 25 micron carbon filter and either a water softener filter or a chloramines filter [depending on your particular water quality and your local government treatment method] and then the main DI system consisting .5-micron filter to remove particulates, a carbon filter then removes any organics within the water. A reverse osmosis filter removes further contaminants and a mixed bed resin filter removes the final dissolved minerals. This is a very basic process for production of DI water on a small scale. Larger systems are very complicated and use pumps and re- circulation loops to provide larger volumes of DI water.

### Types of DI Water

DI water is classified into several types dependent on its use. If you are cleaning high end semiconductor final cleaning of optics or high end medical devices, then type 1 is the correct choice. Type II DI water is also used for high end cleaning and for food grade products. Type III is commonly used for parts cleaning and general lab ware cleaning. The charts below give the specifications for the various types of DI water.

NCCLS Maximum Contaminant Levels in Type I-III Purified Water

| **Contaminant** | **Parameter** | **Type I** | **Type II** | **Type III** |
|---|---|---|---|---|
| Ions | Resistivity at 25°C (megaohms-cm) | >18.0 | >1.0 | >0.05 |
| | Conductivity at 25°C (microsiemens/cm) | <0.056 | <1.0 | <20 |
| Organics | TOC (ppb) | <10 | <50 | <200 |
| Pyrogens | Eu/mL | <0.03 | NA | NA |
| Particulates | size | <0.2 µm | NA | NA |
| Colloids | Silicia (ppb) | <10 | <100 | <1000 |
| Bacteria | CFU/mL | <1 | <100 | <1000 |




## How Filtration and Reverse Osmosis systems work:

### Cartridge Filter

Next is the cartridge type filter. Most common are the 10 1/2 or 20-inch long filters. This type filter will usually have a removable housing, into which different types of "elements" can be placed. A sediment filter cartridge element can be manufactured to remove certain size particles and larger. Most elements for industrial and Lab use will indicate .5 to 15 micron and larger removal. and add the words "Absolute" after it. It simply means that if it says 5 micron absolute, it means it! Very few particles larger than 5 microns will pass through the filter. The regular filter may say 25 microns, meaning that *most* of the particles 25 microns and larger will be caught by the filter.

Remember, these filters actually get better, or more effective, as they are used. The 'junk' in the water collects on the surface of the filter and becomes a part of the filter as well. As it builds up, progressively smaller and smaller particles are trapped, and the flow rate through the filter slowly diminishes. This slowing of the flow rate can be a source of problems to water using appliances in your system. If you use such a filter, regular changing of the filter element is very important. Elements for these filters can also be carbon (block or granular, or powdered), can be manufactured for use in hot water, can be ceramic, pleated as well as many other configurations. Some manufacturers are mixing a small amount of silver into the carbon to help prevent any bacteria growth in them. This has yet to be a proven methodology. In fact, make sure that such a filter doesn't give off more silver than is allowed, if not rinsed thoroughly prior to use, especially after a prolonged period of non-use. Remember, all filters, carbon especially, trap organics that bacteria feed on, and as the water sits without moving, they can multiply rapidly. Always change the elements on a regular, frequent basis.

**Reverse Osmosis**
Reverse Osmosis is a process that is often described as filtration, but it is far more complex than that. We sometimes explain it as a filter because it is much easier to visualize using those terms. We should remember that osmosis is how we feed each cell in our bodies: As our blood is carried into the smallest of capillaries in our bodies, nutrients actually pass through the cell wall to sustain its life. Reverse osmosis is just the opposite: We take water with "nutrients" (in this case particles) in it, and apply pressure to it against a certain type of membrane, and out comes "clean" water.

If you take a jar of water and place a semi-permeable membrane (like a cell wall or a piece of skin) in it, dividing the jar into two sections, then place water in both sides to an equal level, nothing happens. But, if you place salt (or other such substance) into one side of the jar, you will notice that, after awhile, the water level in the salty side begins to rise higher as the unsalted side lowers. This is osmotic pressure at work: The two solutions will continue to try to reach the same level of salt in each side by the unsalted water passing through the membrane to dilute the salty water. This will continue until the "head" pressure of the salt water overcomes the osmotic pressure created by the differences in the two solutions.

Researchers have discovered that if we take that membrane and feed water with sufficient pressure to overcome the osmotic pressure of the two waters, we can 'manufacture' clean water on the side of the membrane that has no pressure. We sometimes say we "filter" the water through the membrane. Depending on the membrane design, and the material it made from, the amount of TDS (total dissolved solids) reduction will range from 80 to over 99 per cent.

