RHOMAR WATER
Heat Transfer Fluids • Hydronic System Solutions

HYDRONIC AND STEAM BOILER WATER TREATMENT TRAINING MANUAL

DESIGNED FOR:

PLUMBING & HEATING CONTRACTORS

PUBLISHED BY:

RHOMAR WATER
2103 E. ROCKHURST STREET, SPRINGFIELD, MO, USA

MESSAGE FROM THE EDITORIAL TEAM

Rhomar Water provides the most advanced hydronic treatment technologies and high-quality cleaners, treatments and inhibited glycol-based heat transfer fluids among other products. Our goal is to continually research and develop new chemistries and water treatment systems; thereby, allowing us to offer better customized service through a combination of Rhomar Water products and services.

RHOMAR WATER PRODUCTS:

All the Rhomar Water products listed on our website at www.RhomarWater.com have the additional benefits herein below:

1. Non-hazardous – 95 % of our products can be shipped without special handling.
2. Safe to handle – users can handle each product without grave concern for safety.
3. Easy to use – all products have simple directions on the label and on technical data sheets. Further technical assistance is available by calling 1-800-543-5975.
4. Compatible with all common hydronic system components – this eliminates the concern of adding a product that may harm a system.

WATER TESTING AND ANALYSIS

Rhomar Water provides testing services for makeup water and system fluid for all her customers. Upon completion of the analysis of the samples, we provide customized reports complete with our assessment of what the cause of the customer-reported issue may have been as well as recommendations of what needs to be done to deal with the problem and how to avoid such issues from recurring, and what Rhomar Water products to use to solve the problem. In addition, technical assistance on the use of our products or with the help evaluating the cause of a problem is offered by calling 1-800-543-5975 or emailing us at TalkToUs@RhomarWater.com.

If you need help getting started with cleaning and treating, please find instructions on the specific product label or check out product data sheets on our website at www.RhomarWater.com. We are committed to providing high quality products and service to the hydronic cooling and heating industry.

Best Regards,
Geoffrey Manani &
Darin Adamson

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HYDRONIC AND STEAM BOILER TREATMENT TRAINING DOCUMENT

INTRODUCTION:

Rhomar Water is an industrial water treatment company located in Springfield, Missouri. With almost 30 years of experience providing treatment and service for all types of industrial, commercial and institutional boilers, cooling systems and wastewater facilities, we are making this knowledge available to the residential heating market.

Rhomar Water provide fluid analytical services to all customers – large or small. Customers may send us a sample alongside a **Water Test Request Form** available on our website. Many contractors who use and/or install our products also perform on-site chemical testing and analysis of fluids in customer systems for the proper control of scale, corrosion and biological problems. In addition, Rhomar custom formulates chemical treatment products – cleaners, treatments, inhibited glycol – to address specific problems for individual systems.

Rhomar Water's staff have extensive experience formulating chemical treatment products for the proper care and treatment of all types of heating and cooling water and steam systems. This technical knowledge and experience have enabled Rhomar to successfully formulate custom blended cleaning and treatment product for the residential and commercial hydronic heating market.

OBJECTIVES:

The purpose of this training document is to:

1. Provide a basic understanding of the characteristics of water.
2. Explain why and how water related problems occur.
3. Give information on how to detect water chemistry issues in a system.
4. Provide information on how to prevent and correct water related problems.
5. Give instruction on the use of simple testing equipment.
6. Instruct industry personnel on the benefits of cleaning and treatment.
7. Introduce Rhomar Water's Hydronic treatment products.
8. Offer technical assistance for the proper use of these products.

This document is written for plumbing and heating personnel and for those who do not have extensive training or experience with water related problems in heating applications.

WATER BASICS:

Water is essential to all life on earth and is abundant in various forms. It can exist in three different states; gas, liquid and solid. These characteristics along with availability and low cost make water an excellent choice for a heat transfer fluid. But there are issues that need to be addressed for satisfactory long-term results. An explanation of the properties of water and how to counteract the negative effects is discussed below.

Water Is A Solvent!!

Pure water is composed of Hydrogen and Oxygen (*Figure 1*). In its pure state it is colorless, tasteless and odorless. However, pure water does not exist in nature! Water will dissolve, to some degree, every substance with which it comes in contact. Because of this property it has been termed a "universal solvent". This "solvent" characteristic of water is what produces our water related problems in the Hydronic industry.

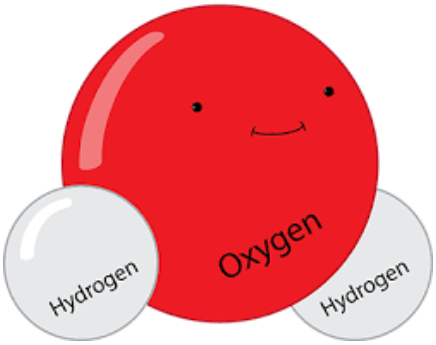

Figure 1: The Water Molecule.

Distilled and RO (Reverse Osmosis) water is typically as close to "pure water" as is available. Even pure water produced in a carefully controlled laboratory setting would be contaminated with minute amounts of the equipment used to purify and hold the water. This solvency power of water increases with the purity of the water being used and can pose a major threat to any water handling equipment if not properly addressed.

Corrosion reactions cause the slow dissolution of metals. These dissolved metals can redeposit on heat transfer surfaces, and on other metal components, reducing operating efficiency.

Water Impurities:

Water impurities are classified as three different types:

A. Dissolved solids.
B. Suspended solids.
C. Dissolved gases.

A discussion of each of these impurities is given below. As stated above, water is a solvent that will dissolve anything it comes in contact with. These dissolved products become impurities in the water. The type of impurity is dependent on the source of the water being used.

The limited amount of water on earth participates in a complicated process for its reuse known as the "Hydrologic Cycle". This process can be said to begin with the evaporation of water due to the influence of sunlight. This gaseous phase may condense as clouds in the upper atmosphere as the temperature drops.

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This form of water is typically as close to "pure water" that is available in nature. However, as this moisture falls in the form of rain, it will absorb gases in the atmosphere such as oxygen, carbon dioxide and industrial pollutants.

As the rain reaches the ground, contact with the soil, vegetation, highways and buildings will further contaminate the water as impurities. Water that is absorbed in the ground will percolate through various types of soil, dissolving and absorbing everything it comes in contact with. The degree of contamination will vary with the amount of contact time.

DISSOLVED SOLIDS:

The minerals water picks up from the soil consist mainly of calcium and magnesium carbonate, calcium and magnesium sulfate, silica (sand), sodium chloride, sodium sulfate and small quantities of iron, manganese, fluorides and aluminum along with other trace minerals.

Water containing large amounts of calcium and magnesium salt is "hard to wash with". These compounds are therefore referred to as "water hardness" or "dissolved solids". The amount of hardness in natural water may vary from several parts per million to over 500 parts per million. Although some dissolved solids such as iron and copper may impart a visible color to the solution, the dissolved solid is not visible to the naked eye and the water will be clear. Typically, water from a reservoir will contain less dissolved minerals then well water due to the fact it has not had as much contact with the soil.

INVERSE SOLUBILITY:

Since calcium and magnesium compounds are relatively insoluble in water, they tend to precipitate (fall out) of solution, especially at higher temperatures, which can cause scale and deposit problems. This tendency is due to a characteristic of calcium and magnesium to be less soluble in water at higher temperatures. Since many compounds tend to be more soluble in water at higher temperatures, i.e. sugar, the term for the calcium and magnesium characteristic is "inverse solubility".

Water hardness, therefore, is an important consideration when evaluating water for use in a heating system.

SUSPENDED SOLIDS:

Suspended solids are substances that are not completely soluble in water and are present as particles. These particles usually impart a visible turbidity to the water. Examples of suspended solids are sand, silt, organic matter and microorganisms. Suspended solids can produce sludge and deposits on heat transfer surfaces if not controlled. This type of water impurity is the easiest to control and remove by simple filtration.

