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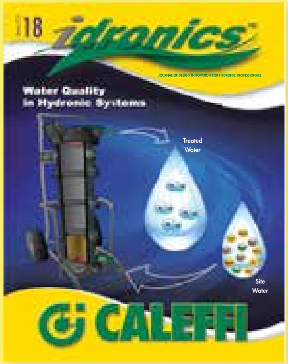
Water Quality in Hydronic Systems

CALEFFI



A Technical Journal
from
Caleffi Hydronic Solutions

CALEFFI NORTH AMERICA, INC
3883 W. Milwaukee Rd
Milwaukee, Wisconsin 53208 USA

Tel: 414-238-2360
FAX: 414-238-2366

E-mail: idronics@caleffi.com
Website: www.caleffi.com

To receive future idronics issues
FREE, register online www.caleffi.com

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Caleffi North America, Inc.
3883 W. Milwaukee Rd
Milwaukee, Wisconsin 53208
T: 414.238.2360 F: 414.238.2366

Dear Hydronic and Plumbing Professional,

Water is the essential fluid in all hydronic systems. Its quality affects the system's efficiency, reliability, life expectancy, and the effectiveness of any chemical additives.

There is a "physical" aspect to water quality, and a "chemical" aspect.

The physical aspect involves procedures for ridding systems of gasses and solid impurities. The devices involved include dirt separators, air vents and magnetic separators. These have been discussed in previous issues of *idronics*, and most recently in *idronics* #15. To complement that information, the focus of this issue of *idronics* is on the chemical aspects of water quality.

The need for water treatment in today's hydronic systems appears to be widely recognized. A 2014 poll of ***Coffee with Caleffi™*** webinar attendees (contractors and designers) gave the following responses to the questions:

When do you choose to treat the initial fill water?

- On most installations 64%
- On some installations 28%
- Never 8%

When you treat initial fill water, what method do you prefer?

- Add chemicals 50%
- Demineralize 22%
- Soften 22%
- Combination or different method 6%

There were also many "write-in" questions submitted during this poll. These responses and questions revealed that while most hydronic heating professionals understand the need for water treatment, many do not know which approaches are required or preferred.

This issue of *idronics* was developed to address these concerns. It discusses problems that can develop within hydronic systems when water quality is ignored. It lays out procedures for converting raw water into high quality water. Emphasis is placed on demineralization for preparing water for use in hydronic systems. It concludes with procedures for testing, flushing, washing, demineralizing, and final adjustment of water quality. The objective is to ensure that the water within the system can provide optimal performance over many years of operation.

We hope you enjoy the 18th issue of *idronics* and encourage you to send us feedback by emailing us at idronics@caleffi.com.

Mark Olson

Mark Olson

General Manager & CEO

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Water Quality in Hydronic Systems

1. INTRODUCTION

The water within a hydronic system serves as a “conveyor belt” for heat. It moves heat from where it is generated to where it is needed in the system.

Water has one of the highest heat absorption abilities of any known material. A given volume of water can store almost 3,500 times more heat than the same volume of air when both materials undergo the same temperature change. This has huge implications regarding the *amount* of water versus the *amount* of air that must be circulated through a heating or cooling distribution system to deliver the desired heating or cooling effect. It’s the underlying reason that a ¾” tube carrying water can transport the same amount of heat as an 8” x 14” duct carrying air, assuming both distribution systems are sized using industry standards.

Figure 1-1

Water is also the “life-blood” of hydronic systems. Accordingly, just as we strive to maintain the health of our own circulatory systems, it’s important to maintain the “health” of water and water-based solutions that circulate through the hydronic systems we create and maintain.

Water in its pure form contains only hydrogen and oxygen. Pure water is colorless, tasteless and odorless. Unfortunately “pure” water does not exist in nature. Due to its solvent characteristics, all water from wells, springs or municipal distribution systems contains other materials. Examples include dissolved minerals such as calcium and magnesium; sediment such as fine silica sand or organic particles; dissolved gases such as oxygen, carbon dioxide and hydrogen sulfide; and microorganisms such as bacteria or algae. There can be wide variations in the impurities contained in water from one geographic location to another.

Figure 1-2

There can also be wide variations in the material chemistry of systems that are filled with water. Many new hydronic systems contain several different metals such as cast iron, copper, brass, aluminum, common steel and stainless steel. Most new systems also have components that contain small amounts of dirt or insects from previous storage, transport or on-site handling. Systems assembled with soldered copper will have residue from solder flux. Systems using steel or iron piping typically contain thread cutting oil or oily films created during manufacturing.

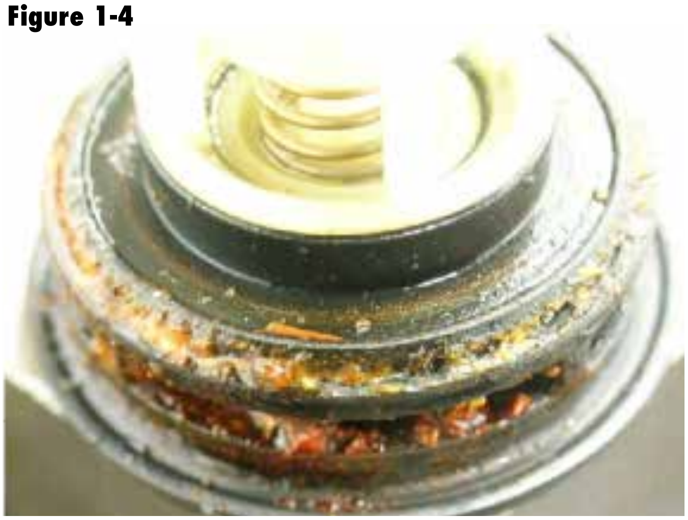
Some hydronic systems also contain *intentionally added* chemicals, such as propylene glycol or ethylene glycol antifreeze solutions. These chemicals can interact with the chemicals in the water, as well as the wetted internal surfaces of solid materials.

The dissolved oxygen content of the water in hydronic systems (not to be confused with the oxygen atoms contained in H_2O molecules) also plays a role in what chemical reactions take place. The presence of dissolved oxygen should be minimized through proper initial purging and ongoing capture and elimination of dissolved gases using high-efficiency air separators.

Older hydronic systems, especially those converted from steam to hot water, often contain sludge formed by oxidized iron. This sludge contains very fine particles that can become lodged between moving parts in valves and circulators, which impedes or totally stops the required motion. Figure 1-3 shows an accumulation of iron oxide particles on the permanent magnet rotor of a modern circulator. Figure 1-4 shows debris and scale that have jammed within a valve.

Figure 1-3

Figure 1-4



The combination of initial water chemistry, solid materials within the system, added chemicals and dissolved oxygen content can lead to a range of chemical reactions within the system. The resulting chemical interactions between these materials can have profound effects on the performance and life of the system.

DEFINING WATER QUALITY

In addition to H_2O molecules, the "ideal" water for use in hydronic systems would contain very little (but not zero) soluble substances (e.g., molecules or *ions* of other materials that coexist with H_2O molecules). Examples of the latter include calcium, magnesium, sodium, iron, chlorine, sulfur, oxygen, carbon dioxide and nitrogen. The "ideal" water would also be free of insoluble substances such as oils, grease, fine sand or metallic particles. It would be non-aggressive toward any of the metal, polymer or elastomeric materials in the system. It would also have very low electrical conductivity (to be discussed later) and would not contain microorganisms such as bacteria or algae.

Water in this "ideal" form is virtually impossible to find, especially when sourced from wells or municipal water systems.

As is true with many other design and installation issues, hydronic heating professionals need to provide realistic approximations of ideal conditions. In the case of water, they need to know if the water that's readily available at the site of the hydronic system is suitable for use in that system, either as it exists directly from its source, or after it has been modified by various processes. The goal is to operate the system with water that will not adversely affect the performance, reliability or life expectancy of the hydronic system.

Water quality in hydronic systems can be divided into two categories:

- Physical water quality
- Chemical water quality

Physical water quality relates to issues such as capturing and eliminating air and dirt from the system.

Over the last 25 years, there have been significant improvements in how North American hydronic heating professionals deal with *physical* water quality issues such as air and dirt removal. Devices such as microbubble air separators and magnetic dirt separators have found increasing application in North American systems. These devices have improved the performance of hydronic heating and cooling systems, and lengthened their service lives. Figure 1-5 shows an example of a magnetic dirt separator being “blown down” to remove the ferrous oxide sludge captured from within an older hydronic system.

Air and dirt removal techniques and hardware have been extensively covered in past issues of idronics. The latest information on air and dirt removal, including magnetic particle separation, is available in idronics #15. This publication can be downloaded for free at: http://www.caleffi.com/usa/en-us/technical-magazine

Figure 1-5a

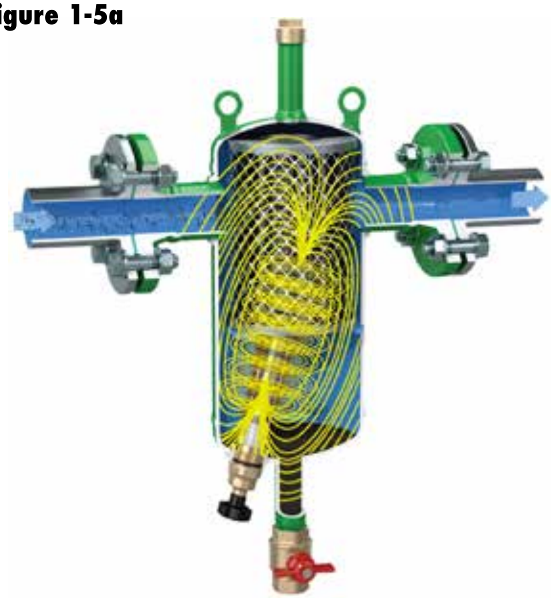


Figure 1-5b

Figure 1-6

Chemical water quality deals with modifying or eliminating various chemical substances in water so that it is well-suited for use in a hydronic system. Examples of the latter include reducing chemical impurities, adjusting the pH value of the water and ensuring that chemicals added to the water, such as a glycol-based antifreeze, do not cause eventual performance and reliability issues.

Ideally, *every new system* would have its chemical water quality adjusted to optimal conditions. Doing so could eliminate subsequent scaling and corrosion problems over the life of the system.

Unfortunately, many existing North American hydronic systems are installed with little if any attention to chemical water quality. Many are just filled with whatever water is available on site. Some will provide many years of operation because of a "lucky" set of circumstances involving the purity of the water source, the materials used in the system, the care taken when assembling the system and its subsequent operation and maintenance. Other systems will experience premature component failure, such as shown in figure 1-7, or widespread corrosion issues due to an "unlucky" combination of these factors.

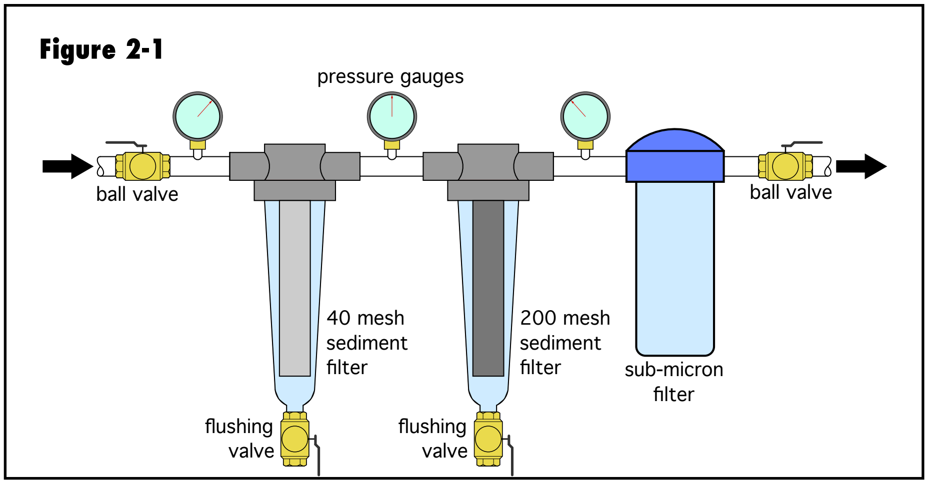
Figure 1-7

Courtesy of Rich Swatton

If on-site water goes into a system equipped with good air and dirt removal details, that system will probably operate fine *initially*. However, with age, problems associated with poor *chemical* water quality can appear. That appearance may be noted as visible discoloration or odor when a sample of water is drawn from the system. It might also be detected as a low pH value, indicating the water has turned acidic. It might also appear as small "pinhole" leaks through tubing or other thin-wall components. The latter usually indicates widespread internal corrosion that may require extensive component replacement or repiping.

This issue of idronics focuses on *chemical* water quality. It discusses the basic theory related to the chemical interactions that are often seen in hydronic systems. It will also cover methods and materials for adjusting water with poor chemical quality so that it is well-suited for use in closed-loop hydronic systems.

2. CHARACTERISTICS THAT DETERMINE WATER QUALITY



Water in its purest form would only contain H_2O molecules. However, due to its ability to act as a solvent, it is very difficult to create or maintain water in this pure form. As water comes in contact with other materials in the atmosphere or in the ground, it "dissolves" these materials. Molecules of these other substances coexist with molecules of water. The presence of these other substances is usually *not* detectable by looking at the water. A glass of water that appears perfectly clear could still contain millions of molecules of other substances.

This section discusses several *undesirable* characteristics of water that result from its ability to dissolve and transport other materials. These characteristics are discussed in the context of water use in hydronic heating or cooling systems. The underlying cause of the undesirable characteristic is presented. Methods for correcting these undesirable characteristics are also discussed.

TURBIDITY

Turbidity is a measure of the optical clarity of water. It is caused by the scattering of light due to very fine particles suspended within water.

Water drawn from sources such as wells, lakes, or rivers usually contains very fine particles of organic and inorganic matter. Examples include silt, clay, silica, microorganisms, and decomposing plant material. These materials affect the clarity of the water, making it appear slightly (or significantly) cloudy when a sample is viewed through a clear container. The turbidity of water can vary drastically, especially if the water comes from surface sources.

By definition, turbidity is caused by suspended particles that are *less than 1 micron in diameter*. Larger particles in the range of 10 to 100 microns are referred to as suspended solids.

Turbidity should not be confused with water color. It is possible to have a sample of water that shows a color tint due to the specific ions it contains, but without turbidity.

If water showing signs of turbidity is being considered for use in a hydronic system, that water should be sent through a filtering system capable of removing sub-micron size particles. This degree of filtration is achievable when specific replaceable cartridges are used in cannister-type filtering devices. It can also be accomplished using activated carbon filters.

A common approach is called "step down filtration." It uses one or more blow down type filtering devices to capture larger suspended particles upstream of the submicron filter, as shown in figure 2-1. This approach prolongs the life of the submicron filter. The upstream filters can remove particles sizes from 700 down to approximately 15 microns depending on the mesh size of their screens, and can be quickly backwashed.