Different minerals have different rejection rates; for instance, the removal rate for a particular membrane is 99.5% for Barium and Radium 226/228; but only 85.9% for Fluoride and 94.0% for Mercury. Removal rates are very dependent on feed water pressures, and some membranes are not tolerant to high or low pH. For small Lab Systems, it is important to make sure you get an RO System; i.e., sediment pre-filter, a carbon pre-filter, membrane, and post carbon filter

A lot of comments have been made concerning the wasting of water by an RO. True, the old style units with the early type membranes were more prone to becoming plugged, or fouled by the material they removed from the water. To help keep this from happening, a small amount of water was allowed to run across the membrane to help carry away those impurities to drain. Early designs only recovered 1 gallon of good water for every 4-8 gallons used to keep the membrane clean. And when your storage tank was full, water still ran to the drain because the early membranes were made of a material that the bacteria in your water supply attacked. So to prevent that, the system let the water run so they couldn't have time to stop grow on the membrane Now membranes are made that not only recover a much higher percentage of the feed water, but the material is resistant to attack Most membranes do not exceed the 4 to 1 ratio today.

Newer systems not only recover more water to begin with, they also have a shut off device that stops all water flow when the storage tank is full. Actual recovery rate is dependent on several factors, including the TDS [Total Dissolved Solids], the total dissolved solids test is used as an indicator test to determine the general quality of the water. The sources of total dissolved solids can include all of the dissolved cations and anions,. The total dissolved solids concentration can be related to the conductivity of the water, but the relationship is not a constant. The relationship between total dissolved solids and conductivity is a function of the type and nature of the dissolved cations and anions in the water and possible the nature of any suspended materials. Most systems have a TDS meter with 2 individual sensors, 1 located before the RO process and one located after the RO process. This gives a good indication of when to change the RO filters. It is not accurate for determining the quality of the water. The Resistivity Meter is the best way to determine water quality in a system. The newer systems also have an automatic flush valve that will flow water over the outside of the membrane on start up of the system and also every hour. This prevents any build up of material on the outside of the membrane.

Temperature, pressure also has a big effect on the amount of product water you can make in a given period. Remember, all RO units are normally rated using a feed water temperature of 77 degrees F

**Mixed Bed Resin Filters**
They are de-ionization cartridges designed to reduce silica, nitrates and phosphate levels in the water. These filters are always used in conjunction with pre filters. These formulated resin cartridges far exceed the performance of previous cartridges, offering enhanced contaminant removal, longer life and higher purity. The mixed-bed resin filters, remove the dissolved Ions of various minerals from the water to bring the water resistively, up to approximately 18 Meg-Ohm cm. In the deionizing process, the contaminated water passes through two columns full of ion exchange media, one of which is saturated with sulfuric acid, the other sodium hydroxide. The $H^+$ from the sulfuric acid replaces any cation contaminants in the water, while the $OH^-$ from the sodium hydroxide replaces any anions.

**DI Water Storage**
Once DI water has been made by the filter system it either has to be stored in a compatible container or used immediately. DI water has had most of its ions removed and will attack any material to get them back. The most preferred container for DI water would be a

stainless steel pure tin lined container. The tin auto-oxidizes & forms a surface which has a very low solubility index in water. As long as the pH is neutral, long term storage in tin is common..

Glass is also effective for storage of distilled and/or de-ionized water. The solubility of glass is extremely low and even ultrapure water will reach saturation quickly at parts per billion.

316 Stainless is perfectly suited for storing DI water--the only susceptible points in the stream might be the welds. Very smooth, clean and passivated welds should be fine. Electro polished contact surfaces are even better. Cross linked High Density Polyethylene tanks also work well with DI water storage in a re-circulation system and have the advantage of low cost. Storing very pure waters in PVC has limitations, even PVC listed as DWC or NSF-DW. There is still a problem with leaching, especially over time, notably on heating. PVC is commonly used in DI water plumbing systems. Since there is a continuous flow in the plumbing [and a DI filter in line with the recirculation there is no problem.] Certain other types of Plastic such as PTFE are also compatible with DI water and are used as high end plumbing.