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DISSOLVED GASES:
Water also dissolves varying amounts of air that is composed of oxygen and other gases including carbon dioxide. These gases can cause serious corrosion problems in steam and hot water systems.

SURFACE AND GROUND WATER
Fresh water supplies may be either surface water (rivers, streams, reservoirs, etc.) or ground waters (shallow or deep wells). In general, ground water sources are more consistent in composition and contain less suspended matter than surface supplies that are affected directly by rainfall and surrounding soil erosion. On the other hand, ground waters are usually harder than surface waters due to permeation through soil and rock. For example, an average surface supply will contain 95 ppm total hardness as opposed to an average of about 200 ppm total hardness for ground supplies.

SEASONAL VARIATIONS
Surface waters, except from very large lakes or reservoirs, can vary greatly in composition during a year. Maximum impurities in rivers can range up to 400 times the minimum amounts. Municipal supplies from rivers, small lakes or reservoirs are therefore subject to seasonal variations.

Generally, water from deep wells will have a uniform composition. However, water from nearby wells may have a different composition. The water from each well should be analyzed separately when trying to determine the cause of water related problems is a system.

MEASUREMENT OF WATER IMPURITIES

Parts Per Million
Measurement of water impurities are usually expressed in parts per million (ppm). Parts per million is a measure of proportion by weight such as one pound in a million pounds. A measurement of 200 ppm of calcium carbonate in water would mean that for every 1,000,000 lbs. of water, you would have 200 lbs. of dissolved calcium.

Grains Per Gallon
Another method used to express results of a water analysis is grains per gallon gpg). One grain per gallon is equal to 17.1 parts per million (ppm). One gpg is also equal to 143 pounds per million gallons.

Specific Gravity
"Specific Gravity" is a term used to compare the ratio of density of a substance to that of water. Pure water is generally considered to weigh approximately 8.33 pounds per gallon and would have a specific gravity of 1.00. However, the weight of water will vary considerably depending on the type and amount of dissolved chemicals it contains. For example, a gallon of water containing 50% caustic soda will weigh around 12.8 pounds and a gallon of water containing 19% aqua ammonia will weigh 7.74 pounds. Some chemical liquids are similar in specific gravity (density) to water and will have little effect on its weight when mixed together.

The weight of any liquid solution can be calculated if the specific gravity is known. For example, if a solution had a specific gravity of 1.15, you would multiply the weight of water times the

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specific gravity to get the weight of a gallon of the solution, or 8.33 X 1.15 = 9.58 lbs./gal.

Alkalinity

Alkalinity is a term that is often used when talking about the chemical properties of water. Alkalinity is primarily the sum of carbonate, bicarbonate and hydroxyl ions in water. Alkalinity is also described as the ability to neutralize acid. Alkalinity testing is often performed to determine the type of alkalinity in a system. This test is generally more helpful for steam boiler maintenance than for hot water boilers.

pH

PH is a logarithmic scale for expressing acidity or alkalinity of water. The pH scale is from 0 - 14 with 7 being neutral. Any reading below 7 indicates increasing acidity, and any reading above 7 indicates increasing alkalinity. The chart below is for the pH scale with a range of 0 – 14 (*Figure 2*) with some of the common chemicals and their respective pH values.

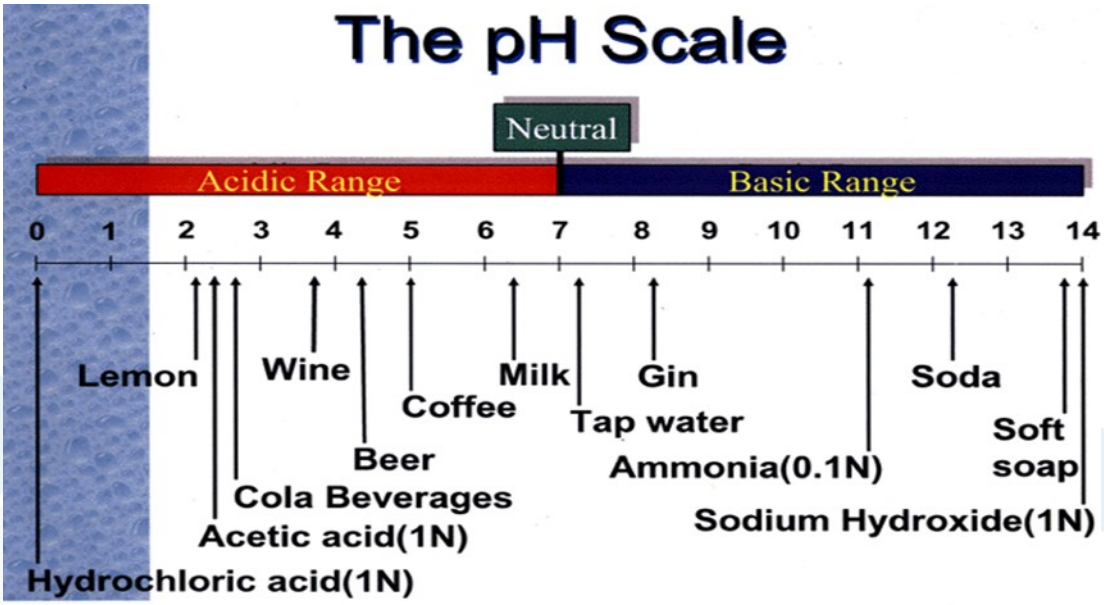

Figure 2: The pH Scale (0 - 14)

Testing pH is easily done with litmus paper strips or with a pH meter. Good pH control is essential for effective control of deposition and corrosion in all types of heating and cooling systems. Most common metals are more susceptible to corrosion from the lower acid range then from the alkaline side of the pH scale. Cast iron, black iron and steel are very resistant to high pH levels in heating systems. It is not unusual to have pH in the 10 - 12 range in steam boilers. Other metals such as copper and aluminum need to have more neutral pH waters.

Aluminum is most affected by higher degrees of acid and alkaline condition. Although a pH of 7.0 is considered neutral, it is a very unstable and easily affected by changing conditions. Therefore, a pH range of 7.5 - 8.5 is recommended as this provides some buffer to acid conditions.

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Conductivity

Conductivity is defined as the ability of a substance to conduct an electric current. The unit of measurement commonly used is µS/cm or mmohos/cm.

Table 1: Conductivity Table for Water

Water Type/Source	Conductivity (µS/cm)
Absolute Water	0.055
Distilled Water	0.500
Mountain Water	1.000
Domestic Water	500 - 800
Max for potable water	1, 055
Sea Water	56, 000

In aqueous solutions conductivity is directly proportional to the concentration of dissolved solids, therefore the higher the concentrations of solids, the greater the conductivity. This characteristic is demonstrated with the "Conductivity Table for Water" shown above. The seawater containing the high concentration of dissolved salt has a conductivity of 56,000 µS/cm compared to distilled water with a conductivity of 0.5 µS/cm.

TDS

TDS stands for "Total Dissolved Solids". This term is often expressed when discussing conductivity. A TDS reading is different than a conductivity reading. Conductivity, which is the measurement of the electrical conductivity of a solution, is affected by and will rise and fall within the increase and decrease of TDS in a solution. However, TDS is measured in ppm and conductivity is a measure of electrical current.

TDS can be calculated using the formula:

$$TDS\ \left(\frac{mg}{L}\right) = k\ \left(\frac{\frac{mg}{L}}{\frac{\mu S}{cm}}\right) * Conductity\ \left(\frac{\mu S}{cm}\right)$$

k is a constant whose value is dependent on the composition of the ionic species in a water sample. This value is usually approximated at 0.67 – 0.70 can be used to estimate the TDS if the conductivity reading s known. This is by multiplying the conductivity reading in µS/cm by the k value (0.67 – 0.70).

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HOT WATER BOILERS

Metals used in heat exchange equipment are chosen based on four factors:

1. Mechanical properties such as strength and ductility.
2. Corrosion resistance, considering both sides of the heat transfer process.
3. Material cost.
4. Thermal conductivity.