MICROBIAL CORROSION

Some ground water sources contain microbes that can establish themselves in copper tubing when water temperatures remain between 75 and 135 ºF. The microbes feed on carbon contained in drawing lubricant residue within the copper tubing. Once established, these microbes will acidify the grain boundaries in the copper. This causes a slow erosion of the copper, and could lead to pinhole leaks over the course of 10-15 years.

It is also possible to have microbes that feed upon iron components within a hydronic system. They are often carried into the system by untreated well water, or water from surface sources. Their presence is usually indicated by water having a reddish or brown color. Some bacteria will also produce slimes inside the system and pungent odors when water samples are evaluated.

Cutting oils and residual solder flux can both serve as food sources for certain bacteria. The best defense against microbial corrosion is to remove the food source when the system is commissioned. This is be done by combining the effects of high performance air and dirt separation (to remove as much dissolved oxygen and "dirt" from the system as possible), followed by chemical cleaning, and use of a film-forming additive. The latter two methods are described in section 4.

SCALING

Scaling is caused by minerals such as calcium and magnesium, which enter a hydronic system with the fill water. These minerals typically exist as chemical compounds called "salts," which are dissolved in the water. Examples include: calcium carbonate ($CaCO_3$), calcium phosphate ($Ca_3(PO_4)_2$), calcium sulfate ($CaSO_4$), calcium chloride ($CaCl_2$), magnesium chloride (MgCl2), or sodium chloride (NaCl), and silica.

The common term used to describe the presence of these salts in groundwater or municipal water is "hardness." The greater the amount of salts, the "harder" the water. Water hardness can vary significantly with location. Figure 2-2 shows a map of typical water hardness for different locations within North America. The hardness of water is referred to by two types of measurements: grains per gallon (gpg) or parts per million (ppm). The conversion formula: 1 gpg x 17.1 = 1 ppm.

CHEMICAL NATURE OF SALTS

Salts are formed when positively charged ions (called cations) combine with negatively charged ions (called anions), such that the resulting compound is electrically neutral. Many salts will dissolve in water. This causes the salt to divide into positive and negatively charged ions. These ions can move about within water, as depicted in figure 2-3.

As the temperature of the water changes, its ability to hold these ions in solution changes. Some salts, such as sodium chloride (NaCl) are *more* soluble in warmer water. As the temperature of the water increases, it can contain more of these soluble salts, or ions formed when these salts dissolve.

Other salts formed from calcium or magnesium become *less* soluble as water temperature increases. As the ability of water to hold these compounds "in solution" decreases with increasing temperature, they eventually precipitate out to form deposits on surrounding metallic and non-metallic surfaces.

Figure 2-2

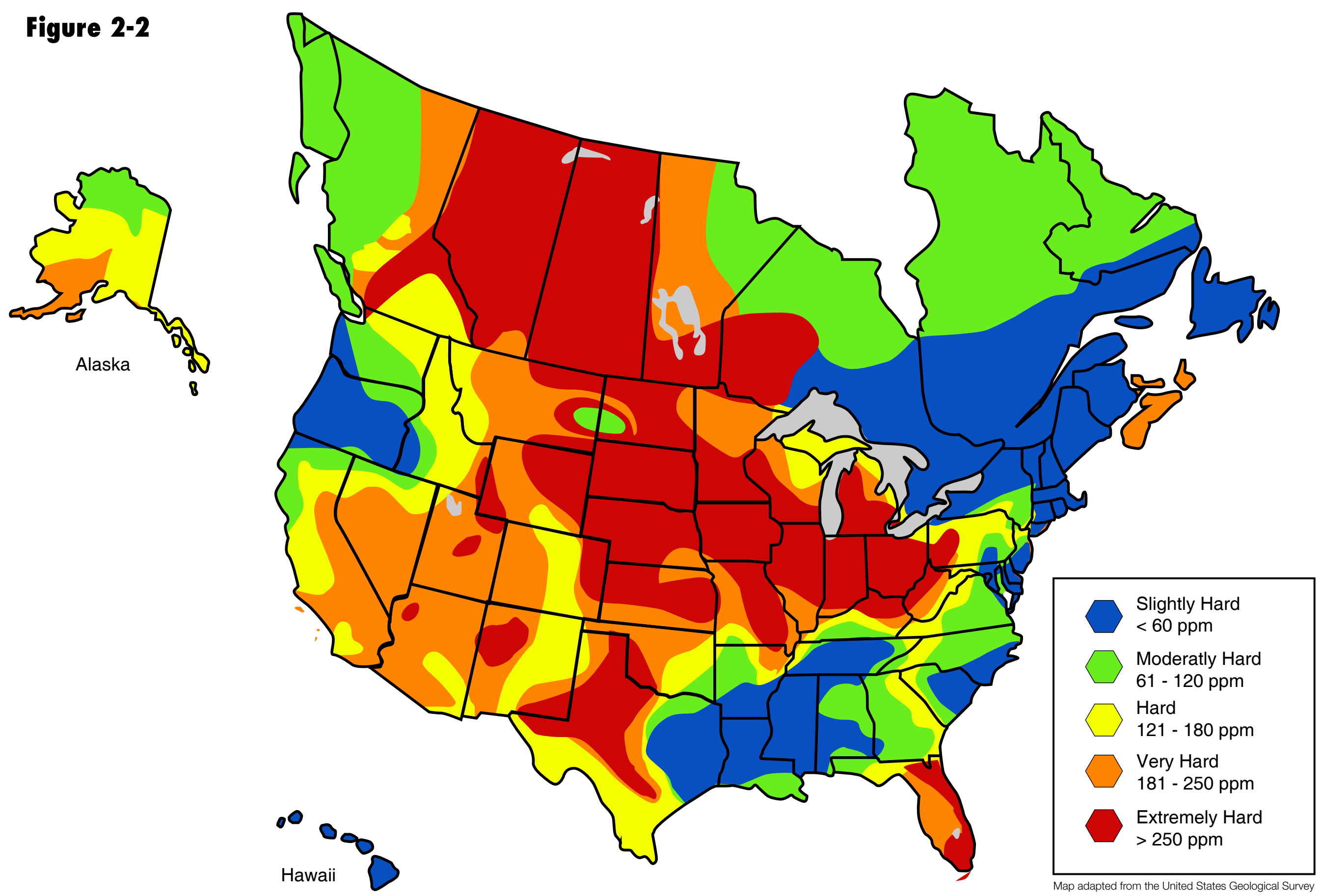
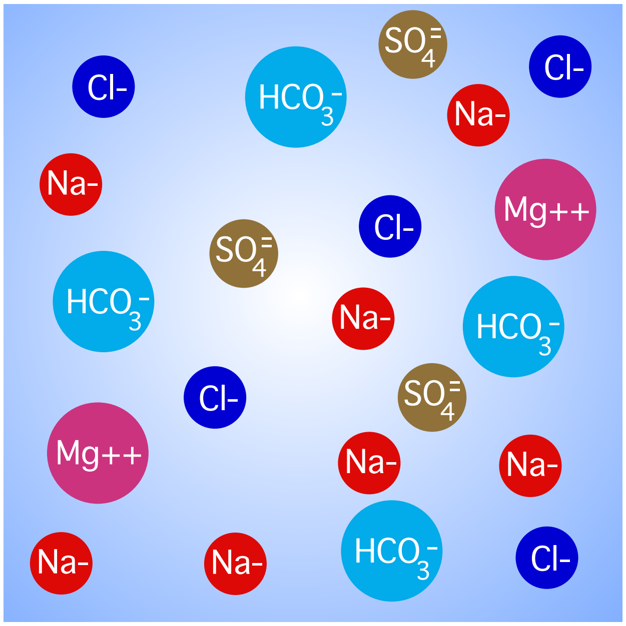


Figure 2-3



The higher the temperature of the surface in contact with the water, the greater the potential for scale formation. This is why scale often forms on the bottom of tea kettles.

It's also why scale forms on the wetted internal surfaces of boiler heat exchangers. Figure 2-4 shows a severely scaled stainless steel firetube heat exchanger from a modulating/condensing boiler.

The "flakes" seen in figure 2-4 are formed on the hottest portion of the heat exchanger due to precipitation of dissolved minerals such as calcium and magnesium. Expansion and contraction of the heated surfaces eventually cause the accumulated scale to flake off from these surfaces and accumulate on the baffle plate below.

Figure 2-5 shows a similar situation. Dissolved minerals have precipitated out of solution and formed scale against the hottest surfaces within a water-tube boiler heat exchanger. In this case, those surfaces are the inside of the water tubes toward the radial center of the heat exchanger.

The scale that accumulates on boiler heat transfer surfaces will have a major effect on the rate of heat transfer across those surfaces. The accumulating scale creates significant thermal resistance between the water and the metal wall of the boiler heat exchanger.

Figure 2-4

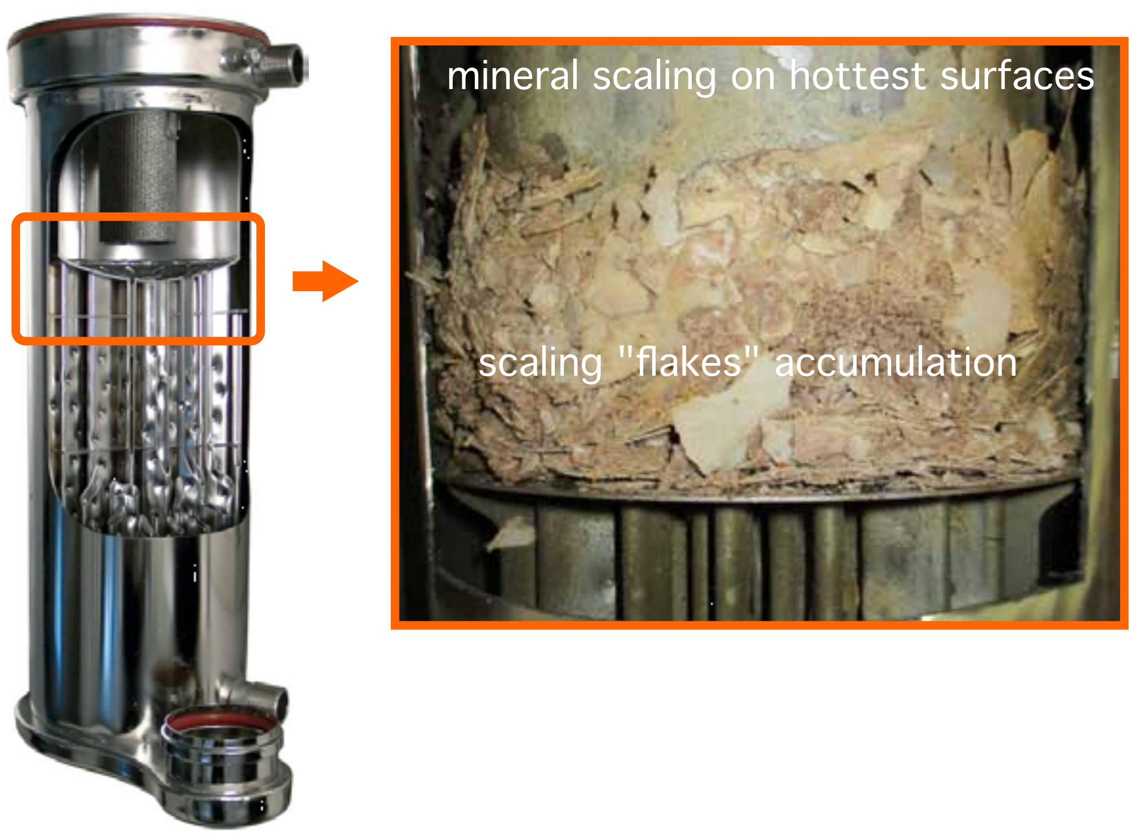
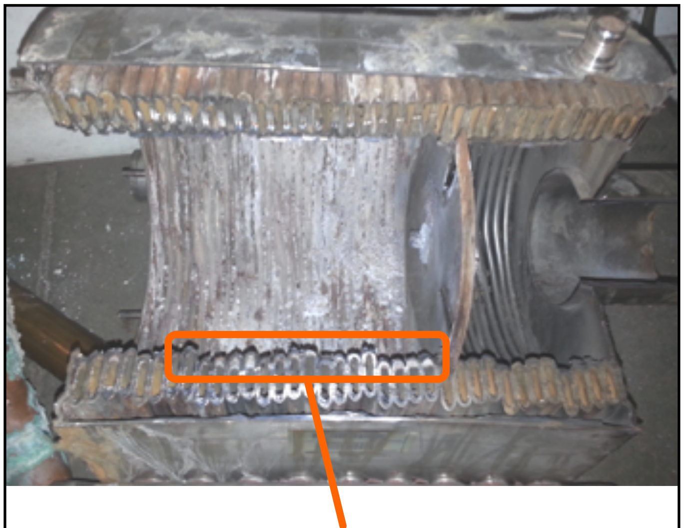


Figure 2-5

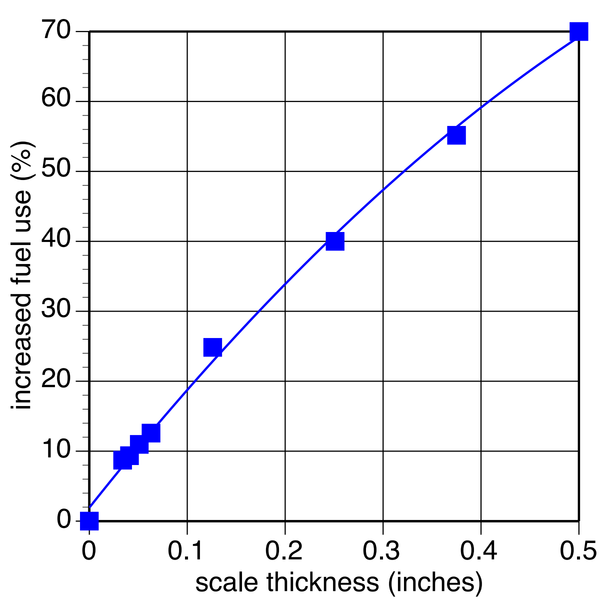


mineral scaling on inner tube surfaces facing combustion zone

The estimated increase in fuel use due to scale formation, based on research at the University of Illinois and U.S. Bureau of Standards, is shown in figure 2-6.

The added thermal resistance causes a corresponding increase of the combustion side surface temperature of the boiler heat exchanger. This can overheat surfaces, leading to warpage (as seen in figure 2-7), metal blistering (as illustrated in figure 2-8), mechanical stress failure, or holes burned through the walls of the boiler's

Figure 2-6



heat exchanger. Any of these can ruin the boiler's heat exchanger and lead to a costly replacement.

The accumulation of scale also increases the flow resistance through the boiler's heat exchanger, reducing flow rate. Insufficient flow often leads to inadequate heat delivery and loss of comfort.