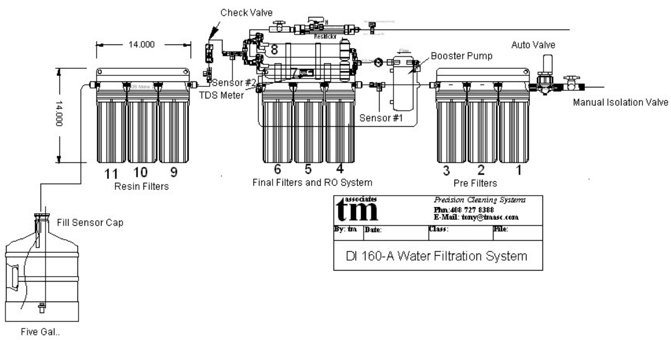
The most common cause of stored DI water to deteriorate is the ingression of CO2 from air. The CO2 converts to carbonic acid in the water which causes the conductivity to increase and pH to go down to around 5.5. This can be overcome by adding an N2 blanket over the DI water in your storage tank.

The most practicable way of storage of DI water is to constantly re circulate it though a filter system that consist of 2 mixed bed resin filters [semiconductor grade resin] and a sediment filter .5 micron. In addition A UV filter will prevent any bacteria from building up in the system. [Remember all the chlorine has been removed from this water so bacteria can live in it.] This type of system will keep the water at 18 Meg Ohm or better indefinitely.

**UV Filters**
In some applications, such as medical, laser, and semiconductor manufacturing an additional step of passing the DI water though an ultraviolet sterilizer filter is required. This kills any live bacteria that may have developed in the system from lack of use., most commonly it is used in systems with polishing loops that re circulate the DI water back though the resin cartages.

**Point Of Use Filtration Systems**
In a laboratory where there are multiple take off points for the DI water a point of use filtration system is commonly used. This consists of a single resin filter and an absolute .1 micron filter. This assures the water from this point is 18 Meg ohm or better. Sometimes a Digital resistivity meter is added to this filter bank to give a visual indication of the water quality.

**Lab DI Water Systems**
A Small Lab size System consists of a pre filter, main filter bank and collection device [tank or bottle] the lab systems are ideal for producing up to 160 to 180 gallons of DI water per day. They operate from your water pressure and do not require pumps. A booster pump will increase the efficiency of the system and prevent back flow due to drops in line pressure. The system consists of the following types of filters.




A. **Pre filter Package:**
The pre filter is usually a particle filter of 25 microns sediment and a charcoal filter; this removes gross amounts of particulates and organics. These filters protect the actual DI system filters and are changed more often.

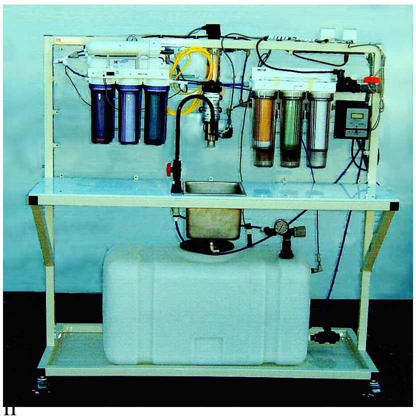
B. **Main DI Filtration System:**
The main filter system consist of a particulate filter, about .5 micron, a charcoal block filter, a reverse osmosis filter and a post RO filter [ with pressure gauge, a useful tool in determining when to change the filter]

C. **Resin Filters:**
The resin filters are a very high quality Semiconductor grade mixed bed resins that remove the last of the Ions from the RO water. This is what gives the final polish to the water and raises the resistance to the 18 Meg Ohm level. A good system will have at least 3 of the resin filters in series; the first is usually a color change type of resin filter that indicates its exhaustion by changing color. The next 2 filters continue to polish the water and bring it up to the correct level.

D. **Collection System:**
Depending on how large your system is, the collection system can be a small 5 gallon container with no recirculation or a large 50 gallon tank with an additional Filtration system such as a polishing loop