The thermal conductivities of common metals vary widely, as shown in the following table. Copper has roughly eight times the thermal conductivity of carbon steel. Admiralty brass provides good corrosion resistance and mechanical strength.

Aluminum is used because of its lightweight and good thermal conductivity, but it has less mechanical strength than other alloys and requires a more neutral pH operating range. Carbon steel, despite its relatively poor thermal conductivity, is widely used for heat transfer applications because of its low-cost relative to other alloys. Stainless steel, with the lowest thermal conductivity of the alloys listed, is used in corrosive environments, and where long life and good mechanical strength are important.

Table 2: Table for the Thermal Conductivity of Metals

Metal	Thermal Conductivity {BTU/(hr.ft.°F)}
Copper	411
Aluminium	164
Admiralty Brass	126
Carbon steel	56
Stainless steel	19

Each of the metals listed will have distinctive characteristics with respect to corrosion. Therefore, it is essential that all materials in a system be known to properly care for and prevent potential damage because of metal corrosion.

Corrosion

Corrosion is defined, in general terms, as the damage caused to a material by reaction (when it interacts or come into contact) with its environment. Another way to consider corrosion is as the tendency of any material to return to its natural state by reacting with its environment.

Corrosion of metals in water systems is an electrochemical process, involving a transfer of electrons and changes in oxidation state of the substances involved in the reaction. This may result in the formation of a metal oxide, cracking or chipping off from the metal.

When referring to boiler heating systems containing metal components, four types of corrosion are mainly of concern:

1. Corrosion due to dissolved oxygen.
2. Low pH (acidic) corrosion.
3. Galvanic corrosion due to dissimilar metals.
4. Microbiologically influenced corrosion (MIC).

Corrosion due to dissolved oxygen

Unless the water being used to fill a system has been pretreated, it will likely contain significant amounts of dissolved oxygen. Distilled, softened, DI (de-ionized) or RO (reverse osmosis) water will still contain dissolved oxygen. The two methods that are used to remove oxygen are preheating and use of chemical oxygen scavengers.

Most municipal water supplies will provide water with a temperature range of 50 - 60 °F and contain 10 - 11 ppm oxygen. By referring to "Oxygen Content Chart" (*Figure 3*) below, you will see that as the temperature of water increases, the level of oxygen decreases. This inverse proportionality of the assumed ideal gas to its absolute temperature in a closed system at constant pressure is the Charles's law. Preheating water to as close to boiling as possible will reduce the level of dissolved oxygen dramatically.

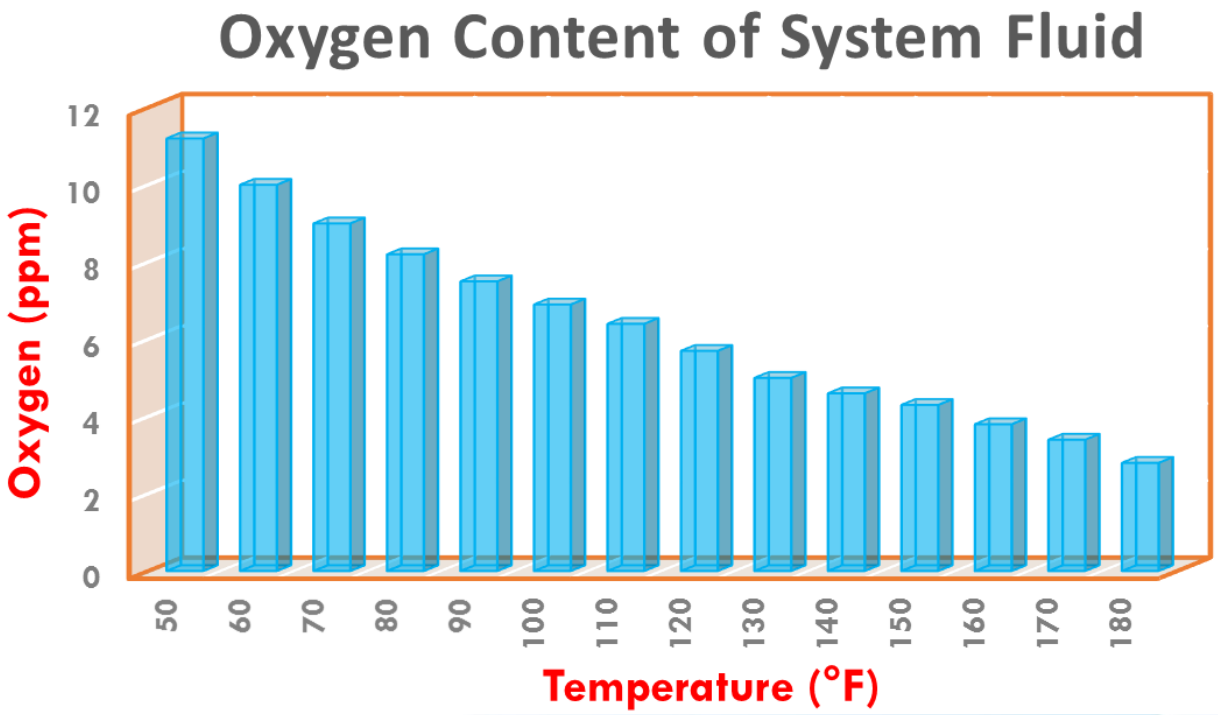

Figure 3: Graph of Dissolved Oxygen Content of a Heat Transfer Fluid as Temperature Changes

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Since preheating water at a residential heating project is not practical, we are left with the option of treating the system water with a chemical oxygen scavenger. This is critical due to the fact that when the heating system is turned on and begins increasing the temperature of the system fluid, oxygen will immediately come out of solution and begin attacking the metal components. Corrosion rates in water solutions tend to double for every 18 to 27 °F (10 to 15 °C).

When referring to a system containing iron, oxygen will react with iron to form ferrous oxide. The first step of this process will produce black ferrous hydroxide. If sufficient dissolved oxygen is present, it will oxidize further to form red ferric hydroxide. This is why some system waters will be orange/red in color while others will be black. The difference being the amount of dissolved oxygen available to complete the electrochemical reaction.

Effect of pH on corrosion

As discussed earlier, the pH of a solution can vary greatly depending on a variety of prevailing conditions. One would hope that system metal corrosion is not influenced by changes in pH (*Figure 4*). However, this is only possible for noble metals such as gold, palladium, and platinum which are not used in hydronic systems because of their rarity and therefore price among other factors.

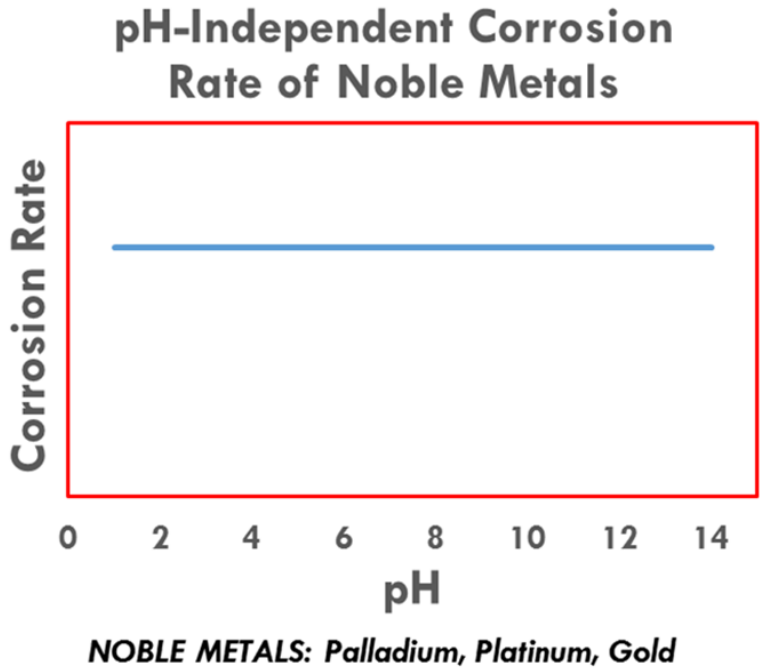

Figure 4: Metals That Do Not Corrode as pH Changes

The metals used in hydronics such as aluminium, copper, cast iron, steel have a narrow pH window over which corrosion rate is at the lowest. The charts below show that copper, steel and iron are more resilient to higher pH levels (*Figure 5*). However, aluminum, commonly used in high efficiency boilers, requires a more neutral pH in the 7 to 9 pH range (*Figure 6*).

