



Shippensburg Pump Company, Inc.

BOILER FEED • CONDENSATE • DEAERATOR • VACUUM

One Schwenk Drive
P.O. Box 279
Shippensburg, PA 17257-0279

Phone: 717-532-7321
Fax: 717-532-7704
www.shipcopumps.com

Re: Dionized Water

Tap water meets the needs of most liquid-cooling applications. However, deionized (DI) water has chemical and electrical properties that make it the optimal choice for cooling when the liquid circuit contains micro-channels or when sensitive electronics are involved.

As the name implies, DI water has an extremely low concentration of ions that imparts important performance attributes. First, it eliminates mineral deposits which block the coolant flow. This will degrade cooling efficiency and system operating performance. Second, it eliminates the risk of electrical arcing due to static charge build up from the circulating coolant. The arcing can damage sensitive control electronics in the equipment being cooled. The lack of ions in DI water eliminates both of these problems.

Today, deionized (DI) water has become an essential ingredient in hundreds of applications. Applications that require the use of DI water are found in industries such as:

- Lasers
- Medical equipment
- Laboratory instrumentation
- Pharmaceutical production
- Cosmetic
- Food processing
- Semiconductor manufacturing
- Plating and other chemical processing

However, care must be exercised when using DI water. The very **lack of ions also makes this coolant unusually corrosive**. Called the "universal solvent," DI water is **one of the most aggressive solvents known**. In fact, to a varying degree, it will dissolve everything to which it is exposed. Therefore, all materials in the cooling loop must be corrosion-resistant.

Copper and many other common materials are not compatible with DI water and will contaminate it. Therefore, copper or copper alloys (brass, bronze or solder) are not recommended. They may deteriorate and cause premature failure unless the resistivity of the water is maintained at less than 10,000 ohms (100 microsiemens). Again, it is recommended that a 50 micron filter be installed on the chiller outlet of each water circuit to remove any foreign particles circulating in the system.

Deionized water can also be corrosive to carbon steel due to its low hardness content. Harder waters, (based on calcium carbonate) can be protective due to the protective scale they deposit on the steel surface.

When designing a system using DI water, DI-compatible materials such as stainless steel or nickel should be specified. 316 stainless steel (See Attachment B) is commonly used to handle and store deionized water. Deionized waters are also commonly handled and stored using austenitic stainless steels (i.e., See Attachment A), as the carbon steels will contaminate the relatively pure water.

If there is a problem with 316 stainless steel pitting rapidly, the pitting may be occurring at sites of iron contamination. The cause also could be use of a low carbon grade of 316 stainless steel; therefore, solution annealing after welding should not be necessary (it is also not practical).

In a heat exchanger or cold plate, manufacturers typically recommend a stainless steel fluid path. A DI friendly recirculating chiller should contain a nickel-brazed evaporator, a stainless steel pump head, and nickel-plated fittings. Finally, to maintain the DI water purity, a deionization cartridge must be included. As with all consumables the DI cartridge must be replaced periodically.

In summary, DI water-cooled systems are critical to the reliable operation of many types of equipment. When properly designed and maintained, these systems can provide reliable cooling and leak-free operation for many years.

THE DEIONIZATION PROCESS

The vast majority of dissolved impurities in modern water supplies are ions such as calcium, sodium, chlorides, etc. The deionization process removes ions from water via ion exchange. Positively charged ions (cations) and negatively charged ions (anions) are exchanged for hydrogen (H⁺) and hydroxyl (OH⁻) ions, respectively, due to the resin's greater affinity for other ions. The ion exchanges process occurs on the binding sites of the resin beads. Once depleted of exchange capacity, the resin bed is regenerated with concentrated acid and caustic which strips away accumulated ions through physical displacement, leaving hydrogen or hydroxyl ions in their place.

DEIONIZER TYPES

Deionizers exist in four basic forms:

- disposable cartridges,
- portable exchange tanks,
- automatic units, and
- continuous units.

A two-bed system employs separate cation and anion resin beds. Mixed-bed deionizers utilize both resins in the same vessel. The highest quality water is produced by mixed-bed deionizers, while two-bed deionizers have a larger capacity. Continuous deionizers, mainly used in labs for polishing, do not require regeneration.

TESTING DI WATER QUALITY

Water quality from deionizers varies with the type of resins used, feed water quality, flow, efficiency of regeneration, remaining capacity, etc. Because of these variables, it is critical in many DI water applications to know the precise quality. Resistivity/conductivity is the most convenient method for

testing DI water quality. Deionized pure water is a poor electrical conductor, having a resistivity of 18.2 million ohm-cm (18.2 megohm) and conductivity of 0.055 microsiemens. It is the amount of ionized substances (or salts) dissolved in the water which determines water's ability to conduct electricity. Therefore, resistivity and its inverse, conductivity, are good general purpose quality parameters.

Because temperature dramatically affects the conductivity of water, conductivity measurements are internationally referenced to 25°C to allow for comparisons of different samples. With typical water supplies, temperature changes the conductivity an average of 2%/ °C, which is relatively easy to compensate. Deionized water, however, is much more challenging to accurately measure since temperature effects can approach 10%/°C! Accurate automatic temperature compensation, therefore, is the "heart" of any respectable instrument.