Figure 2-7

Figure 2-8

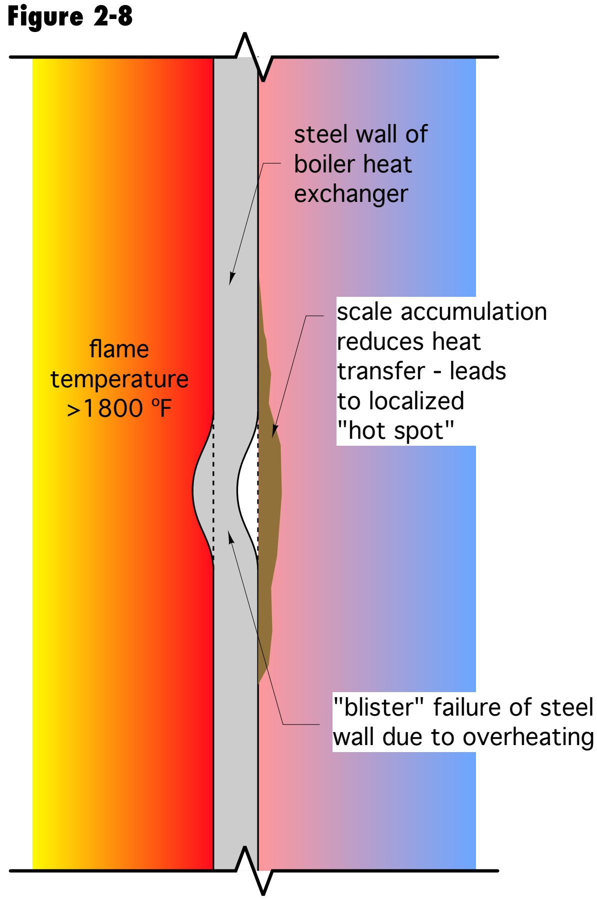


Figure 2-9

Courtesy of Ray Parent

Figure 2-10

Figure 2-9 shows how scaling can also constrict the flow path through a copper tube.

Scale formation is often associated with "hard water" in potable water plumbing systems. These systems handle fresh water, which may provide a continuous source of dissolved minerals, and thus, present significant opportunity for scaling. However, scaling can also occur within hydronic systems.

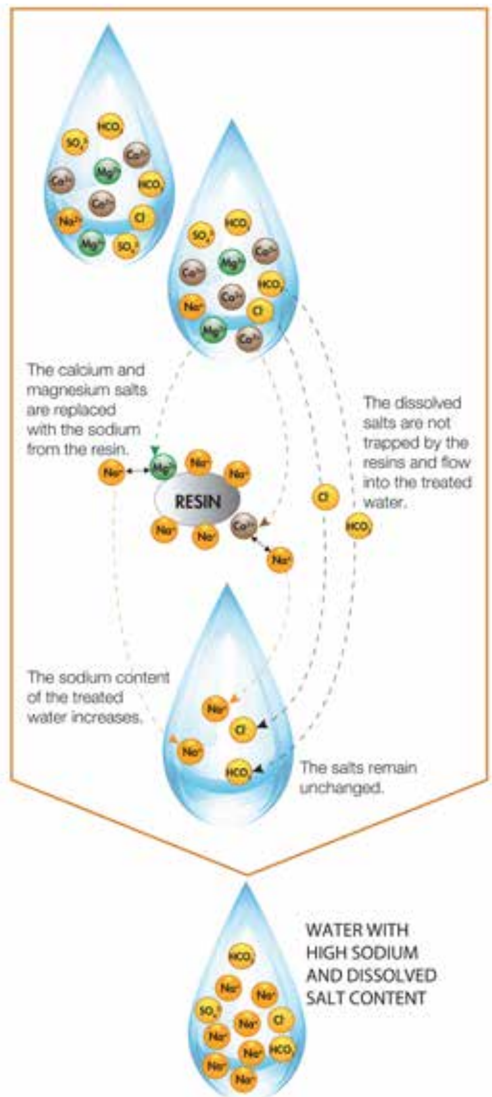
TREATMENT FOR HARD WATER SCALING

The most common treatment for hard water is to "soften" it using an ion exchange process. This is the process commonly used in residential water softeners.

During softening, the positively charged calcium ions (Ca^{++}), magnesium ions (Mg^{++}), and manganese ions (Mn^{++}) that are present in the water make their way into thousands of tiny resin beads contained in a standing column. Figure 2-10 shows a magnified view of these resin beads, which are porous and only about 0.6 mm in diameter.

The resin beads are made of organic polymers that have a higher affinity (e.g., attraction) for calcium, magnesium and manganese than they do for sodium. The chemical reaction that occurs within the resin bead column exchanges two sodium ions (Na+) for each calcium, magnesium or manganese ion captured. The net result is an *exchange* of sodium ions for calcium, magnesium and manganese ions. The sodium ions bond to other ions within the beads, creating salts such as sodium sulfate. These salts do not have the scaling potential of the ions originally in the water, but they do leave the water with significant electrical conductivity, which is not desirable. Figure 2-11 illustrates the ion exchange that occurs in a typical water softener.

Figure 2-11



Although water softening is commonly used to control scaling in potable water systems, it is not recommended for use with water that will be used in hydronic systems. The reason is that the sodium added to soften the water also causes it to remain electrically conductive. This can accelerate other undesirable conditions such as galvanic corrosion.

DISSOLVED MINERALS

The ion exchange process used in common water softeners *exchanges* the mineral salts that cause scaling with a sodium-based salt that does not cause scaling. It does not strip all ions from the water. Although often adequate for correcting hard water in potable water plumbing systems, *softening is not the preferred method for improving water quality in hydronic systems.*

TREATMENT TO REMOVE MINERALS (E.G., DEMINERALIZATION)

The preferred process for removing *nearly all* minerals from water is known as demineralization. As its name implies, demineralization is a process that strips the source water of dissolved minerals. These minerals are soluble in water and exist as positively charged molecules called *cations*, or negatively charged molecules called *anions*. Demineralization causes these cations and anions to be “exchanged” with either *hydrogen cations (H+)* or *hydroxide anions (OH-)*. The latter two ions then recombine to form H_20 (e.g., pure water). In effect, the original cations and anions “disappear” from the source water and are replaced with molecules of pure water.

As in “ion exchange” water softening, demineralization is done by passing the source water through a vertical column filled with very small polymer (e.g., plastic) resin beads. These beads create an inert fill media through which water can flow, as shown in figure 2-12.

The resin beads are created with specific ions that are chemically bonded to porous polymer materials. These ions are “fixed” within the beads. They can react with other ions but cannot leave the beads.

Some beads are formulated with ions that attract positively charged cations in the water. These “fixed” ions attract the undesirable cations such as calcium (Ca^{++}), magnesium (Mg^{++}) and sodium (Na^{+}). When a cation such as (Ca^{++}) enters a bead, it is captured, and as a result, two hydrogen cations (H^{+}) are released from the bead. The two positive charges of the entering cation (Ca^{++}) are balanced by the positive charges of the two exiting cations (H^{+}). This ion

Figure 2-12

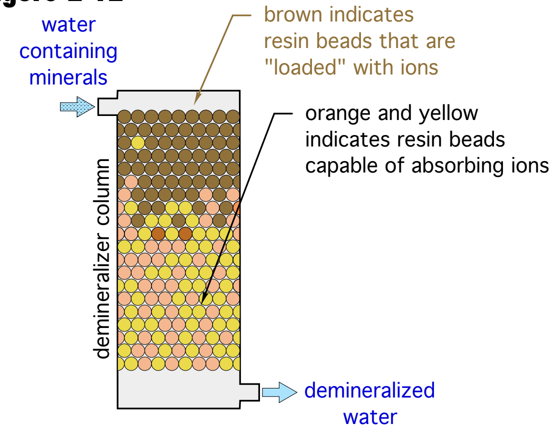
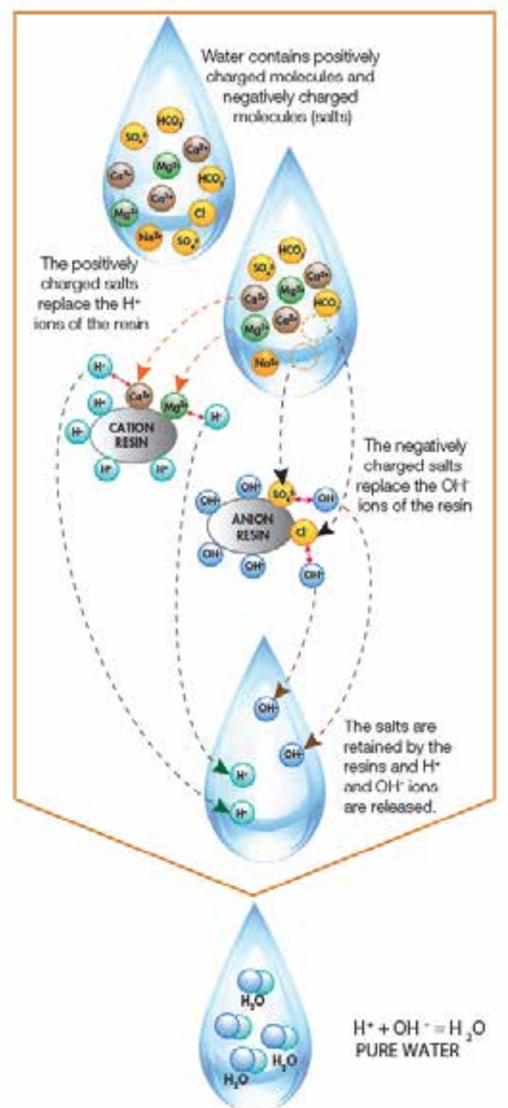


Figure 2-13



exchange also occurs when a single magnesium cation (Mg^{++}) enters a resin bead and is exchanged for two (H^{+}) cations. A sodium cation (Na^{+}) being captured within a bead only releases one (H^{+}) cation. In all cases, the total positive charges of the cations captured equal the total positive charges of the hydrogen cations released from the bead. Thus, the bead remains electrically neutral.

Other beads are created with ions that attract negatively charged ions (e.g., anions) in the water. For example, when a chlorine anion (Cl^{-}) enters a bead, the resulting reaction captures it and releases a single hydroxide anion (OH^{-}). When a carbonate ion (CO_3^{--}) enters a bead, it is captured, and the resulting reaction releases *two* hydroxide ions (OH^{-}). The total negative charges of the captured anions are balanced by the total negative charges of the anions leaving the bead.

The hydrogen cations (H+) immediately react with the hydroxide anions (OH-) to form H_20 (pure water), as shown in figure 2-13.

Nearly all cations and anions in the water passing through a modern demineralizer cartridge are stripped from the water. This can be verified by measuring the electrical conductivity of the demineralized water, which will be discussed later.

This ion exchange process is independent of the flow direction through the resin bead column. Although the illustrations in this section show water pushed downward through a demineralizer column, water can also be demineralized when pushed upward through a column by a pressure source.

The resin beads used in demineralization eventually reach a point where they are “fully loaded” with undesirable ions and can no longer exchange these ions for ions that will combine to form pure water. This process is illustrated in figure 2-14, with the brown circles representing resin beads that are fully loaded.

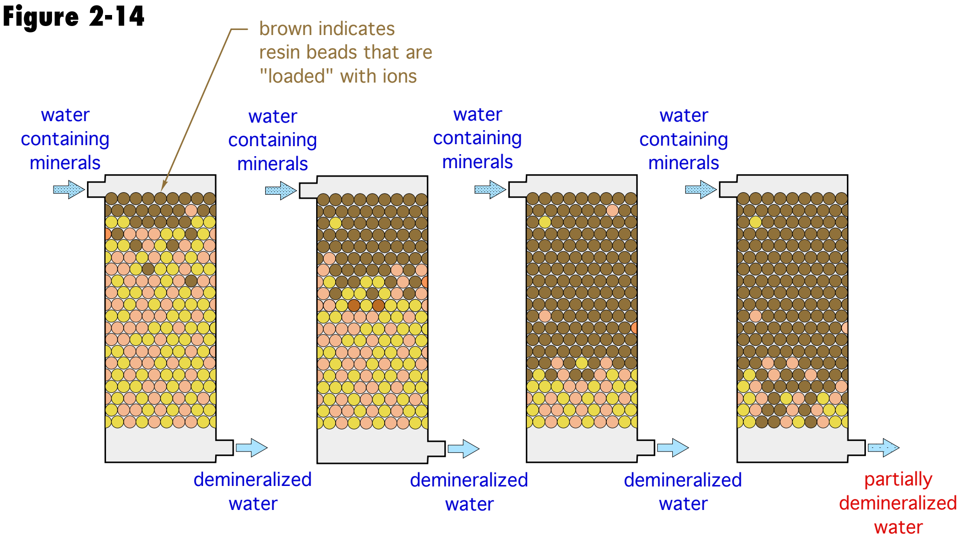
The resin bead column eventually reaches a condition where the number of mineral ions in the *discharge* water rises beyond acceptable limits. This is called “leakage,” and represents a condition where the resin beads either have to be regenerated or replaced.

It is possible to chemically regenerate the resin beads in a demineralizer column, restoring their ability to further absorb undesirable cations and anions. However, the strong acids and base chemicals needed and the processes involved do not lend themselves to small applications. Instead, the “spent” beads are discarded and replaced with new beads. The spent resin beads are not toxic. They only contain the ions that were in the source water. In most cases, they can be disposed of in recyclable trash.

CONDUCTIVITY TESTING

The presence of ions in water affects its electrical conductivity. In the absence of *all* ions, water has zero electrical conductivity. Water with zero ion content is only possible through distillation or reverse osmosis. *Such water is NOT desirable in hydronic systems.* Water that has been totally stripped of ions can combine with carbon dioxide to form carbonic acid. This can lead to metal erosion and other corrosion reactions. This can lead to metal erosion and other corrosion reactions. Water with zero conductivity would also prevent proper operation of low water cutoff devices, such as those required by code in many hydronic systems.

Figure 2-14



The ion content of water can be determined by testing its electrical conductivity.

One common way to express the degree to which water has been demineralized is through an index called *Total Dissolved Solids* (TDS). The fewer the ions in the water, the lower the TDS reading. TDS values are expressed in parts per million (abbreviated as PPM), or in milligrams per liter (mg/L), which is equivalent to PPM.

In a laboratory, the TDS value can be determined by boiling off a precisely measured weight of water and then weighing the solid residue left behind. Most untreated water from rivers, lakes or wells will have a TDS value between 50 and 500 PPM. In contrast, sea water can have a TDS value as high as 40,000 mg/L or 40,000 PPM.

To ensure proper operation of low-water cutoff devices, the water used in hydronic systems should have a TDS reading of at least 10 PPM. This provides sufficient mineral content to allow an electrical current to pass through the water at the probe of a low-water cutoff. A suggested maximum value for the TDS of water in a hydronic system is 30 PPM. This limits electrical conductivity, and thus, discourages galvanic corrosion, as well as other corrosion reactions that depend on electrical currents passing through water.