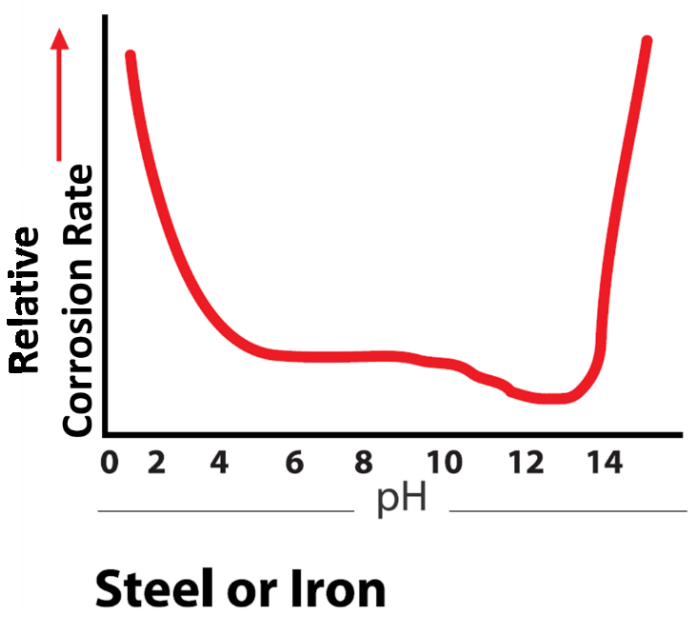

Figure 5: Corrosion Rate of Iron & Steels with pH

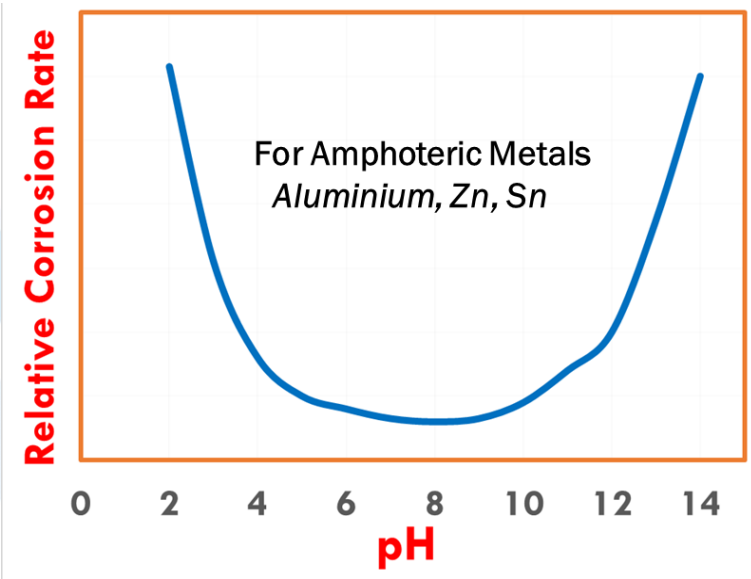

Figure 6: Corrosion Rate of Aluminium with pH

A good quality corrosion inhibitor such as Rhomar Water's Pro-Tek® 922 (Pro-Tek® AL or Pro-Tek® QT) is also recommended for long-term protection. Care should be taken when choosing an inhibitor for systems containing aluminum as most products for this purpose were designed for cast iron systems and contain ingredients and pH boosters that will harm aluminum. The same issue pertains to standard inhibited glycols. A glycol that was designed specifically for systems containing aluminum should be chosen.

Galvanic Corrosion

Galvanic corrosion is defined as corrosion accelerated by the potential differences between different metals when they are electrically connected and exposed to an electrolyte (system fluid). Water is necessary to complete the electrical circuit so that corrosion current can flow.

Some metals are more reactive than others. Some of the more commonly used metals are listed in "The Galvanic Series of Metals" table. These metals are arranged in order of their electrode potentials in specific environments, for example seawater.

Galvanic corrosion is often severe where the dissimilar materials are immediately adjacent to each other and at sharp edges or comers. A typical example is the well- known severe thread damage that occurs when a steel pipe nipple is screwed directly into a brass valve. The greater the difference in electrode potential between the metals being connected, the greater the rate of corrosion will occur. One common method to reduce the potential for galvanic corrosion is to use dielectric unions

Microbiologically Influenced Corrosion

The term "microbiologically influenced corrosion" (MIC) was coined to describe corrosion processes in which bacteria play a significant role. This type of corrosion is not as common in hot water boilers due to the elevated temperatures the systems normally operate. However, it is normally accepted that a system needs to operate above 160 °F to effectively kill most bacteria.

Many hydronic heating systems operate well below 160 °F and are shut down for several months a year. If the system was not adequately cleaned prior to being put in service, the potential for a bacteria problem becomes more likely. In addition, some system treatment chemicals such as Nitrite can provide a food source for bacteria.

Scale Formation

The term "scale" when referring to a boiler system is commonly used to describe a variety of problems. Typically, in the water treatment industry scale is used to describe deposits that have accumulated on boiler heat exchange surfaces. These deposits can contain a variety of minerals including calcium carbonate, magnesium, iron and silica. Sometimes these deposits will include water treatment chemicals that have not been properly controlled such as calcium phosphate. These deposits can often be more difficult to remove than naturally occurring scales.

Corrosion deposits are often referred to as scale but may actually be the flaking off of the metal itself due to corrosion damage. Corrosion scaling can occur when metal components are corroded and leach into the system fluid to redeposit at other locations in the system. The graph below (*Figure 7*) shows the effect of scale on the efficiency of a system. If for example there is up an eighth of an inch of scale forming on the walls of the system piping, the system loses up to 25 %

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of its efficiency. A quarter an inch of scale will affect the efficiency by up to 40 %. So, the thicker the scale, the lower the efficiency of a system.

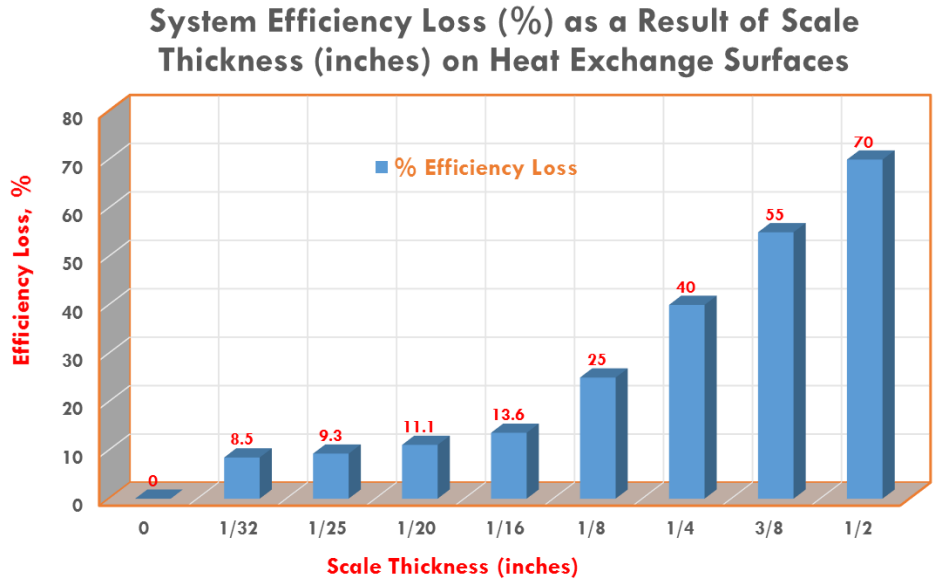

Figure 7: Scale Thickness (inches) and Loss of System Efficiency (%)

The thicker the scale, the higher the heating cost (*Figure 8*).