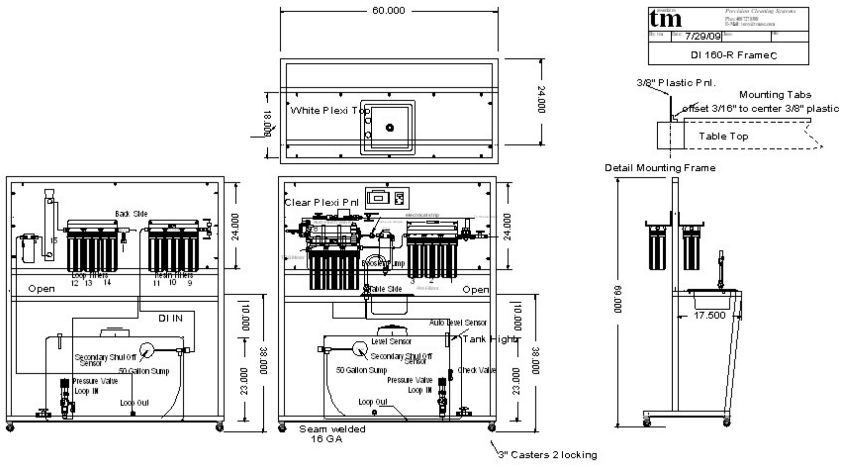
**E. Polishing Loop:**

In small Lab DI systems most of the water is used immediately or shortly after it is made. There really is no necessity to keep re filtering the water in the containment vessel. In larger systems where you need 50 gallons always available, under pressure for rinsing and always at high quality, it is necessary to include a polishing loop in the system. The polishing loop is a series of resin filters that has the water pumped from the holding vessel though the filters and back into the containment vessel. This keeps the water at a high resistivity rate in the holding vessel. In this type of system a faucet or spray wand can be added in the loop since the water is always under pressure in the pumping loop. This is an ideal system for a small lab that requires 100-200 gallons per day of DI Water. The entire system, including pre filters, sensors, holding tank and monitors can be built into a console that provides a ready source of DI water for the Lab. The larger systems have incorporated additional instrumentation that monitors the quality of the DI water and displays it on a digital Resistivity Meter. A built in alarm also is included



The system on the left is a typical DI system Mounted in a console to feed a lab with 5 stations that require DI Water. The system contains a polishing loop that has plumbing that extends into the individual stations. At each station a final point of use .5 micron absolute filter prevents any particulates from reaching the use point.

This system is entirely mounted on a 5 ft console with all the filters and pumps easily accessible for replacement. The electronics for the system are mounted in the rear of the upper back plane. A resistivity monitor and a TDS monitor control the system and sound an alarm if resistivity drops below a certain level. This system produces up to 180 gallons of DI [18 Meg Ohm] per day and stores another 50 gallons.




e system incorporates a sink and Lab Faucet. The system may also be fitted with a sump if no drain is available nearby. The sump vessel will pump the reject product and any drain water from the sink to a nearby drain. Small ultrasonic tanks can also be installed in the system to give you a complete cleaning system on a cart. Heaters can also be added to the system to provide hot DI on demand.

Special filters can be added to the loop system to provide biophage removal for medical applications.

Larger Lab systems up to 500 gallons per day are available; these systems will provide water enough for limited production cleaning of parts. They can also be designed to supply 4-5 stations within a lab to provide water to faucets or other equipment on demand. These Systems can be remote controlled by having the control panel in the lab and the DI unit in another room.

The systems can also have water chillers and heaters to maintain a specific tempature of the DI water in the Loop.

Options such as point of use filters at specific stations in the lab give the water a final polish just before use.

**Maintaining a DI Water Filtration System**

Maintaining a DI system requires some basic steps that must be followed or the system will not produce the water quality you require.

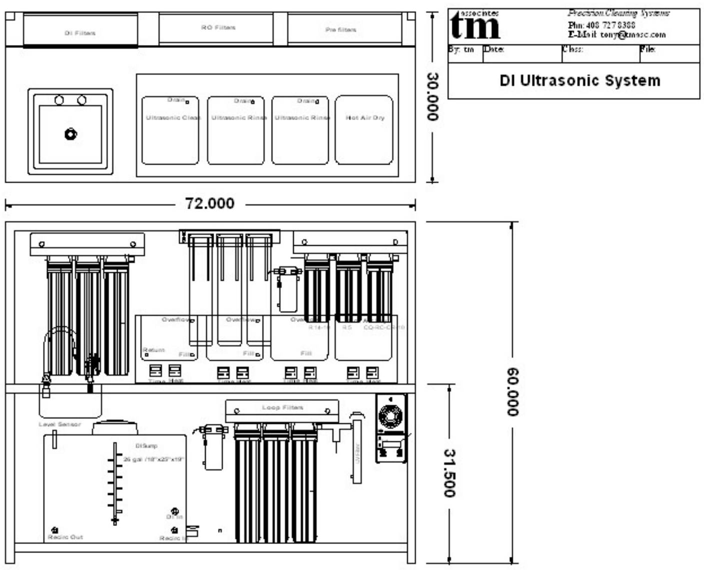
1. Use the system every day to produce at least 2 gallons of DI. This keeps the water in the filters from producing bacteria.
2. Watch the TDS [total dissolved solids] meter. When the incoming # from sensor 2 starts to approach the # from sensor 1 it is time to change the Pre filters and possibly the main sediment filters.