Figure 2-15

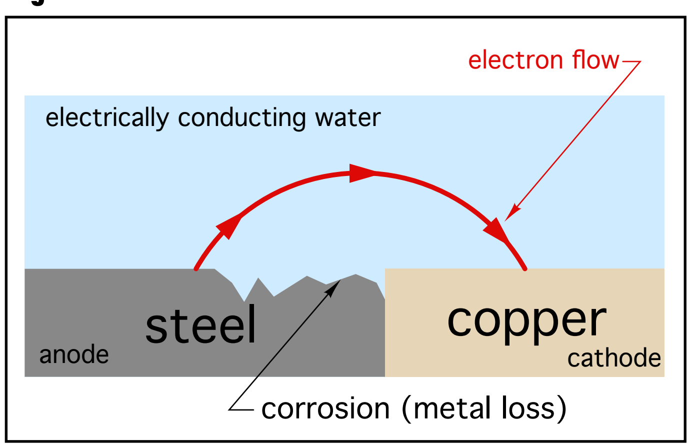
The TDS value of water can also be determined using a Caleffi meter NA575002 shown in figure 2-15. This particular meter can also be set to read the pH value and temperature of the water.

GALVANIC CORROSION

When different metals are in contact with each other, and an electrically conducting fluid (such as water with a high concentration of ions) is in contact with both metals, an electric current will flow between them. This is called a galvanic cell, and the chemical reactions that occur are similar to those in a battery. One metal acts as the anode of the galvanic cell, while the other metal serves as the cathode. Electrons flow from the anode to the cathode. The loss of electrons by the anode will cause it to corrode at a higher rate than if it were not part of a galvanic cell. The gain of electrons by the cathode will cause it to corrode, *but at a rate slower than if it was not part of a galvanic cell.* The latter reaction is sometimes intentionally used to reduce the rate of metal corrosion in large steel structures such a bridges, towers and underground storage tanks. It is called cathodic protection.

An example of galvanic corrosion is when a copper pipe fitting is screwed into a steel thread, and both materials are wetted by a fluid that is electrically conducting (such as water with a high concentration of dissolved minerals existing as ions). The steel serves as the anode, the copper serves as the cathode, and the water containing a high concentration of ions provides the pathway for the electrical current, as shown in figure 2-16.

Figure 2-16



The loss of electrons from the steel will eventually show as pitting and the characteristic orange color of oxidized iron.

The strength of the galvanic cell depends upon the electrode potential of the two metals involved and the electrical conductivity of the water that contacts them.

Figure 2-17

The electrode potential of the metals is often referred to as their "nobility," which is shown in figure 2-17.

Highly noble metals such as gold, titanium and high nickel content copper alloys act as strong cathodes. Lower nobility metals such as cast iron, low carbon steels, zinc and magnesium serve as strong anodes.

Magnesium, in particular, is often used as a "sacrificial anode" in tank-type water heaters. If the water in the heater contains dissolved minerals (e.g., ions), a galvanic cell will be set up between the magnesium anode and any wetted areas of the steel tank wall, which serve as a cathode. The loss of electrons from the magnesium anode is intentional and serves to extend the life of the steel tank. Over time, the magnesium anode is consumed (e.g., "sacrificed") by this reaction and should be replaced to prolong the life of the steel tank.

It is obviously not practical to construct hydronic systems entirely of highly noble metals such as gold or high nickel copper alloys. Materials such as copper, steel and cast iron have been, and will continue to be, the most common metals used in hydronic systems. *The most cost-effective way to minimize galvanic corrosion in hydronic systems is to ensure that the water in the system is minimally conductive. This can be done by demineralizing the water to remove all but a trace of ions.* The small amount of ions that remain minimize the overall corrosion potential of the water and allow enough conductivity for proper functioning of low-water cutoff devices.

It is also good practice to use metals with intermediate nobility between two metals that have significantly higher and lower nobility. For example, a brass or bronze union used between a copper tube and a cast iron or steel threaded component will reduce the rate at which the lower nobility metal (in this case, cast iron or steel) is corroded.

3. DEMINERALIZING DEVICES

Demineralized water is often specified for use in commercial hydronic systems. It is possible to buy demineralized water and have it trucked to the site, as depicted in figure 3-1. However, this can be expensive based on location, site access, on-site handling requirements, temperature at time of delivery and other logistics.

Figure 3-1

Courtesy of PURETEC Industrial Water

In most cases, it is significantly less expensive to create demineralized water on-site rather than purchasing demineralized water and having it delivered to the site.

Caleffi has developed a family of products that make the benefits of demineralized water available to hydronic heating professionals. The anchor product is the HYDROFILL demineralizer, which is easy to transport, operate and maintain. Figure 3-2 shows the larger and smaller versions of the HYDROFILL.

Figure 3-2

The bodies of the HYDROFILL units are made of engineered polymer. The head of the unit is rotated to disconnect it from the cylindrical body, as seen in figure 3-3.

Figure 3-3

The body is designed to hold highly permeable bags containing the resin beads needed to demineralize water. These bags are simply lowered into the top of the body, as shown in figure 3-4.

Figure 3-4

The smaller HYDROFILL holds two resin bags. The larger HydroFILL column holds 4 bags. Once the resin within these bags is "spent," the head of the HYDROFILL is opened and the bags are lifted out. These bags only contain polymer resin beads and the ions that have been stripped from the site water. These are the same ions that were present in the site water. The spent resin bags can be disposed of in recyclable trash.

The HYDROFILL also comes with a meter that shows the total dissolved solids (TDS) value of the water leaving its upper port. This meter, shown in figure 3-5, can be used to verify the effectiveness of the resin beads and determine when the resin beads require replacement. The resin bags should be changed when the meter indicates water is leaving the HYDROFILL with a TDS value that is approaching the limits allowed by the boiler or chiller manufacturer's water specifications. In the absence of such specifications, a suggested criteria for resin changeout is when the HYDROFILL TDS meter reaches 30 PPM.

Figure 3-5

Procedures for using the HYDROFILL to provide demineralized water in small and large systems are described in the next section.

4. COMMISSIONING HYDRONIC SYSTEMS FOR HIGH WATER QUALITY

The benefits of using demineralized water in hydronic systems have been discussed. The hardware required to produce demineralized water has also been introduced. However, simply filling a newly assembled hydronic system with demineralized water will not achieve optimal fluid quality. This section describes several procedures that lead to internally clean systems operating with optimal water quality.

PRESSURE-TEST THE SYSTEM

Pressure testing should be a routine aspect of commissioning any hydronic system. It verifies if the system is free of leaks. If leaks are detected, they can be located and corrected before any liquid is added to the system.

Pressure testing should be done using air rather than water. If any leaks are found, the air pressure can be quickly released so that the leak can be repaired. If water is used for pressure testing, it will have to be drained before any type of soldered or welded joint can be repaired. Using water for pressure testing also brings the risk of freeze damage if the testing is done during cold weather. Air leakage also doesn't carry the risk of water damage to surrounding materials should a leak remain uncorrected for several minutes after the pressure test begins.

Air pressure testing begins by closing the caps on any automatic air venting devices in the system. This includes air separators, combined air and dirt separators, and any float-type vents in the system. Also be sure the drain ports on any purging valves are closed.

If the system will be tested to a pressure approaching or exceeding the rated opening pressure of the system's pressure relief valve, the outlet of that valve should be *temporarily* plugged.

An easy way to add air to the system is through a Schrader valve that has been adapted to a female hose thread fitting, such as shown in figure 4-1.

Be sure a hose washer is inserted into the adapter fitting and screw it to the male hose threads on a drain valve. Add air using a portable air compressor.

Figure 4-1a

Figure 4-1b

With exception of specifications that require certain test pressures, there is no universally accepted pressure to which all hydronic systems should be tested. A suggested test pressure is 1.5 times the pressure relief valve rating, *assuming that all components in the piping system have a pressure rating that is at least 25% higher than this suggested test pressure*. If there are system components that are not rated for this pressure, they must be removed or temporarily isolated during the pressure test, or a lower test pressure must be used. If the test will be conducted at 1.5 times the rated relief valve pressure, the pressure relief valve must be *temporarily* plugged during the test.

Once the system reaches the desired test pressure, turn off the compressor, watch the pressure gauge and carefully listen for any escaping air. If the gauge pressure drops steadily, or if hissing sounds are heard, a leak is present.

Air hissing from a joint is an obvious leak. If no hissing is detected, the preferred procedure for finding leaks is to prepare a 50% solution of dishwashing detergent and water, and put this in a spray applicator bottle. Spray this solution on the joints in the system and watch for bubbles. It is best to check all accessible fittings in succession, and while there is still at least 20 psi air pressure in the system. Identify all leaks and take the necessary steps to correct them. Repressurize the system with air to verify that all leaks have been corrected.

When pressure testing, keep in mind that temperature changes to the air or hardware in the system will affect the pressure gauge reading. Air entering the system from a compressor is partially heated due to compression. As it cools within the system, its pressure will slowly decrease. Likewise, if the system is filled with compressed air when some or all the components are warm due to heating from soldering or influence from adjacent equipment, the pressure will drop as these components cool. Ideally, the system pressure should be verified as stable over 15-30 minutes when the components and air within the system remain at the same temperature.

Once the system is verified as leak-free, allow the air to escape by opening the cap on any automatic air vents and/or opening a drain valve. Verify that any temporary plugs installed in pressure relieve valves or piping from those valves have been removed. The system is now ready for a wash.

DEBRIS FLUSHING & CHEMICAL CLEANING

Newly assembled hydronic systems, as well as older systems that have been significantly modified, should be flushed to remove solid particles from the inside of the system.

Examples of debris found in many *newly assembled systems* include solder balls, metal chips and shavings, casting sand, sawdust, drywall dust, insects, paper labels and dirt that entered the piping during transportation, storage or handling on the installation site. Figure 4-2 shows an example of the debris flushed from a small, newly assembled hydronic system.

Figure 4-2

Figure 4-3

Courtesy of Ken Shockley, Battersby Danielson Associates

In older systems, especially those that once operated with steam rather than liquid water, there may also be scale fragments, as seen in figure 4-3, and iron oxide sludge. The system may also contain strands of hemp thread sealant or globs of hardened pipe dope.

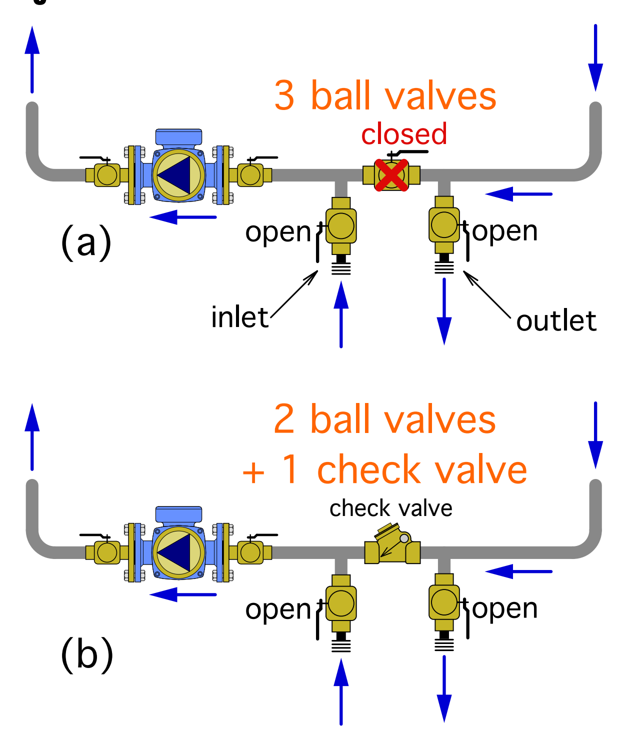
Chemical cleaning removes oils or greases from the internal surfaces of piping and other components in new systems. These substances come from thread cutting, residual soldering flux or small amounts of machining oil remaining inside components.

The preferred method for chemically cleaning the *inside* of a hydronic system is by circulating a hydronic detergent mixed with hot water through the system. When the cleaning solution has been sufficiently circulated, it is drained from the system, carrying the dissolved oil and grease residue with it.

Both debris flushing and chemical cleaning can usually be accomplished with the same procedure.

Experience has shown that flow velocities in the range of 5 to 6 feet per second are needed to entrain the type of debris particles often found in hydronic piping systems.

Figure 4-4ab



The system needs to be equipped with appropriate valves for adding fluid and removing both air and dirty fluid. There are several ways to do this.

Figure 4-5

One is to install three ball valves, as shown in figure 4-4a. Another is to install a check valve in combination with two ball valves, as shown in figure 4-4b. The pressure differential created by the purging flow holds the check valve in its closed position.

It's also possible to use a specialty valve, such as the Caleffi NA256011 purging valve shown in figure 4-5, to achieve the same functionality as the three ball valves.

When possible, purging valves should be located upstream of components such as circulators and heat exchangers. This minimizes the chance of flushing debris in the piping through these components.

During flushing and purging, hoses are connected to the inlet and outlet purging valves, and both valves are opened. The "inline" ball valve between the inlet and outlet valves (shown in figures 4-4a and 4-5) is closed. This forces fluid through the system in one direction, allowing air and returning fluid to exit the system very close to where it entered. Be sure the flow direction of filling and purging is the same as that allowed by any check valves in the flow path.

Flushing and purging begins by forcing water into the *inlet* purging valve at a high rate. In many projects, this flow can be created using the pressure available from the building's plumbing system.

Figure 4-6

Courtesy of Little Giant Pumps

If the building's plumbing system is not operational, or incapable of generating the required pressure, the flow needed for purging can be created using a flushing pump. In smaller systems, a portable submersible sump pump with a motor between 1/6 and 1/3 horsepower is usually sufficient. An example of such a pump is shown in figure 4-6.

Larger residential or commercial systems, or geothermal earth loops, may require a filling/flushing pump with more power. One option is to use a "flush cart," such as shown in figure 4-7. This cart is equipped with a 1/2 HP motor.

Figure 4-7

If even higher flow rates are needed, a swimming pool filter pump in the range of 1.5 to 2 HP can be used.

Large industrial or commercial hydronic systems, or extensive geothermal earth loop systems, can be filled and flushed using large engine-driven fluid handling devices, such as the one shown in figure 4-8.

The high flow rate of the entering water will push air through the piping. It will also entrain much of the debris

Figure 4-8

Courtesy of PurgeRite

within the piping. The objective is to force the air and debris from the system through the outlet purging valve.

If the system contains multiple branches, it is best to close all but one branch at a time to maintain the highest possible flow velocity within each branch as it is filled and purged.

If the system contains *instruments* such as flow meters or heat meters, care must be taken not to force debris through them. The debris could jam in small orifices or otherwise affect sensitive moving parts within these devices. If the flushing water enters the system close to the inlet of these devices, there is a minimal chance of debris being forced through them. However, if this is not the case, manufacturers of such equipment generally recommend that their hardware be removed from the system or fully bypassed until the initial flushing is complete.

One should also be careful not to flush debris into the small fluid passages of brazed-plate heat exchangers, compact mod/con boiler heat exchangers or the coaxial heat exchangers used on some heat pumps. Ideally, these components should be piped and equipped with isolating valves, and they should also be equipped with their own device-flushing valves that can be operated to fill and flush without using the potentially dirty water that has passed through the remainder of the system.