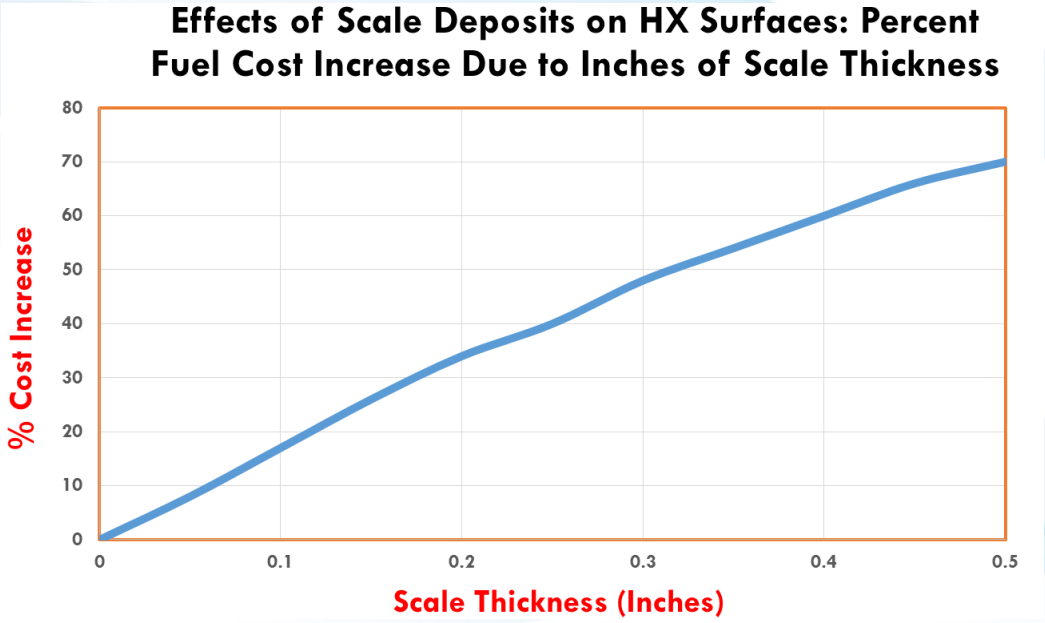

Figure 8: Effects of Scale Deposits (inches) and the System Fuel Cost Increase (%).

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CLOSED LOOP TREATMENT

Water treatment can include a variety of options including mechanical and chemical. Each type of system needs to be evaluated for the type of problems that will most likely occur. It is always advisable to consult with a professional water treatment company that is experienced with the type of system being used. Closed loop hot water boilers have different requirements than steam boilers.

There are many different chemicals used to treat hot water and steam boilers. Nitrites, nitrates, sulfites, molybdates, phosphates, phosphonates, azoles, amines, polymers and dispersants are some of the more common. Each chemical has its own characteristics that make it a benefit for a specific purpose. Most quality treatment products will be a blend of different chemicals that are formulated for a specific type of system. Since there are a variety of problems that can occur due to different water conditions, a blended treatment product is required to address all of the possible issues.

GLYCOL TREATED BOILERS

Many Hydronic radiant heating systems contain glycol for freeze protection. Although this could be considered a treatment the glycol itself may or may not contain additives for scale and corrosion. If a glycol does contain inhibitors, the percentage of glycol being added to a system can vary greatly, usually from 20 to 50%, which can also vary the amount of inhibitors. The different inhibited glycol products produced by Rhomar Water include the propylene glycol based RhoGard™, EnviroGard™, and ThermaGard™ among others while the ethylene glycol based ones include RhoTherm™ and RhoTherm™ 921.

While high-quality glycol solutions may last in excess of 20 years, hard use, improper maintenance, or chemical contaminants will significantly shorten fluid life. This may be through the degradation of the glycol into organic acids that then lowers the fluid's pH.

Rhomar Water's Pro-Tek® 922, Pro-Tek® AL and Pro-Tek® QT treatment products are compatible with and can be used to boost corrosion inhibitor levels in systems containing glycol.

WATER QUALITY

When evaluating a system treatment program, water quality should also be considered. Since the chemistry of water will vary greatly from location to location, and with different sources, such as wells and reservoirs, the quality can also vary.

It is advisable to have each source of water that will be used to fill a system tested. High levels of calcium, silica and iron can cause scale buildup on heat exchange surfaces. High chlorides will rapidly corrode stainless steel. An unusually high or low pH can require special attention to prevent damage to metal components and valves. Visible sediment or color in a water supply can indicate a potential water problem that needs to be addressed. The solution may be to install a water filter to the makeup feed water line.

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Oxygen Scavenger

When considering the type of water treatment product to use in a hot water boiler system, oxygen treatment is one of the most critical ingredients. Cold fill water will normally contain 10 - 11 ppm of dissolved oxygen. As the water is heated when the system is operated, the oxygen will come out of solution and immediately attack the metal components.

Rhomar Water's PRO-TEK® 922/AL/QT treatments contain an oxygen scavenger that will quickly react to neutralize any dissolved oxygen in the system as it is heated. In addition, a residual amount of scavenger is included in the product to deal with any oxygen that may enter the system through tubing, seals and valves. However, it is advised that all leaks be sealed as soon as they occur.

pH Control

The pH of a system fluid is an item that until recently was, for the most part ignored. In the past, heating boilers and piping were usually composed of cast iron, black iron and steel. Due to the heavy gauge and thickness of these materials, they were able to withstand many years of abuse. Most inhibited glycols were designed for iron and steel and contained additives to raise the pH to the 9 - 10.5 range. This was usually the only treatment that was ever added to a system and pH was not usually tested.

With today's high efficiency, multi-metal boilers, pH has become one of the most critical items to monitor and control. Aluminum, which is becoming more common in boilers, is more sensitive to pH than other metals.

A water treatment for today's modem boilers should buffer the system fluid against both high and low pH conditions. The ideal range for the safety of all metals would be 7.5 to 8.5. Referring to the pH corrosion chart for aluminum shows a pH of 8.0 to be the ideal range. In addition, 7.5 - 8.5 will provide some buffer against acidic conditions below 7.0 that would affect all metals.

The Rhomar Water's PRO-TEK® 922/AL/QT treatment products contain buffering ingredients that will typically produce a solution pH of 8.0 to 8.6 with most municipal and residential water supplies.

Scale Inhibitors

As mentioned earlier, scale is typically the formation of mineral deposits on boiler heat exchange surfaces. Testing of the fill water to be used in a system will provide information on the likelihood of scale formation in a boiler.

Calcium and total hardness greater than 6 - 10 grains (100 - 170 ppm) are high enough to cause problems. In addition, high alkalinity and pH readings will increase scaling potential. The higher

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the temperature a system operates, the greater the potential for scaling due to the inverse solubility of calcium and magnesium.

Using softened, DI (deionized) or RO (reverse osmosis) water will reduce the potential for scaling but will increase the potential for corrosion. A chemical treatment product can be used to inhibit scale formation. However, if the water being used contains copious amounts of calcium (or high hardness), chemically treated calcium will produce a sludge that may cloud the fluid and settle in low areas during off periods.

Dispersants

A dispersant is usually a high molecular weight polymer designed to disperse contaminants in a system to prevent them from re-depositing at some other location.

Scale, rust, chemically produced calcium sludge and other corrosion products, are contaminants that would be suspended in the system fluid by a dispersant. Dispersants are also used to remove existing scale and corrosion in fouled systems that have not been properly cleaned and treated.

PRO-TEK® 922/AL/QT contain several quality scale inhibitors and dispersants for excellent control of all types of scale and sludge.

Corrosion Protection

The most serious and common problem experienced in hydronic heating systems is corrosion. Oxygen pitting, low pH erosion and galvanic corrosion cause permanent damage to system valves, piping and boilers. Scale formation can be removed with proper cleaners, but severe corrosion may require expensive replacement of system components.