If you are recirculating the fluid, chances are the deionized water is dissolving enough of the copper and or stainless to make itself less corrosive to the stainless. However, if you are exchanging the water or you are seeing corrosion (look at the welds for the first sign of damage), adding a bit of sodium carbonate or another non-halogen soluble salt to the water should abate any corrosion in this situation. (you don't need very much to virtually eliminate the corrosive nature of water) If you require a food-grade additive for FDA approval, there are many to choose from. As stated before, avoid chlorides, fluorides, iodides & bromides & try to keep the pH neutral or slightly basic.

ACKNOWLEDGEMENTS

Shipco® is not expert on dionized water or chemicals. This article paraphrases information collected from various sources. Its purpose is to provide some basic understanding. For more detailed information and trouble shooting of a specific problem, consult a professional who works with dionized water.

Sincerely,

Shipco® Marketing and Sales Department

Last Update: 12/18/06

Attachment A Types of stainless steel

There are different types of stainless steels: when nickel is added, for instance, the austenite structure of iron is stabilized. This crystal structure makes such steels non-magnetic and less brittle at low temperatures. For higher hardness and strength, carbon is added. When subjected to adequate heat treatment these steels are used as razor blades, cutlery, tools etc.

Significant quantities of manganese have been used in many stainless steel compositions. Manganese preserves an austenitic structure in the steel as does nickel, but at a lower cost.

Stainless steels are also classified by their crystalline structure:

- Austenitic stainless steels comprise over 70% of total stainless steel production. They contain a maximum of 0.15% carbon, a minimum of 16% chromium and sufficient nickel and/or manganese to retain an austenitic structure at all temperatures from the cryogenic region to the melting point of the alloy. A typical composition is 18% chromium and 10% nickel, commonly known as **18/10 stainless** is often used in flatware. Similarly **18/0** and **18/8** is also available. "Superaustenitic" stainless steels, such as alloy AL-6XN and 254SMO, exhibit great resistance to chloride pitting and crevice corrosion due to high Molybdenum contents (>6%) and nitrogen additions and the higher nickel content ensures better resistance to stress-corrosion cracking over the 300 series. The higher alloy content of "Superaustenitic" steels means they are fearsomely expensive and similar performance can usually be achieved using duplex steels at much lower cost.
- Ferritic stainless steels are highly corrosion resistant, but less durable than austenitic grades. They contain between 10.5% and 27% chromium and very little nickel, if any. Most compositions include molybdenum; some, aluminium or titanium. Common ferritic grades include 18Cr-2Mo, 26Cr-1Mo, 29Cr-4Mo, and 29Cr-4Mo-2Ni.
- Martensitic stainless steels are not as corrosion resistant as the other two classes, but are extremely strong and tough as well as highly machineable, and can be hardened by heat treatment. Martensitic stainless steel contains chromium (12-14%), molybdenum (0.2-1%), no nickel, and about 0.1-1% carbon (giving it more hardness but making the material a bit more brittle). It is quenched and magnetic. It is also known as "series-00" steel.
- Precipitation-hardening martensitic stainless steels have corrosion resistance comparable to austenitic varieties, but can be precipitation hardened to even higher strengths than the other martensitic grades. The most common, 17-4PH, uses about 17% chromium and 4% nickel.
- Duplex stainless steels have a mixed microstructure of austenite and ferrite, the aim being to produce a 50:50 mix although in commercial alloys the mix may be 40:60 respectively. Duplex steel have improved strength over austenitic stainless steels and also improved resistance to localised corrosion particularly pitting, crevice corrosion and stress corrosion cracking. They are characterised by high chromium (19-28%) and molybdenum (up to 5%) and lower nickel contents than austenitic stainless steels.

Attachment B

Stainless Steel Grades

- 200 Series— austenitic chromium-nickel-manganese alloys
- 300 Series— austenitic chromium-nickel alloys
 - Type 301— highly ductile, for formed products. Also hardens rapidly during mechanical working.
 - Type 303— Free machining version of 304 via addition of sulfur
 - Type 304— the most common; the classic 18/8 stainless steel.
 - Type 316— the next most common; for food and surgical stainless steel uses; Alloy addition of molybdenum prevents specific forms of corrosion. Also known as "marine grade" stainless steel due to its increased ability to resist saltwater corrosion compared to type 304. SS316 is often used for building nuclear reprocessing plants.
- 400 Series— ferritic and martensitic chromium alloys
 - Type 408— heat-resistant; poor corrosion resistance; 11% chromium, 8% nickel.
 - Type 409— cheapest type; used for automobile exhausts; ferritic (iron/chromium only).
 - Type 410— martensitic (high-strength iron/chromium).
 - Type 416
 - Type 420— "Cutlery Grade" martensitic; similar to the Brearley's original "rustless steel". Also known as "surgical steel".
 - Type 430— decorative, e.g., for automotive trim; ferritic.
 - Type 440— a higher grade of cutlery steel, with more carbon in it, which allows for much better edge retention when the steel is heat treated properly. It can be hardened to Rockwell 58 hardness, Also known as "razor blade steel". Available in three grades 440A, 440B, 440C (more common) and 440F (free machinable).
- 500 Series— heat resisting chromium alloys
- 600 Series— martensitic precipitation hardening alloys
 - Type 630— most common PH stainless, better known as 17-4; 17% chromium, 4% nickel