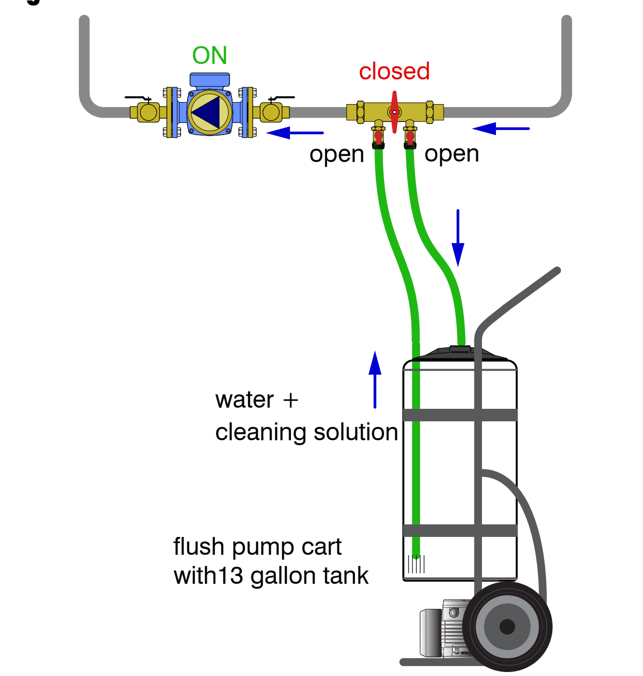
The flushing water pumped into the inlet purging valve will eventually begin flowing from the outlet purging valve. The outlet flow should be directed through a hose into a clean plastic bucket or barrel where debris can be easily seen.

Maintain flow until all branches have been individually flushed. Then open all branches simultaneously to achieve maximum flow rate through the system. If debris has been returned to the outlet bucket, stop the flushing and empty the debris from the bucket, or switch to another (clean) bucket. The goal is to observe when the flushing water is returning from the system with no entrained debris or air bubbles. At that point, the piping system is filled with “relatively clean” but untreated water.

INTERNAL WASHING

The next step is to add a chemical cleaning solution to the system and circulate it. The cleaning solution can be added to systems by pouring it into a clean flush cart tank and circulating it through the system using the flush cart pump, as illustrated in figure 4-9.

Figure 4-9



Turn on the flush pump and open both the inlet and outlet purging valves. The inline ball valve should remain closed. The cleaning solution will be injected into the system as an equal amount of water comes back into the tank.

Circulators in the system can also be turned on to create higher flow rates and ensure good dispersal of the cleaning solution through tightly fitting components within the circulators.

The solution needs to fully disperse within the system. A minimum circulation time of 1 hour is suggested for good mixing in smaller systems. *Manufacturers of hydronic cleaning solutions often recommend that the system be brought up to normal operating temperatures during this time to maximize the effectiveness of their cleaning solution.* If an existing system is suspected of containing hard scale, cleaning times can be extended, in some cases up to one week of continuous circulation.

After the recommended circulation of the cleaning solution, the system needs to be drained. Whenever possible, allow the cleaning water to drain by gravity into pails. When gravity flow stops, additional cleaning water can be forced from the system using compressed air injected at the inlet purging valve to force fluid from the outlet purging valve or other accessible drain valve locations in the system. Be sure all air vents are closed before flushing with compressed air.

The wash water should be disposed of based on the instructions provided by the supplier of the cleaning solution.

FINAL FILL & DEMINERALIZATION

The system is now ready for a final fill. The method used to refill the system, purge it and provide demineralized water will depend on the size of the piping and the associated required purging flow rate. The two procedures that follow are based on use of the Caleffi HYDROFILL for effective demineralization of the water.

(A) ONCE-THROUGH METHOD

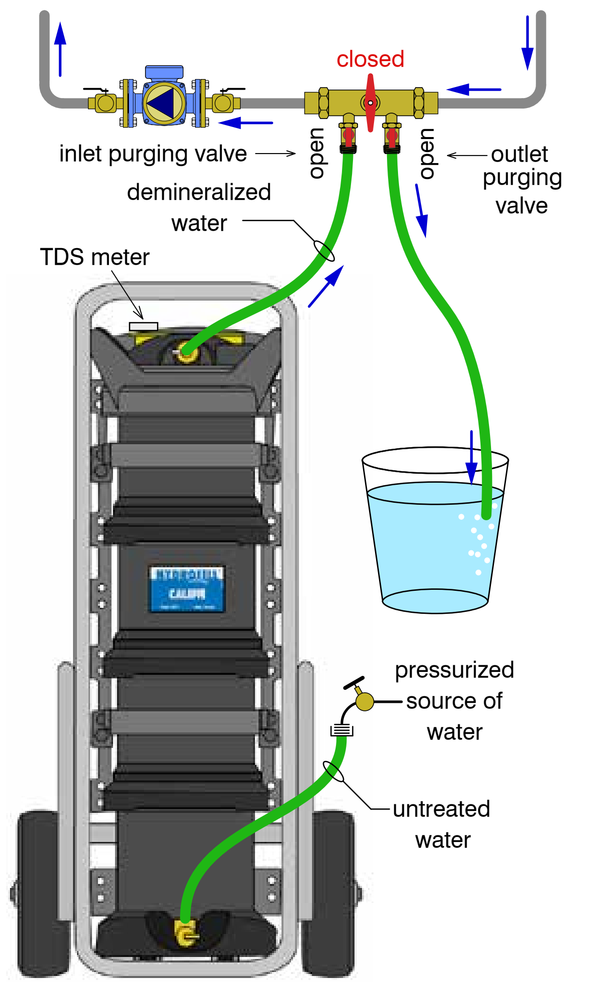
If the allowable flow rate through the HYDROFILL is sufficient to purge air from the piping, the once-through method can be used. The minimum suggested purging velocity in piping up to 2-inch size is 2 feet per second. The larger HYDROFILL unit can provide up to 12 gallons per minute flow of demineralized water. This should be adequate to purge piping up to 1.5-inch size. The smaller HYDROFILL can provide up to 6 gallons per minute flow. This should be adequate to purge piping up to 1-inch size.

These flow rates are based on delivering demineralized water to the system with a TDS reading between 10 and 30 PPM *in a single pass* through the HYDROFILL. The small residual ion content of the water provides sufficient electrical conductivity for proper operation of low-water cutoff (LWCO) controllers.

The objective of the once-through fill procedure is to provide sufficient flow to remove bulk air from the system, but also not to waste excessive amounts of demineralized water.

The HYDROFILL unit would be connected as shown in figure 4-10.

Figure 4-10



Untreated water from a pressurized source passes through a short hose connected to the bottom hose connection on the HYDROFILL. It is demineralized as it flows upward through the resin beads and exits from the upper hose connection. It flows through another short hose to the inlet purging valve on the system.

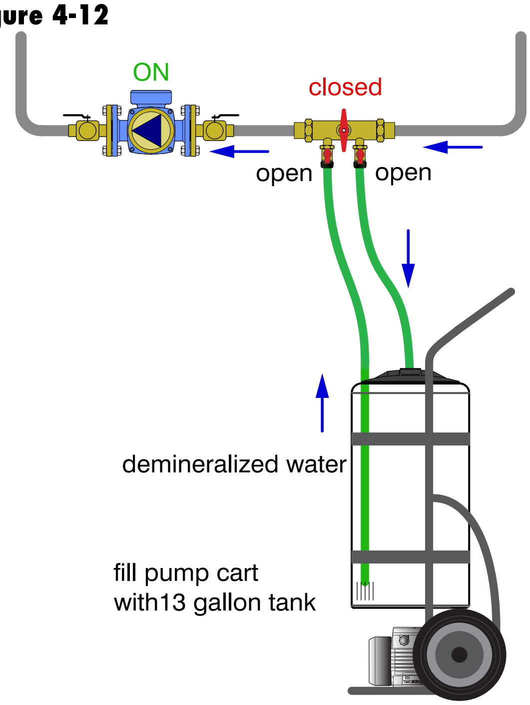
As the demineralized water enters the system, air is pushed out through the open outlet purging valve. A hose from this valve is routed to a clean pail or barrel to capture any water leaving the system during purging.

Maintain flow through the HYDROFILL into the system until a steady stream of water exits the outlet purging valve. The bulk air should now be purged from the system. Close the inlet and outlet purging valves simultaneously.

During fill and purging, periodically check the TDS meter on the HYDROFIL to verify that it does not rise above 30 PPM. See figure 4-11.

Figure 4-11

Figure 4-12



If the system has many branches that require individual purging, and thus, prolong the time over which purging is required, it is possible to fill a *clean* pump cart tank with demineralized water from the HYDROFILL, and then continue the purging process using the cart pump to circulate demineralized water through the system until all air is purged. This is shown in figure 4-12.

(B) RECIRCULATION METHOD

When the flow rate needed to purge the system is more than the maximum allowable flow rate through the HYDROFILL, the water can be demineralized *after* it is added to the system.

This approach requires recirculation through the HYDROFILL and periodic sampling of the system water to verify its TDS level.

Begin by filling the system with untreated water. Execute the previously described purging procedure to remove as much bulk air as possible using untreated water.

When the system is fully purged, connect the HYDROFILL unit, as shown in figure 4-13.

A short hose runs from the outlet purging valve on the system to the lower connection on the HYDROFILL. Another short hose runs from the upper connection on the HYDROFILL to the inlet purging valve on the system. Leave the latter hose loosely connected at the inlet purging valve to allow air to escape as the hose fills with water.

The inline ball valve between the inlet and outlet purging valve should be partially closed to force some flow through the HYDROFIIL.

Open the outlet purging valve to allow water to flow from the system into the bottom of the HYDROFILL. The system's automatic make-up water system should supply this flow. The water level will rise up through the resin bead column and out through the loose end of the other hose. Hold a bucket under the loose hose connection to catch this water. Tighten the hose connection to the inlet purging valve. The HYDROFILL and its attached hoses should now be filled with untreated water.

Figure 4-13

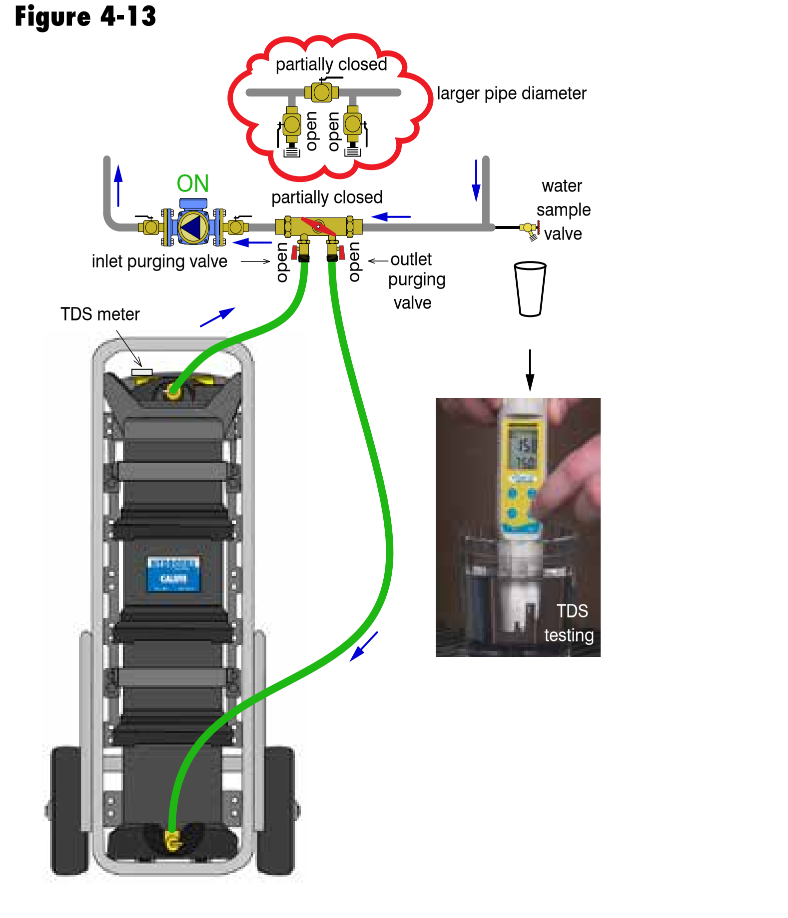


Figure 4-14

Turn on the system circulator(s) to create flow in the system. With the inline ball valve closed, this flow will be directed through the HYDROFILL.

Keep in mind that the TDS reading on the HYDROFILL monitor is that of the water leaving the HYDROFILL and not necessarily that of all the water in the system.

Allow this recirculation flow to continue for several minutes. Then, draw a sample of system water from another drain valve in the system into a clean plastic or glass cup. Test the TDS level of this sample using a hand-held meter such as the one shown in figure 4-14.

In most cases, the initial TDS level will drop rapidly as the untreated water makes its first pass through the HYDROFILL. The rate at which the TDS level drops will decrease with time. The ideal range for TDS is 10 to 30 PPM. Continue circulating the system water through the HYDROFILL, periodically sampling and testing the system water until the TDS level is acceptable.

When the demineralization process is finished, the demineralized water within the HYDROFILL can remain in it, unless it will be subject to freezing temperatures before its next use. In the latter case, the water should be drained through the valve at the bottom of the column.

Once the demineralization process has been completed, the system should be operated with the heat source on and all air separation and venting devices active. Whenever possible, the heat source should produce an outlet temperature of 140ºF or higher. This heating and circulation should be maintained for at least one hour. Raising the temperature of the water helps force dissolved gases out of solution. These gas molecules will coalesce to form microbubbles that can be captured by a high-performance air separator, such as a Caleffi Discal, and ejected from the system. The elimination of these gases helps stabilize the pH of the demineralized water.

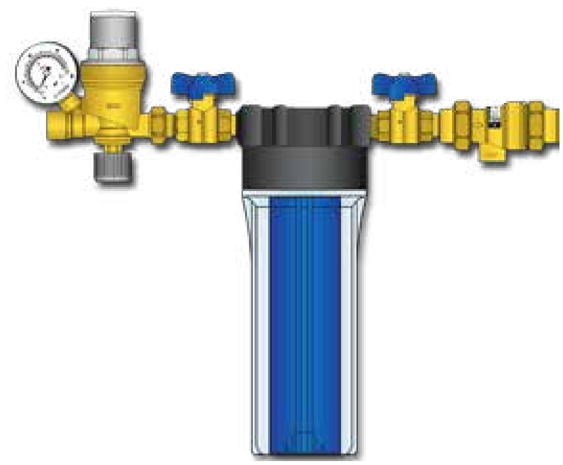
DEMINERALIZED MAKE-UP WATER

Most closed-loop hydronic systems lose small amounts of water over time. These losses come from weepage at air vents, valve packings or circulator flange gaskets. Fluid loss also occurs when a component such as a circulator is replaced.