All systems will immediately begin to corrode as soon as they are filled with fluid and put in service. The only difference from one system to another is the rate at which corrosion will occur. The only way to control corrosion long-term is with chemical treatment products.

The quality of the treatment product being used is critical to the long-term efficient operation of the system. Oxygen scavengers, pH buffers and film forming chemicals are all required to provide adequate protection. PRO-TEK® 922/AL/QT's corrosion inhibitors and pH buffers will protect the system components from the moment they are added.

Additional (residual) additives in the treatment product will begin forming a protective nanomolecular film on the metal surfaces to provide long term protection once the oxygen scavengers are depleted.

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TESTING SYSTEM FLUID

The chemical testing of hydronic system fluid is required for industrial systems but rarely performed in the residential market. The only method to determine the quality of water being used, the condition of system fluid and the level of treatment chemicals and glycol in a system is with proper testing.

Although most HVAC contractors and their employees are not familiar with water treatment testing, most required tests are quite simple. It is also interesting and fun to do once it is learned.

Frequency of Testing

It is always advisable to check the fill water the first time you use it to fill a system or are called in to service a system that might have a water related problem. This can tell you if any special water chemistry problems might exist due to the fill water itself. It is also recommended that a record of the results be kept with that customer's documents for future reference.

Determining the exact volume of fluid, a system will require is often very difficult and sometimes incorrect. Testing of the system fluid after filling with water, glycol and treatment should be performed after sufficient operation of the system to thoroughly blend the chemicals. This is required to determine if adequate amounts of glycol and/or treatment were added.

Once proper levels have been achieved, a follow up test analysis should be performed after 6 months if possible or prior to the beginning of the heating season. Testing annually should be the maximum amount of time between testing and other inspections.

It is beneficial to do water tests in front of the customer during these scheduled visits. They enjoy seeing it done and it will raise their level of confidence in your personnel and company.

Conductivity Testing

Checking conductivity is one of the simpler tests to perform. It requires a "conductivity meter" which measures the amount of dissolved solids in the system fluid using electrical current. Normally a small 1-2 Oz. sample is all that is required.

By taking an initial reading of the system fluid and documenting it, you will have a baseline for comparison in the future. Any significant decrease in the reading will indicate a loss of fluid. Untreated make-up fill water entering the system will usually have a lower conductivity reading than the system water. This would gradually lower the conductivity of the system.

Some exceptions might be if RO (or DI) water were used in the system, it could lower conductivity in the system below that of the domestic fill water.

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pH Testing

The pH test is also a simple test to perform. Monitoring pH is essential for controlling corrosion and can also indicate the loss of fluid and/or the breakdown of glycol. Glycols can, over time decompose to form acids which lower pH and create the potential for corrosion and the loss of freeze protection.

pH pens and meters are available in various sizes and price ranges. The test itself involves placing the pH pen or meter probe in a small sample of the system fluid, stir and allow several minutes for the reading to stabilize. It is preferable to allow the sample to cool slightly if taken from a hot system. Some meters have temperature compensation but are limited to around 120 °F.

Glycol Testing

A simple and inexpensive method for testing ethylene and propylene glycol in the field is with a refractometer. These small handheld devices only require a few drops of fluid on a lens and are then held up to a light source. The level of glycol is easily read on a scale displaying percentage of glycol and approximate freeze protection level.

Chemical Test Kits

Depending on the chemical treatment product used, different tests may be required to determine the level of treatment in a system. Performing an accurate test to determine the level of treatment in a system is critical for proper protection.

Once the proper amount of treatment is added to a system, testing and documenting the test results for future reference is required. Establishing a baseline for pH, conductivity and chemical treatment will provide a reference for future tests.

The supplier of the treatment used should provide information on the proper level of chemical that should be maintained in the system. Testing annually or more often will indicate if and when additional treatment should be added.

Rhomar Water provide pH pens, conductivity meters, refractometers and test kits for onsite testing of system fluids. Technical assistance is also available at 1-800-543-5975.

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STEAM BOILERS

Although steam boilers experience many of the same problems as hot water boilers, higher temperatures, and the production of steam change some of the methods for controlling these problems.

The higher temperatures experienced at the heat exchange surfaces, increases the potential for calcium carbonate, iron, silica and other types of scale formation. The higher the temperature, the less soluble these minerals become.

Steam produced by the boiler is harder to contain and more likely to leak from valve and pump seals, threaded joints and unions. This increases the amount of make-up water required, bringing in additional minerals and oxygen.

Steam boilers will often have condensate return tanks that are vented. This allows additional water vapor to be lost, requiring more makeup water.

Corrosion in the Boiler

In a steam boiler, oxygen pitting at the heat exchange surfaces is the most prevalent corrosion problem. Higher temperatures combined with more oxygen from makeup water create conditions that need to be addressed.

Steam heating boilers will typically operate sporadically with weather conditions. During the frequent periods the boiler is off long enough to cool down, the steam lines and air space above the boiler water line can go into a vacuum. This can allow oxygen to leak into the boiler and steam lines through fittings, valves, seals and pipe threads. When the boiler heats back up, the oxygen begins its attack. This process can happen over and over until serious damage occurs.

Corrosion in Steam and Condensate Return Lines

Steam lines in a boiler system will experience corrosion attack from oxygen. As the water is heated in the boiler, oxygen and carbon dioxide gases are boiled off and will escape with the steam. The oxygen will attack any metal piping it comes in contact with as it is carried with the steam. Controlling oxygen in the boiler water is the best solution to preventing this type of problem in the steam lines.

Carbon dioxide gas is produced when carbonate alkalinity in the boiler water breaks down during the heating process. This gas is carried with the steam. As the steam cools, carbon dioxide gas is absorbed to form carbonic acid in the condensate. The pH of untreated condensate can be as low as 3.5 – 4.0, creating a very corrosive solution.

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Typical damage to steam/condensate lines due to low pH conditions will be evident by thin walled pipe and pipe threads. Often, pipe threads will become so thin the pipe joints can be broken in two by hand. Pipe walls will usually show thinning on the bottom portion due to the acidic condensate water laying or moving along the bottom of the pipe. The metal has actually dissolved and been washed away, usually into the boiler itself where it can deposit as scale on heat exchange surfaces.

Scale Formation in Steam Boilers

As mentioned previously, the term scale is typically referring to the buildup of water impurities on heat exchange surfaces. Calcium carbonate and/or iron and copper corrosion products are the most common components of scale in boilers.

The tendency for steam boilers to require more makeup water can result in a constant supply of calcium, magnesium and other minerals entering the boiler. This makes water quality a greater concern compared to hot water boilers.

Foaming, Surging and Carryover

"Foaming" in a steam boiler is due to the accumulation of minerals and chemical treatment products in the boiler water. The water will gradually become dirtier over time. These contaminants will accumulate in the upper 4-6" of the boiler water due to the boiling off process when steam is produced.

As this process continues, the surface tension of the water increases until small bubbles begin to occur, causing foam.

"Surging" is a term that is typically used to describe boiler water that is fluctuating wildly, often causing the boiler to shut down due to water levels dropping below the low water cutoff setting. A mechanical issue such as intermittent blockage of the steam/condensate lines from excess condensate, corrosion debris or malfunctioning valves usually causes this type of problem.

"Carryover" is the transfer of boiler water into the steam lines. When a steam boiler is functioning properly, steam will be termed "dry" with little liquid moisture present other than in condensate return lines.

Boiler water carryover will reduce operating efficiency by cooling and restricting the proper flow of steam in the system.

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STEAM BOILER TREATMENT

Steam boilers will generally require more treatment and attention than a hot water system. This is due to their tendency to use more makeup water and the higher operating temperatures. A brief explanation of the different treatments is given below.

Rhomar's Boiler Pro™ 903 (or its more concentrated equivalent Boiler Pro™ 901) premium multi-purpose steam boiler treatments are formulated to provide continuous protection from scale and corrosion in steam boiler systems and steam/condensate lines as well as dispersing suspended solids for easy removal during blowdowns.