3. Change the RO filters every year [they can last up to 1-2 years with flushing.]
4. The RO filters have either a manual reverse flush valve or automatic reverse flush valve. If you have a manual valve always flush the RO filters every day for about 5 min. to remove and build up on the outside of the membranes. Automatic flush valves will do this without any effort on your part.
5. When the color change resin filters show about ¾" exhaustion, its time to replace the filter. Also Replace the first resin filter with the second filter and put a new resin filter in the last position [ this assures that you will never completely exhaust the resin capacity]
6. Watch the Resistivity Meter on the Loop filtration system; if it is getting lower, it's time to replace the resin filters in the loop.
7. Do not place the system in an area where there is sunlight directly on the filters, as this can promote bacteria growth in the system. [After water passes though the pre filter it has all the chlorine removed bacteria and algae can grow in the water if the system sits idle for an extended period of time.]

**DI Water and Ultrasonic Cleaning**

DI water is important in high end cleaning for the following reasons;

1. Since it has all or most of its mineral content removed it is very hungry to acquire minerals from your parts [mostly from the dirt and contaminates on the surface of your parts.]
2. A lack of particulates in the DI water enables the ultrasonics to act more efficiently in producing cavitations.
3. Because it is such an active cleaner it is Ideal for use in ultrasonic cleaning systems with or without detergents.
4. DI water leaves no residue on your parts, so you have no water spotting when they are dried.
5. DI water will remove any remaining detergent or soaps from your parts when it is used as a rinsing agent in the rinsing phase and since it has no mineral content it leaves no residue on the parts. It is much more effective if it is heated to about 110 deg.
6. In test performed with an ultrasonic cleaner DI water with detergents outperformed chlorinated solvents, solvents will only remove the particular contaminates it is designed for DI water will remove a large range of contaminants.
7. Detergents and other cleaning agents perform better is solution with DI water. The cleaning action is enhanced and the detergent is not wasted in converting the mineral content of the water, all of its cleaning action can be directed to the part.
8. Since all contaminates have both organic and inorganic components to them, a system can be set up to monitor the final rinse of the product in an ultrasonic tank. If you know the resistivity of the water in the tank without parts, you can dial in a set point that will keep the rinse going until the parts resistivity has reached the level on the set point. It will never return to the level of the tank with no parts but it will get above 10 Meg Ohms. This assures that the part is clean. Hot DI water is even more active than cold. It will rinse better and clean better than cold DI water, remember that any cleaning process cleans by providing energy to the part. Hot DI has more energy than cold and is much more effective in cleaning. Whenever possible use DI water in your ultrasonic tank for both cleaning and rinsing.




The drawing at the left shows a 500 gallon per day Lab system with a small multi stage ultrasonic cleaning system and built in sink with lab faucet and spray gun.

The ultrasonic console consists of a detergent ultrasonic tank, 2 overflow rinse ultrasonic tanks and a forced air dry tank.

This system provides a complete mini cleaning station for Ultra Clean applications in semiconductor medical and optical applications.

The system can be placed anywhere required and very easily moved.

All systems are pre-plumed and ready to use, the system needs only a power water and drain connection to house facilities

**Choosing and Sizing A DI Water System**
**This is an outline for setting the requirements for a DI water filtration system for lab use of up to 500 to 1000 gallons per day. Larger systems require much more extensive planning**
In choosing a DI water system consideration must be given to the following factors
1. What grade of DI Water do I need? [type 1,2,3]
2. How much DI will I need per day? [Always size the system for double the expected use to prevent overuse]
3. How much DI water will I need at any one time? [This will enable you to size the reserve tank]
4. How many delivery points will I need?
5. What type of delivery points? i.e. faucets, machinery, spray guns, ultrasonic cleaning tanks
6. Do I need a temperature control for my water?
7. Will some of the applications require hot DI water?
8. What is the chemical analysis of my house water supply? [ available from local government sources]
9. Do I need any special filtration for particular contaminants in my water?
10. Is my water pressure above 50 PSI?
11. Is there any equipment or other high demand systems that require water in the plant?
12. What space is available for the system? [do I have room for a console or must I locate the system outside the lab]
13. If the system is located outside the lab area, what displays and controls do I need in the lab area?
14. How long will the plumbing loop be from the DI system to my take off points?
15. What will be my requirements in 6 months, 1 year and 2 years from now?