A make-up water assembly consisting of a backflow preventer, pressure-reducing valve and pressure gauge is commonly used to automatically feed small quantities of fresh water into the system.

Over time, a standard make-up water assembly would allow untreated water to enter a system as demineralized water is lost. The untreated water could bring undesirable compounds, such as calcium carbonate, back into the system. To prevent this, Caleffi offers an enhanced make-up water assembly NA573022 that includes a demineralizer cartridge. This assembly is shown in figure 4-15.

Figure 4-15



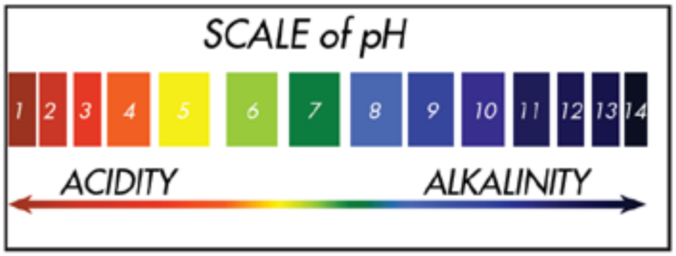
This assembly uses a special 10-inch cartridge insert containing the color changing resin beads necessary to demineralize water passing through it at relatively low flow rates. The cartridge assembly can be isolated by closing the two ball valves. The clear housing can then be unscrewed to remove and replace the cartridge.

The Caleffi cartridge will appear blue color when new. Its internal color will change to amber as the resin beads approach a spent condition. Each cartridge can demineralize approximately 30 gallons of water. This should provide several years of normal make-up water supply, assuming only minor water losses from the system occur.

PH ADJUSTMENT

The pH of a liquid is a number that expresses it acidity or alkalinity. A pH of 7.0 is neutral (e.g., neither acidic or alkaline). pH valves lower than 7.0 indicate acidity, while pH values greater than 7.0 indicate alkalinity. The pH scale ranges from 1 to 14, as shown in figure 4-16.

Figure 4-16



The pH scale is logarithmic. This means that a pH of 5.0 is 10 times more acidic than a pH of 6.0, etc.

Demineralizing water can lower its pH. Although demineralization removes most ions from water, it does not remove dissolved gases such as nitrogen, oxygen, and carbon dioxide. The latter gas will quickly react with the demineralized water to form a very weak carbonic acid (H_2CO_3), which lowers the water's pH.

It is possible for the pH value of demineralized water to *initially* drop into the range of 5 to 6 depending on the amount of carbonic acid formed. This pH value is lower than desired. Fortunately, the pH of water in closed-loop hydronic systems has demonstrated a tendency to rise with time. This time can be minimized by operating the system at its design heating temperature after it is filled with demineralized water. Doing so helps drive dissolved carbon dioxide molecules out of solution to form microbubbles. These bubbles can then be captured and ejected from the system by a high efficiency air separator such as a Caleffi Discal.

If system components such as the boiler require a specific pH value *when the system is installed*, it is possible to increase the water's pH by adding a "pH boost" chemical. This chemical may be part of an overall water treatment formulation, such as a film-forming product to be discussed next. If the "pH boost" chemical used in not part of such an overall formulation, it should be checked for compatibility with any other chemicals used in the system.

FILM-FORMING WATER TREATMENTS

Regardless of the water used, small amounts of oxygen can enter closed-loop hydronic systems over time due to molecular diffusion through polymer tubing, gaskets and pump seals. Good system detailing, such as the use of high-performance air separating devices and magnetic dirt separators, reduces the potential for this oxygen to negatively affect water quality.

The use of a "film-forming" water treatment product, specifically formulated for the multiple metals found in many new hydronic systems, further increases the long-term protection against oxygen-related corrosion. Figure 4-17 shows examples of products formulated to provide such protection.

Figure 4-17

Film-forming water treatments create extremely thin molecular films on metal surfaces that minimize interaction between those metals and any oxygen molecules in the system water. These films do not inhibit heat transfer. Because it strips out mineral impurities, the use of demineralized water enhances the effectiveness of film-forming water treatments.

SUMMARY:

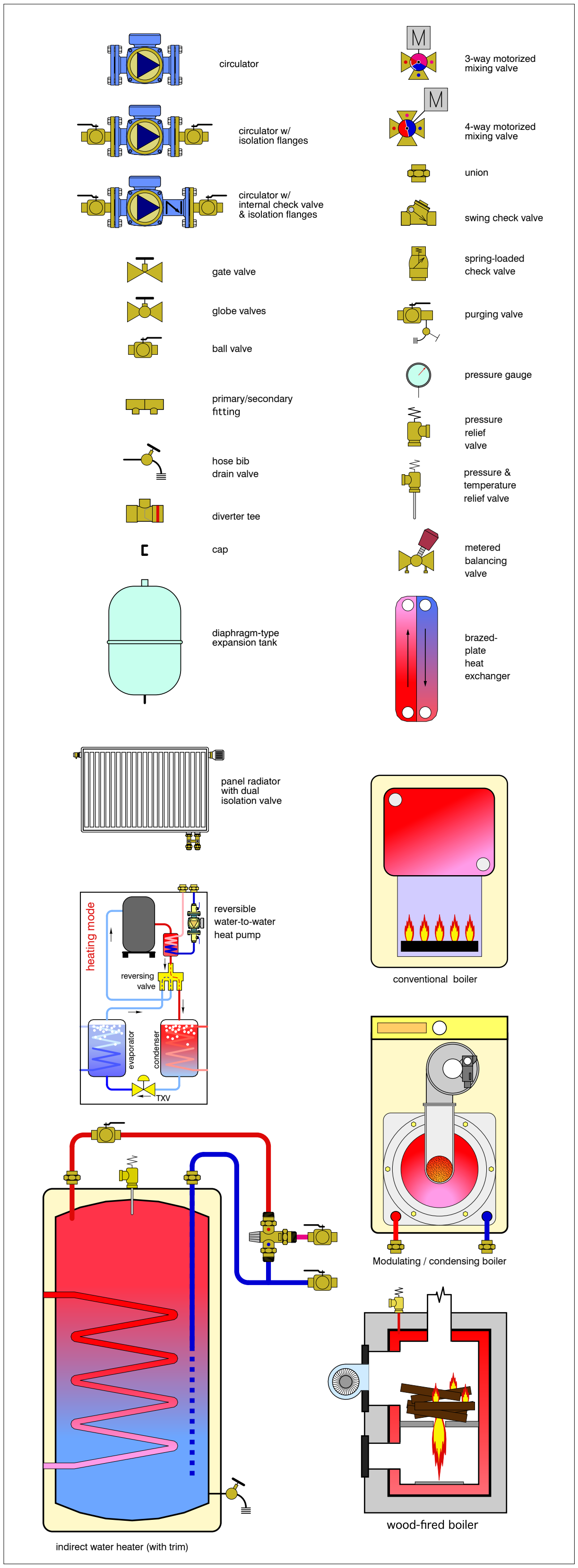
Water is the life-blood of every hydronic system. The quality of that water can significantly affect that system's efficiency and service life. The physical water quality issues most relevant to closed hydronic systems relate to air and dirt. These are discussed at length in idronics #15. Caleffi provides a wide range of products to reduce the air and dirt content of water within hydronic systems.

The chemical water quality issues most relevant to closed hydronic systems are based on dissolved mineral content. These include avoidance of scaling and reducing the electrical conductivity of water to minimum levels. The latter greatly reduces the potential for several types of corrosion.

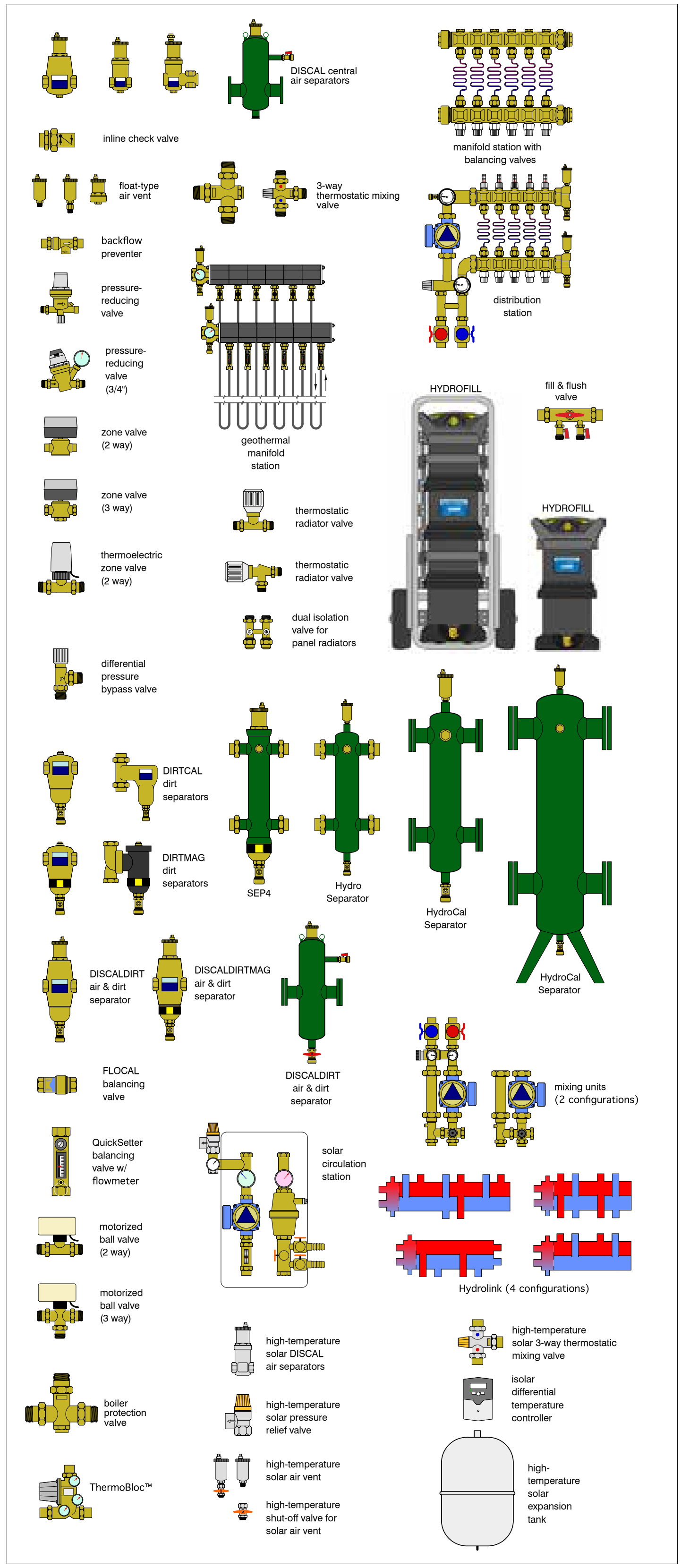
The products now available from Caleffi allow demineralized water to be easily produced and installed in a wide range of hydronic systems. They provide a perfect complement to the air and dirt separation products Caleffi is well known for.

APPENDIX A: SCHEMATIC SYMBOLS

GENERIC COMPONENTS



CALEFFI COMPONENTS



HYDROFILL™ water treatment unit

NA5709 series

Function

HYDROFILL™ is a water treatment filling unit that produces from site sourced water, demineralized water of an ideal grade for use in closed hydronic heating and cooling systems. Salts and other soluble minerals are almost entirely eliminated so as to prevent premature equipment malfunction including reduced efficiency or component failure due to lime scale formation – a common affliction of heat exchangers. The treated water results in low electrical conductivity to minimize corrosion due to galvanic attack. Also, by eliminating the variability of site produced water having different mineral content values from location to location, using treated water makes for more reliable dosing when chemical additives are used – such as glycol.

Product range

Code NA570912	HYDROFILL™ water treatment filling unit including two disposable resin filter bags	6 gpm filling rate
Code NA570924	HYDROFILL™ water treatment filling unit with cart including four disposable resin filter bags	12 gpm filling rate
Code NA570971	HYDROFILL™ one disposable resin filter bag in plastic bucket with lid	
Code NA570974	HYDROFILL™ four disposable resin filter bags in plastic bucket with lid	

Technical specifications

Filling unit body
Materials:

- Body and cover:	PP-H A GF50
- Screen:	stainless steel
- Seals:	EPDM

Shut-off ball valve

- Body:	brass
- Ball:	stainless steel
- Seals:	EPDM

TDS meter

- Range:	0-999 ppm
- Resolution:	1 ppm
- Accuracy:	±2%
- Battery:	2 x 1.5V button cell (LR44/ 357A)
- Battery life:	approx. 1000 hours of continuous use

Filling unit cart
Materials:

- Frame:	stainless steel
- Hardware:	stainless steel
- Wheels:	semi pneumatic rubber

Disposable filter bags
Material:

- Bag:	nylon
- Contents:	mixed bed exchange resins

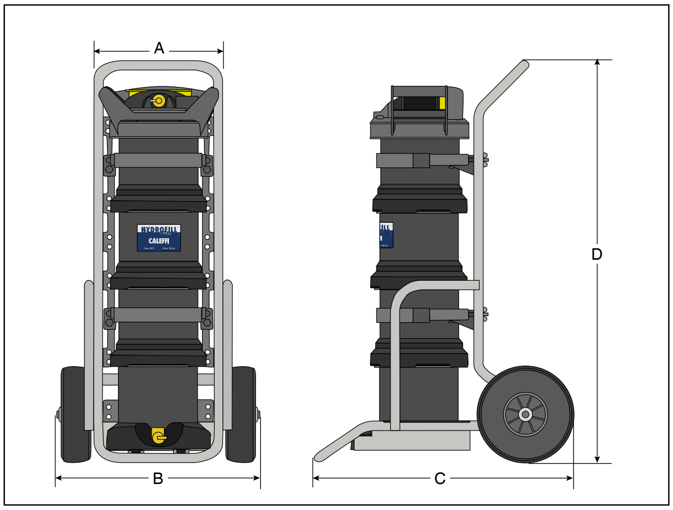
Filter resin capacity:

- Two bags:	0.42 cu. ft.
- Four bags:	0.84 cu. ft.