Pretreatment

Pretreatment for boilers is the treatment of water prior to feeding the water to the boiler. This can be either a mechanical or chemical process.

Mechanical pretreatment can be with a water softener to remove hardness, a dealkalizer to remove alkalinity, demineralizers, deaerators to remove oxygen or as simple as a filter to remove sediment. Most of these forms of pretreatment, with the exception of a small water softener, are not financially practical for residential or light commercial systems. If the home already has a softener installed for domestic water usage, it can be used to supply makeup water to the boiler.

Oxygen Treatment

Oxygen treatment for the prevention of corrosion in steam boilers is the most critical part of a treatment product. Oxygen can quickly erode pinholes in heat exchange metals, causing boiler failure.

The most common form of chemical prevention of corrosion due to oxygen is with "oxygen scavengers". These are chemicals that quickly react to neutralize oxygen in the boiler water before it can cause any damage. They are usually catalyzed to speed up the reaction when water is heated.

Alkalinity Builders

Most steam boilers are composed of black iron, cast iron or steel. Due to the chemical reactions that occur in high temperature boiler water, it has been determined that these metals are better protected at higher pH levels.

In order to maintain pH in the alkaline range, specific chemical hydroxide alkalinity builders are a normal part of most steam boiler treatments.

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Scale Inhibitors

All boiler treatment products will contain specific additives to help prevent scale formation. The original additives were simple phosphates. The level of calcium in the water limited the success of these phosphates. Very hard water containing high levels of calcium could result in calcium phosphate scale.

Today, there are many other additives that are more flexible and provide better protection than phosphates. Combinations of organic inhibitors and polymers can produce excellent results. Modem treatment products will offer the best blend of chemicals available for scale control. These "scale inhibitors" will chemically bond with scale forming minerals in the water. This process will distort the molecules and make them less likely to form scale. Scale buildup on boiler heat exchange surfaces will quickly reduce operating efficiency and increase operating cost.

Sludge

The term "sludge", when used in reference to boilers, is referring to the precipitate or flocculant that is produced when scale inhibitors in a treatment product bond with calcium and other scale forming minerals in the boiler water. The resulting combination of chemicals and minerals can fall to the bottom of the boiler and accumulate as sludge.

Dispersants

Quality boiler treatment products such as Rhomar Water
's Boiler Pro™ 903/901 will contain extra additives to "disperse" contaminants and sludge in a boiler. Without these extra additives, boiler sludge can accumulate and over time become dense and hard to remove.

In addition, corrosion products that might come from the steam/condensate lines can settle on boiler surfaces and reduce efficiency. These chemicals are usually some form of water treatment polymer.

Steam and Condensate Line Treatment

Unlike hot water boilers, steam boilers circulate steam instead of water through the heating lines. Treating the water in a hot water boiler will treat the whole system. However, this is not the case for steam boilers.

Oxygen scavengers, scale inhibitors, alkalinity boosters and dispersants will remain in the boiler water when steam is produced. This is true if the boiler water is not allowed to become too dirty, causing foaming and carryover.

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In order to properly protect steam and condensate lines, it is necessary to add special treatments to the boiler for this purpose. These chemicals, called amines, will volatize (evaporate) with the steam and travel through the system to provide protection.

Amines can be either neutralizing or film forming. Neutralizing amines are very alkaline in nature and will react with and "neutralize" the carbonic acid that is formed with the condensate. Film forming chemicals will also evaporate with the steam and "plate out" on the metal surfaces as they move through the piping, forming a protective film against acid attack.

Film forming amines are generally not as effective as neutralizing amines due to the fact they tend to plate out quickly, leaving the further reaches of condensate piping unprotected.

TESTING STEAM BOILER WATER

Steam boilers will have different test parameters than those for a hot water boiler. This is due to higher temperatures, the production of steam and the tendency for greater makeup water requirements.

Testing Frequency

Testing a hot water boiler annually is typically adequate for proper monitoring of the system fluid. Steam boilers however, should be tested monthly or more often during the peak heating season.

Depending on the amount of steam and water loss, testing is the only accurate way to determine when additional treatment is required to protect the system.

Oxygen Scavenger Testing

The oxygen scavenger treatments that are added to a steam boiler will be quickly depleted when makeup water is added. In addition, any air that enters the boiler or steam/condensate lines during off periods will also rapidly deplete this chemical additive.

Since oxygen scavengers are the main chemical treatment for corrosion protection, it is important to maintain adequate levels for the long-term protection of the system.

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Conductivity Testing

The conductivity of steam boiler water will gradually increase over time. This is due to the accumulation of minerals from makeup water and chemical treatment being added to the boiler.

As steam is produced and leaks from the system, it leaves the minerals behind in the boiler water. These contaminants are said to "cycle up" in the water. This process will continue until the water begins to foam and cause "carryover".

The ABMA (American Boiler Manufactures Association) recommends a limit of 7000 µS/cm in steam boilers. This limit is primarily set to prevent foaming. It is the informed opinion of Rhomar Water through the experience acquired through sample analysis and feedback we get from users that that most steam boilers should be kept to 4000 µS/cm to keep various contaminants from getting too high. This level will help prevent scaling and excess sludge formation.

Blowdowns

As boiler water mineral and chemical levels increase, more sludge will also accumulate and settle in low areas of the boiler. In order to remove the sludge and lower dissolved solids, the boiler is blown down to remove some of the dirty water.

This process is termed "blowdown". By removing dirty water, clean water is fed to the boiler as makeup, diluting the solids and conductivity of the boiler water to acceptable levels.

Conductivity meters can be used to check conductivity levels for the purpose of determining "blowdown" frequency.

pH Testing

The pH of steam boiler water will usually be higher than most closed loop hot water boilers. The testing of pH on steam boilers is normally performed on the condensate to check for low pH or acidic conditions.

This process may only be useful for reference only as small residential and light commercial steam boilers are normally treated with a premixed all-in-one product. This does not allow for the addition of individual steam line treatment if needed.

Rhomar Water's Boiler Pro™ 903/901 steam boiler treatment will typically contain enough steam/condensate treatment to maintain a safe alkaline pH (11.0 – 12.0) in the condensate.

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IDENTIFYING SYSTEM PROBLEMS

The key to solving a boiler system problem is to identify the cause. For many years, the system fluid has been routinely ignored as a source for system problems. Identifying a water related problem is often quite simple. If the water color is not clear, or if large amounts of metal sediment are visible when a sample is taken, then proper water treatment was probably never included with the installation or, it has been lost from the system due to leakage or repairs.

Corroded zone valves, pump volutes, piping or leaking boiler heat exchangers, are indications of a system that has experienced severe corrosion, probably due to a lack of proper chemical treatment.

The only solution is to replace the damaged components, thoroughly clean and flush the system with a quality cleaning product such as Rhomar Water's Hydro-Solv™ 9100/9250 or Hydro-Steam™ 9150 for water systems and steam boilers respectively, then refill with new fluid and a long-term treatment product like Rhomar Water's PRO-TEK® 922/AL/QT for hot water boilers or Steam-Pro™ and Boiler Pro™ 903/901 for steam boilers.

CLEANING AND DESCALING A SYSTEM

There are many different ideas on what to use for cleaning a hot water or steam boiler system. Everything from vinegar to TSP are common responses when researching for information. The type of chemical product to use is dependent on the type of contaminant that needs to be removed, and the system components. Acids, such as hydrochloric, work well on calcium carbonate-based scales, but they should be properly inhibited to prevent damage to the metal components.

Calcium scales are rare in hot water and residential steam heating boilers. Corrosion products are the most common contaminant in older systems along with some glycol-based inhibitor films. Most acids are not very effective on these substances.

New systems are generally fouled with manufacturing contaminants in addition to construction products. Cutting oils, tapping fluids, metal shavings and welding debris are common substances from manufacturing along with flash rust, dust, dirt and pollen from storage. These same contaminants along with bacteria, solder flux, and other construction debris can enter the system during installation.

The most effective cleaning chemicals for corrosion, sludge, sediments, construction and manufacturing debris, and film forming contaminants are dispersants, polymers, detergents and chelants.

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Well-formulated cleaning products such as Rhomar Water's Hydro-Solv™ 9100 and Hydro-Steam™ 9150 will contain a careful blend of these ingredients. They will not only remove most contaminants, but also will not harm system metals and piping.

When heavy calcium carbonate scale buildup, typically in steam boilers, has been identified, acid descaling may be beneficial However, due to the potential for system damage, a professional water treatment company should supervise this process.

Care should be taken when selecting a cleaning product. System components such as aluminum, copper, oxygen barrier and other types of flexible tubing could be damaged if the product contains the improper ingredients.

SELLING CLEANING AND TREATMENT

In the past, water treatment, if any, may have consisted of flushing the system with water, or, in more exotic instances, washing out the system with TSP (trisodium phosphate).

Actual chemical treatment of the system was limited to inhibited glycols, or to a few products that may or may not have provided any benefit. Some of these products were poorly formulated or may have been intended for some other use.

With today's new high efficiency, multi-metal boilers, proper water chemistry has become critical to long term efficient and trouble-free operation. The use of more sensitive metals such as aluminum and copper can open the door to short term system failures.

The use of cleaning and treatment chemicals has been required for many years in the industrial and large commercial fields. The time has come for this technology to move into the residential market where it has been neglected.

A residential customer that is new to the Hydronic heating market will not be a good reference for this type of system if they begin to experience problems within the first few years of ownership. Proper cleaning and treatment will help to ensure we have a good reference from our Hydronic customers.

List Cleaning and Treatment Separately

Many contractors are often concerned about the cost that chemical cleaning and treatment will add to their proposal, generally thinking that it may make them less competitive in the marketplace. When presented properly, this process can actually help them appear more professional. When preparing a proposal for a customer, the cleaning and treatment costs should be listed and priced as a separate item. This will help the customer to distinguish your services and professionalism from other companies that are competing.

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Maintaining System Efficiency

The greatest effect of scale or corrosion buildup in a boiler is the rapid loss of operating efficiency and an increase in maintenance and repair costs. A 1/10 inch of scale can increase fuel cost by 20 %. It only takes a 1/3 inch of buildup on heat exchange surfaces to double the boiler fuel bill. Typically, the boiler is the most expensive utility cost a homeowner will have during the winter months.

As energy costs continue to rise, utility bills are a constant concern for most homeowners. Making the customer aware of how the proper cleaning and treatment of their new or used system will help to keep their utility costs from going up and their maintenance costs down, will always be a good selling strategy.

Show Pictures of Damaged Components

When presenting your proposal to a potential customer, showing pictures of what can result if proper cleaning and treatment is not performed, will almost always sell this service. Rhomar Water's "Gallery of Scale and Corrosion" flyer was designed for this purpose and copies are available to contractors at no charge by calling Rhomar Water at 1-800-543-5975.

Most contractors will also have used metal components that were replaced due to corrosion damage. These items can also be used to show why chemical treatment is recommended.

Let the Customer Decide

If you have concerns about the cost of your quote when including cleaning and treatment, list this cost as an option and give the customer the choice of whether to include this service. However, I personally would feel uncomfortable with the future performance of the system if it is left out.

By listing the cleaning and treatment cost separately in your proposal, you show the customer why your total cost may be higher than a competitor. By showing pictures and/or damaged components, along with the benefit of lower utility and maintenance bills, there will usually be no hesitation by the customer on including this option.

"Make the Other Guy Look Bad"

If you include cleaning and treatment as part of your routine service, and you properly explain why this service is needed as recommended above, your customer will be hesitant to use any contractor that does not do the same.

Customers understand why they add the proper fluids and chemicals to their automobiles, lawn mowers, etc. You can make the "other guy" look bad by educating the homeowner on this important part of system maintenance.

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RHOMAR TREATMENT PRODUCTS

As mentioned at the beginning of this document, Rhomar Water is a water treatment company specializing in the chemical treatment of boiler and cooling water systems.

Our many years of hands-on experience designing, formulating and producing cleaning and treating industrial and commercial hydronic systems, have enabled us to learn what chemistry is most effective for each type of system and problem.

The products we have formulated for the residential and light commercial market are specifically designed for these small compact systems. They have many benefits that fill specific needs in these systems. Some of these benefits are listed below.

HOT-WATER BOILER TREATMENTS

Hydro-Solv™ 9100, Hydro-Solv™ QC & Hydro-Solv™ 9250

These are multipurpose cleaners designed for the different types of hydronic systems. They are all designed for cleaning hot water boilers. They can be used in all types of boilers to remove a variety of new installation and corrosion debris. When used as directed, they are safe on all metals and tubing, will prepare new systems for service and will restore lost operating efficiency in older fouled systems.

Both Hydro-Solv™ 9100 and Hydro-Solv™ 9250 are in liquid form and are available from 1-gallon up to any amount needed by the customer. They can be diluted at the rate of 1: 50 and 1: 250 respectively. Hydro-Solv™ QC on the other hand is in a 16 fl. Oz. aerosol can (is suitable for systems of up to 25 gallons) which is easy and convenient to dose into a hydronic system through the boiler drain (see ***Figure 9*** below).

Pro-Tek® 922, Pro-Tek® QT & Pro-Tek® AL

These are premium multimetal corrosion inhibitors. They are designed for today's modem high efficiency, multi-metal boilers. It will remove oxygen, prevent scale, neutralize acids, disperse sludge, and provide corrosion protection for all metals, including aluminum. They all compatible with all types of common inhibited glycols – propylene glycol, ethylene glycol and even glycerin. They can also be used to provide corrosion protection in uninhibited glycols.

Pro-Tek® 922 and Pro-Tek® AL are in liquid form with the latter being the more concentrated form of the former. The dilution rates are 1-gal of product to 50 gallons of system volume and 1-gal to 150 gallons of system volume respectively. Pro-Tek QT is the aerosol form of the first two products and it was designed to enable quick and easy treatment of systems. This is because it can be dosed to a system through the boiler drain while that system is still under pressure. This product may be sold independently or as a kit alongside the Hydro-Solv™ QC. Together, they may be used to clean and treat residential hydronic systems of up to 25 gallons.

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Figure 9: Hydro-Solv™ QC and Pro-Tek® QT shown with the swivel connector that is connected to the boiler drain valve as shown in the image on the left.

BoilerGard™ 1202
This product has been reviewed by the NSF and is rated HTX-1. This means that it can be used as an ingredient or a corrosion inhibitor for that matter for a system that requires a product (heat transfer fluid) that is incidental food contact safe such as geothermal systems and those that are installed in food processing facilities.

STEAM BOILER TREATMENTS

Hydro-Steam™ 9150
Hydro-Steam™ 9150 is a cleaner that is formulated specifically for steam boilers. It not only contains a blend of scale, rust and sludge removal chemicals, but also contains steam and condensate line treatments to help flush contaminants from these areas.

Boiler Pro™ 903, Boiler Pro™ 901 & Steam Pro™
Boiler Pro™ 903 is an "all-in-one" steam boiler treatment. It contains a blend of oxygen scavenger, alkalinity builder, scale inhibitor, sludge dispersants and steam and condensate line treatment. The Boiler Pro™ 903 product has been formulated to address all the problems associated with the use of steam boilers. This dilutes at the rate of 1 gallon to every 40 gallons of system volume. Subsequent additions of the treatment should be done following a blowdown at half the normal dosage. This may also be done if the sulfite levels drop to below 20 ppm (portable sulfite test kits are available) or when the conductivity levels reach 4000 µS/cm (use a conductivity meter to measure fluid conductivity).

A ready to use (RTU) option Steam Pro™ is also available. The more concentrated form of this product is Boiler Pro™ 901. All these products can be used with hard or soft water.

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