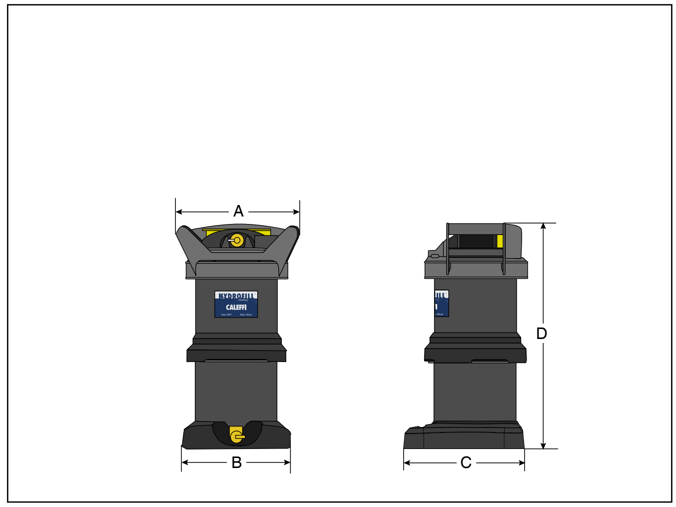
Performance

Medium:	tap water
Maximum working pressure:	120 psi
Working temperature range:	40 – 100°F
Storage temperature range:	15°F – 120°F
TDS of water after treatment:	< 30 ppm
Connections:	3/4" GHT

Dimensions

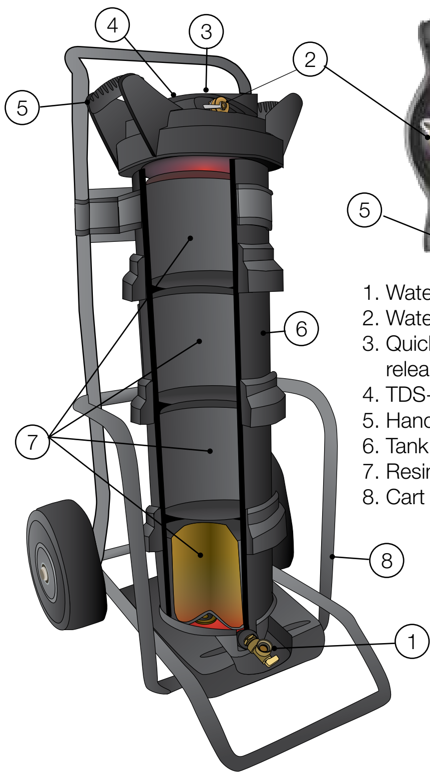


Code	A	B	C	D	Wgt. Lbs.
NA570924	13½”	21”	27”	42½”	98



Code	A	B	C	D	Wgt. Lbs.
NA570912	13”	11”	12”	22”	44

Characteristic components



1. Water IN connection
2. Water OUT connection
3. Quick opening lever to release pressure and open
4. TDS-Meter
5. Handles to carry and open
6. Tank
7. Resin Bags
8. Cart (NA570924 only)

Water treatment capacity

Water classification	Hardness (ppm)	NA570912 (gallons)	NA570924 (gallons)
Slightly hard	< 60	1,750	3,500
Moderately hard	61 - 120	1,375	2,750
Hard	121 - 180	1,000	2,000
Very hard	181 - 250	475	950
Extremely Hard	> 250	250	500

Capacities based on treating water containing 180 ppm (10.5 gpg) total dissolved solids (expressed as calcium carbonate), consisting of 25% sodium, 50% alkalinity, 77°F (25°C), delivering 30 ppm of treated water

Construction details

Large yellow lever enables quick and easy opening of the tank. Lever includes a pressure release valve. In one motion as the lid is turned to the full open position, the tank depressurizes and opens to the full diameter of the tank.

Highly accurate built-in TDS meter 0 - 999 ppm with resolution of 1 ppm due to its advanced microprocessor technology. Auto-Off function conserves battery power. The unit shuts off automatically after 10 minutes of non-use. Replaceable battery with a life of approximately 1000 hours of continuous use.

Pre-packed resin bags save time and simplify resin change process. No more time-consuming, inconvenient filling up of narrow tanks and no more spilled, wasted resin. Resin change process is simple as removing the used bags and inserting new ones. Each bag is made from a water permeable material and contains a pre-proportioned amount of high capacity premium grade virgin mixed bed resin.

Innovative flow distribution screen design evenly distributes the inlet water over the entire column of resin. Producing up to 30% more treated water from a single resin refill compared to other types of demineralization tanks. Reduced operational cost through less frequent resin replacement. Less waste, less time spent on changing resin.

Operation

Site water flows up through a column of mixed bed resin beads which are charged with negative and positive ions. The effectiveness of removing minerals from site water through exchange depends on the TDS of input water and the time the site water has in contact with the resin beads. The column height of resin and the water flow rate will determine the effectiveness of the ion exchange.

HYDROFLUSH™ fill and flush cart

NA25510

Function

The HYDROFLUSH™ pump cart is portable and leak-tested for a safe, quick and clean way to fill and flush solar, geothermal and hydronic systems. Assembled with a leak test pressure gauge, the fill and flush cart makes it easy to test a system
.

The HYDROFLUSH™ Cart was designed for easy maneuvering, with 10 inch tires and back arm bars, this cart will maneuver any stair or landscape and ease the process loading into a van or truck. Another feature of the cart is the attached pump. The 1/2 HP (120 V AC) pump, produces up to 100 psi, provides the power needed to clear all of the air out of any hydronic system.

Large 13 gallon tank allows for mixing cleaning chemicals to wash a system clean. Connection on tank lid allows cleaning solution back into tank. Stainless steel inlet filter keeps debris from returning into the system. Large tank is suited for mixing glycol on-site and filling at high rate to purge air from the system

Product range

NA25510 HYDROFLUSH™ fill and flush cart........................connections 3/4" GHT

Technical specifications

Fill and Flush Cart

Materials	- cart frame:	welded steel chassis, powder-coat frame
	- diaphragm and seals:	NBR
	- filter:	stainless steel
	- tires:	10" rubber

Ratings

Max. tank medium temperature:	150°F
Suitable fluids:	water, glycol, and hydronic cleaning fluids

Connections

- isolating ball valves:	3/4" garden hose thread
- transfer hoses:	6' with 3/4" GHT (2 ea)
- liquid filled pressure gauge:	2" dial, 0–100 psi

Pump

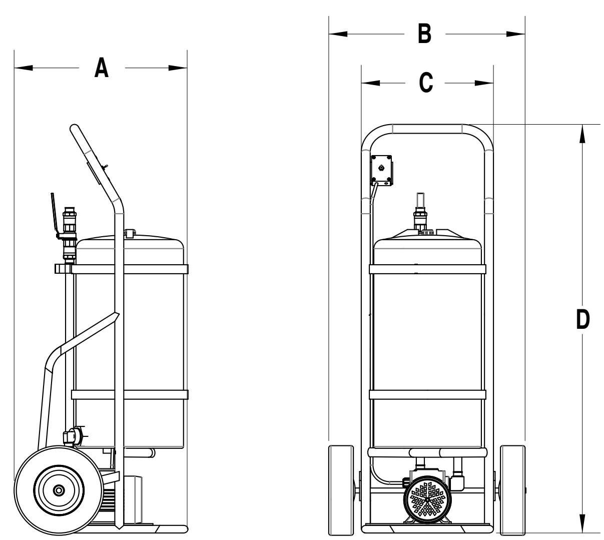
Materials	- body:	cast iron, with threaded ports
	- motor bracket:	aluminum with brass insert
	- impeller:	brass

Performance

Pump delivery flow:	1-13 gpm
Pump feet of head:	220
Max. pump pressure:	0-100 psi
Pump power:	1/2 HP (120 V AC)

Connections	- valves:	3/4" garden hose thread
	- drain pipe:	3/4" GHT

Dimensions:



Code	A	B	C	D	Weight	Capacity
NA25510	20 ½"	20 ¼"	13 ¾"	46 ¾"	65 lbs.	13 gallon

Multi-parameter TDS, pH & temperature tester kit

NA575002

Function

One sensor measures 3 parameters; TDS, pH, and temperature. No need to switch sensors for different measurements. Accuracy up to ±0.01 for pH; ±1% full-scale for TDS for a wide variety of applications. Long-lasting pH sensor with PVDF reference junction having a large volume of polymer gel reference which gives long, clog-free sensor lifespan. Stainless steel pin-style conductivity sensors which is durable and compatible with a wide range of samples. Adjustable TDS factor and temperature coefficient provide accurate readings under changing conditions Push-button calibration is more precise than trimpot adjustment, no screwdrivers necessary. Automatic temperature compensation (ATC) gives accurate readings even with fluctuating temperatures Waterproof, dust-proof housing meets IP67 rating, plus it floats. Hold function freezes reading until you can record it and auto shutoff extends the life of battery.

Product range

NA575002 Multi-parameter tester kit with carry case and calibration packets...TDS, pH & Temperature

Technical specifications

Range	
TDS:	0 - 1,000 ppm
pH:	0.1 - 14.0 pH
Temperature:	32 - 122°F (0 - 50°C)
Resolution	
TDS:	1 ppm
pH:	0.1 pH
Temperature:	±0.1°
Accuracy	
TDS:	±1% full-scale
pH:	±0.1 pH
Temperature:	±0.9°F (±0.5°C)
Calibration	
TDS:	2 points
pH:	3 points
Temperature:	1 points
Temperature compensation	ATC 32 - 122°F (0 - 50°C) or manual
Operating temperature	32 - 122°F (0 - 50°C)
Power	
Alkaline battery:	4 x 1.5V button cell (LR44/ 357A)
Battery life:	approx. 250 hours of continuous use
Dimensions	Unit only: 6½" x 1½" dia (16.5 x 3.8 cm)
Weight	Unit only: 3.25 oz (90 g)
Carry case	13¾" x 10" x 3½"
Calibration packets	pH packets assortment (4, 7 &10 pH) conductitivty fluid

Characteristic components

1. Waterproof battery compartment uses common button cells
2. ATC for accurate readings even in varying conditions
3. Accurate readings with high resolution
4. LCD display with unit of measurement, self-diagnostic messages and temperature readout
5. Scroll-menu with four control push-button mode operations for simple, quick and accurate calibration procedures
6. Twist-and-lock sensor replacement with no tools required
7. TDS sensor module with 2-pin stainless steel for minimal bubble entrapment
8. Temperature sensor within dome-shaped casing for faster temperature compensation
9. pH sensor with fast response tough glass bulb, minimal clogging with easy to clean single-junction sensor

DIRTMAG®
magnetic dirt separator

5463, 5465M & NA5465, series

CALEFFI

Function

In heating and air conditioning control systems, the circulation of water containing impurities may result in rapid wear and damage to components such as pumps and control valves. It also causes blockages in heat exchangers, heating elements and pipes, resulting in lower thermal efficiency within the system.

The DIRTMAG® magnetic dirt separator removes both ferrous and non-ferrous impurities continuously, featuring powerful removable magnets that remove up to 100% of the ferrous impurities, including magnetite, that can form in a hydronic system. The DIRTMAG® has 2 ½ times the removal performance of a standard dirt separator.

Product range

5463 series	DIRTMAG® magnetic dirt separator, in brass	connections 1" to 2" NPT female and sweat
5463 series	DIRTMAG® magnetic dirt separator, in brass	connections 1" and 1¼" press
5465M series	DIRTMAG® magnetic dirt separator, in steel	connections 2" to 4" ANSI flanged
NA5465M series	DIRTMAG® magnetic dirt separator, in steel, ASME	connections 2" to 6" ANSI flanged

Technical specifications

Brass body dirt separators and magnetic dirt separators

Materials
- body, dirt collection chamber and top plug: brass
- internal element: glass reinforced nylon PA66G30
- hydraulic seal: EPDM
- drain valve: brass
- magnet (5463 series): neodymium rare-earth

Performance

Suitable fluids: water, glycol solution
Max. percentage of glycol: 50%
Max. working pressure: 150 psi (10 bar)
Temperature range: 32–250°F (0–120°C)
Particle separation capacity: to 5 μm (0.2 mil)
Ferrous impurities separation efficiency (magnetic models): up to 100% removal

Connections
- main: 1", 1¼", 1½" and 2" NPT female; 1", 1¼", 1½" and 2" sweat; 1" and 1¼", press
- top: ½" NPT female (with plug)
- drain: ¾" garden hose connection

Steel body dirt separators and magnetic dirt separators

Materials
- body: epoxy resin painted steel
- top cap: brass
- internal element: 5465M, NA5465M stainless steel and HDPE
- hydraulic seal: non-asbestos fiber
- drain valve: brass
- magnet(M series): neodymium rare - earth
- magnet probe drywell: brass

Performance

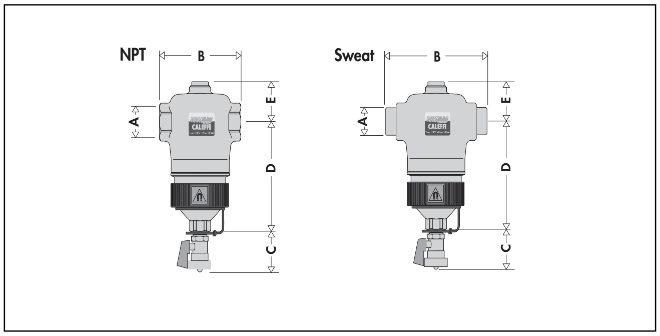
Suitable fluids: water, glycol solution
Max. percentage of glycol: 50%
Max. working pressure: 150 psi (10 bar)
Temperature range (vessel): 32—270°F (0—132°C)
Particle separation capacity: to 5 μm (0.2 mil)
Ferrous impurities separation efficiency (magnetic models): up to 100% removal

Connections - flanged: 2"–6" ANSI B16.5 150 CLASS RF

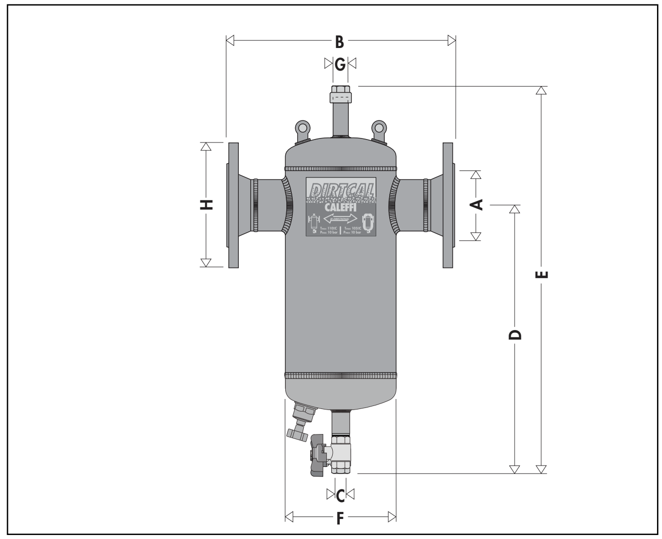
Agency approval

NA546M series designed and built in accordance with Section VIII, Division 1 of the AMSE Boiler and Pressure Vessel Code and tagged and registered with the National Board of Boiler and Pressure Vessel Inspectors, with ASME U stamp.

Dimensions



Code	A	B	C	D	E	Wt. lb (kg)
546306A	1" NPT	4 5/16"	1 1/4"	5"	2"	4.2 (1.9)
546328A	1" SWT	5 1/16"	1 1/4"	5"	2"	4.2 (1.9)
546366A	1" Press	7 1/16"	1 1/4"	5"	2"	4.2 (1.9)
546307A	1 1/4" NPT	4 7/8"	1 1/4"	6"	2"	5.3 (2.8)
546335A	1 1/4" SWT	5 3/16"	1 1/4"	6"	2"	4.2 (1.9)
546367A	1 1/4" Press	7 3/16"	1 1/4"	6"	2"	4.2 (1.9)
546308A	1 1/2" NPT	4 7/8"	1 1/4"	6"	2"	6.2 (2.8)
546341A	1 1/2" SWT	5 3/4"	1 1/4"	6"	2"	4.9 (2.2)
546309A	2" NPT	5 1/8"	1 1/4"	6"	2"	6.2 (2.8)
546354A	2" SWT	6 1/8"	1 1/4"	6"	2"	5.5 (2.5)

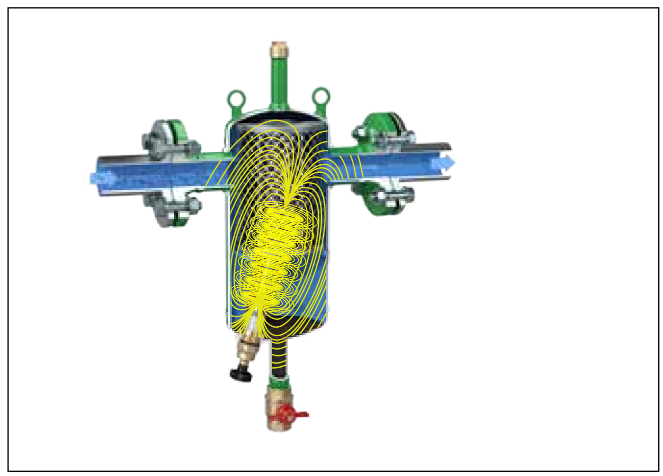


Code	A	B	C	D	E	F	G	H	Cap. (gal)	Wt. (lb)	Wt. (kg)
546550AM	2"	13^{3}"	1"	16 9/16"	23 1/4"	6 5/8"	1"	6"	1.8	41	20
546560AM	2 1/2"	13 3/4"	1"	16 9/16"	23 1/4"	6 5/8"	1"	7"	1.8	41	20
546580AM	3"	18 3/8"	1"	21"	30 1/2"	8 5/8"	1"	7 1/2"	4.8	58	26
546510AM	4"	18 1/2"	1"	21"	30 1/2"	8 5/8"	1"	9"	4.8	58	26
NA546550AM	2"	13^{3}"	1"	16 9/16"	23 1/4"	6 5/8"	1"	6"	1.8	41	20
NA546560AM	2 1/2"	13 3/4"	1"	16 9/16"	23 1/4"	6 5/8"	1"	7"	1.8	41	20
NA546580AM	3"	18 3/8"	1"	21"	30 1/2"	8 5/8"	1"	7 1/2"	4.8	58	26
NA546510AM	4"	18 1/2"	1"	21"	30 1/2"	8 5/8"	1"	9"	4.8	58	26
NA546512AM	5"	25"	1"	23 1/16"	34 11/16"	12 3/4"	1"	10"	13.7	141	65
NA546515AM	6"	25"	1"	23 1/16"	34 11/16"	12 3/4"	1"	11"	13.7	151	70

Operating principle DIRTMAG®

Non-ferrous and ferrous impurities, including magnetite, in hydronic systems can deposit onto heat exchanger surfaces and accumulate in pump cavities causing reduced thermal efficiency and premature wear. The small and often microscopic magnetic particles, called magnetite, form when iron or steel corrodes. Highly abrasive, the extremely fine particles are difficult to remove by traditional means. DIRTMAG® separators offer highly efficient separation of typical dirt as well as magnetite. The versatile DIRTMAG® magnetic dirt separator removes both ferrous and non-ferrous impurities continuously. In addition to removing sand and rust impurities with an internal element in a low-velocity-zone chamber, the DIRTMAG® features a powerful removable magnet below the flow line for fast and effective capture of ferrous impurities. The magnet removes up to 100% of the ferrous impurities, including magnetite, that can form in a hydronic system.

For the brass DIRTMAG®, the ferrous impurities are captured by a strong neodymium rare-earth magnetic field created by a powerful removable magnet around the body below the flow line.



For the steel DIRTMAG®, the ferrous impurities are captured by a concentrated magnetic field created by a stack of neodymium rare-earth magnets positioned inside a brass dry-well below the flow stream.

Draining off dirt and ferrous impurities

The dirt separator collection chamber has a drain valve. Using the handle provided it is possible to drain off the accumulated dirt particles even with the system in operation.

For the brass DIRTMAG®, captured impurities are easily flushed by unclamping the magnetic collar and purging.

To purge the ferrous impurities in the steel DIRTMAG®, the flexible magnetic stack is removed from the brass dry-well and, with the system still running, the drain valve is opened. Aided by the system pressure, the dirt and ferrous impurities, including magnetite, flushes out quickly and effectively.

DISCAL*DIRTMAG*®
magnetic air & dirt separator

NA546 & 5461 series

Function

Air and dirt separators are used to continuously remove the air and debris contained in the hydronic circuits of heating and cooling systems. The air discharge of these devices is very high. They are capable of automatically removing all of the air present in the system down to the microbubble level. The DISCALDIRTMAG® air and dirt separator also removes both ferrous and non-ferrous impurities continuously, featuring powerful removable magnets that remove up to 100% of the ferrous impurities, including magnetite, that can form hydronic system. The DISCALDIRTMAG® has 2½ times the ferrous impurities removal performance of a standard air and dirt separator.
The impurities collect at the bottom of the device and can be flushed through the integral drain shut-off valve. The circulation of fully de-aerated and cleaned water enables the equipment to operate under optimum conditions, free from noise, corrosion, localized or mechanical damage.

Product range

5461 series	DISCALDIRTMAG® air and dirt separator with magnet in brass	connections 1" NPT male
5461 series	DISCALDIRTMAG® air and dirt separator with magnet in brass	connections ¾", 1"& 1¼" sweat
NA546M series	DISCALDIRTMAG® magnetic air and dirt separator, in steel, ASME	connections 2½" –6" ANSI flanged
NA546TM series	DISCALDIRTMAG® magnetic air and dirt separator, in steel, ASME	connections 2" NPT threaded

Technical specifications

Brass body magnetic air and dirt separators

Materials

- body:	brass
- internal element:	glass reinforced nylon, PA66GF30
- air vent float:	PP
- air vent float guide pin:	stainless steel
- air vent float linkages:	stainless steel
- spring:	stainless steel
- seals:	EPDM
- bottom drain shut-off valve:	brass
- magnet:	neodymium rare-earth

Performance

Suitable fluids:	water, glycol solution
Max. percentage of glycol:	50%
Max. working pressure:	150 psi (10 bar)
Temperature range:	32–250°F (0–120°C)
Air separation efficiency:	100% removal to microbubble level
Particle separation capacity:	to 5 µm (0.2 mil)
Ferrous impurities separation efficiency:	up to 100% removal

Connections

- main:	¾", 1", 1¼" sweat; 1" NPT male
- drain shut-off valve:	3/4" GHT

Steel body magnetic air and dirt separators

Materials

- body:	epoxy resin painted steel
- air vent body:	brass
- internal element:	stainless steel and HDPE
- air vent float:	PP
- air vent float guide pin & linkages:	stainless steel
- spring:	stainless steel
- seals:	EPDM
- bottom & side drain shut-off valve:	brass
- magnet:	neodymium rare-earth
- magnet probe drywell:	brass

Performance

Suitable fluids:	water, glycol solution
Max. percentage of glycol:	50%
Max. working pressure:	150 psi (10 bar)
Temperature range (vessel):	32–270°F (0–132°C)
Air separation efficiency:	100% removal to microbubble level
Particle separation capacity:	to 5 µm (0.2 mil)
Ferrous impurities separation efficiency (M models):	up to 100% removal

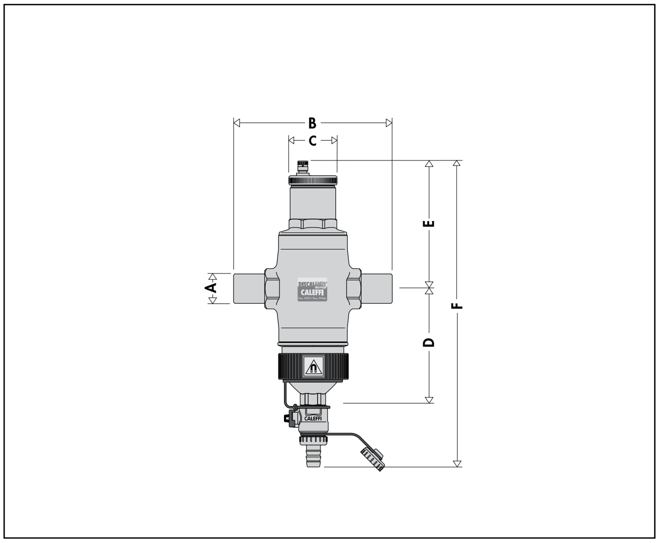
Connections

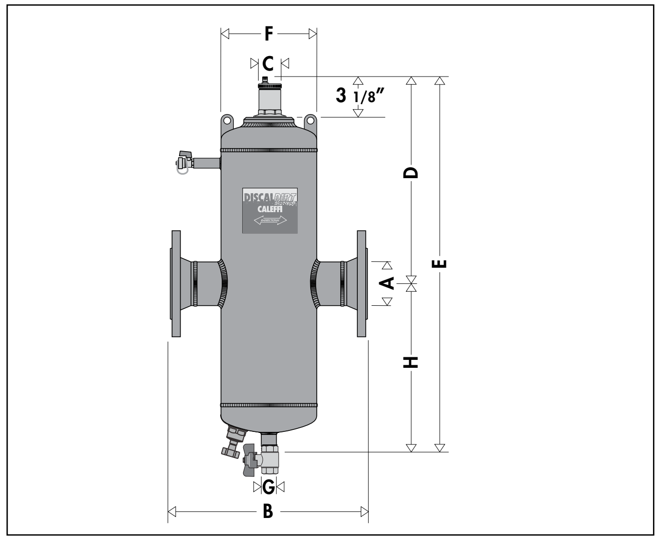
- flanged:	2½"–12" ANSI B16.5 150 CLASS RF
- threaded:	2"
- bottom drain valve:	1" NPT female

Agency approval

NA546M series designed and built in accordance with Section VIII, Division 1 of the AMSE Boiler and Pressure Vessel Code and tagged and registered with the National Board of Boiler and Pressure Vessel Inspectors, with ASME U stamp.

Dimensions





Code	Connections	A	B	C	D	E	F	Wt. (lb)	Wt. (kg)
546195A	Sweat	¾"	7⅜"	2⅛"	5"	5½"	12¾"	8.5	3.9
546196A	Sweat	1"	7⅜"	2⅛"	5"	5½"	12¾"	8.5	3.9
546116A	NPT male	1"	7⅜"	2⅛"	5"	5½"	12¾"	8.5	3.9
546197A	Sweat	1¼"	6³⁄₁₆"	2⅛"	5"	5½"	12¾"	8.5	3.9

Code	A	B	C	D	E	F	G	H	Cap. (gal)	Wt. (lb)	Wt. (kg)
NA546050TM	2"	13³"	2³⁄₁₆"	14⁹⁄₁₆"	28¼"	6⅝"	1"	13¹¹⁄₁₆"	3.6	28	12.7
NA546060AM	2½"	13¾"	2³⁄₁₆"	14⁹⁄₁₆"	28¼"	6⅝"	1"	13¹¹⁄₁₆"	3.6	42	18.6
NA546080AM	3"	18⅜"	2³⁄₁₆"	17"	34½"	8⅝"	1"	17½"	7.6	73	33.1
NA546100AM	4"	18½"	2³⁄₁₆"	17"	34½"	8⅝"	1"	17½"	7.8	78	35.4
NA546120AM	5"	25"	2³⁄₁₆"	21¹⁄₁₆"	46¹¹⁄₁₆"	12¾"	1"	25⅝"	22.4	181	82.1
NA546150AM	6"	25"	2³⁄₁₆"	21¹⁄₁₆"	46¹¹⁄₁₆"	12¾"	1"	25⅝"	23.0	188	85.3

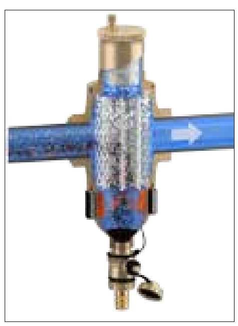
Operating principle DISCALDIRTMAG®

Microbubble air separation

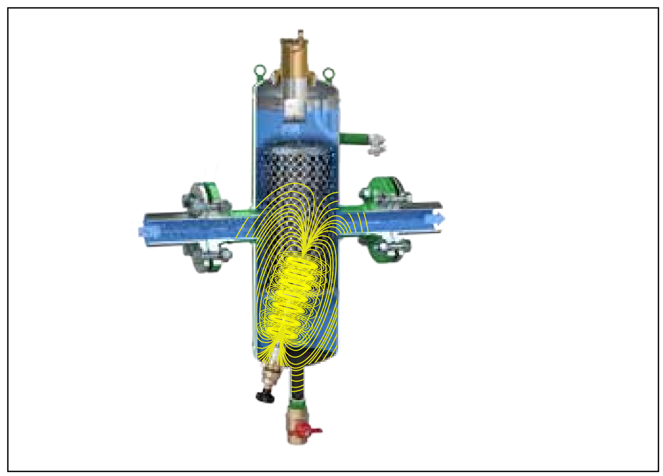
The air and dirt separator uses the combined action of several physical principles. The active part is the internal element concentric mesh surfaces. These elements create the whirling movement required to facilitate the release of micro-bubbles and their adhesion to these surfaces.

The bubbles, fusing with each other, increase in volume until the hydrostatic thrust is such as to overcome the adhesion force to the structure. They rise towards the top of the unit from which they are released through a float-operated automatic air vent valve.

Microparticle dirt separation



The DISCALDIRTMAG® dirt removing element separates and collects any impurities present in the system. Impurities in the fluid upon striking the surfaces of the internal element, get separated and drop to the bottom of the body in the dirt collection chamber where they collect. In addition, the large internal volume of slows down the velocity of the fluid thus helping, by gravity, to separate the particles it contains. DISCALDIRTMAG® features a powerful removable magnet below the flow line for fast and effective capture of ferrous impurities. The magnet removes up to 100% of the ferrous impurities, including magnetite, that can form in a hydronic system.



For the steel DISCALDIRTMAG®, the ferrous impurities are captured by a concentrated magnetic field created by a stack of neodymium rare-earth magnets positioned inside a brass dry-well below the flow stream.

Draining off dirt and ferrous impurities

The dirt separator collection chamber has a drain valve. Using the handle provided it is possible to drain off the accumulated dirt particles even with the system in operation.

For the brass DISCALDIRTMAG®, captured impurities are easily flushed by unclamping the magnetic collar and purging.

To purge the ferrous impurities in the steel DISCALDIRTMAG®, the flexible magnetic stack is removed from the brass dry-well and, with the system still running, the drain valve is opened. Aided by the system pressure, the dirt and ferrous impurities, including magnetite, flushes out quickly and effectively.