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It is imperative to proactively address Water Quality before and during boiler commissioning as well as during routine maintenance. Common water quality heat exchanger failures such as scale buildup, are easily prevented when properly addressed.

What can I do? Please follow our recommended System Water Best Practices:

- Test system fill water and understand what you are putting into the system.
- Ensure that there is adequate air elimination in the system.
- Treat all boiler feed water as though it is hard water.
- Use chemical inhibitors on **every** job.
- Flush old and new systems with an appropriate chemical system cleaner.
- Use magnetic dirt separators on systems containing large amounts of iron.
- Use Y Strainers, Filters, and Dirt Separators to remove debris from system water.
- Where possible, treat boiler feed water.
- Repair system leaks immediately to prevent untreated water from entering the system.

NTI recommends the following parameters to maintain your system:

CH Loop Total Water Hardness Specifications	
Contaminant	**Maximum Allowable Level**
Total Hardness	120 mg/l (7 grains/gallon)**
DHW Loop Total Water Hardness Specifications	
Contaminant	**Maximum Allowable Level**
Total Hardness (below 140°F water temperature)	50-200 mg/l (3-11.7 grains/gallon)
Total Hardness (above 140°F water temperature)	120 mg/l (7 grains/gallon)
CH and DHW Loop Total Water Hardness Specifications	
Contaminant	**Maximum Allowable Level**
Aluminum	0.05 to 0.2 mg/l or PPM
Chloride	100 mg/l or PPM
Copper	1 mg/l or PPM
Iron	0.3 mg/l or PPM
Manganese	0.05 mg/l or PPM
pH	7-9
Sulfate	205 mg/l or PPM
Total Dissolved Solids (TDS)	300 mg/l or PPM
Zinc	5 mg/l or PPM
Dissolved Carbon Dioxide (CO2)	15 mg/l or PPM

CH Loop Additives	Recommendation
Molybdate corrosion inhibitor	100 – 300 ppm. Film-forming inhibitor that protects against iron corrosion
Glycol Freeze Protection (if applicable)	20-35%. Concentrations below 20% can promote bacteria growth and above 35% will reduce efficiency and may require de-rating the boiler

**NOTE: The maximum allowable total water hardness is relative to the total system water volume. If the system water volume exceeds 300 US gallons, then limit the total water hardness to 120 ppm. If the system water volume exceeds 500 US gallons, then use a heat exchanger to isolate the boiler from the system.

It is important to understand water quality parameters and how a deviation from the recommended range will cause damage to your system. The following explains commonly measured parameters:

Corrosion Inhibition

Corrosion in systems comes in many forms. The most common form of corrosion is caused by oxygen in the water. Oxygen in water will cause oxidative corrosion. Other types of corrosion include galvanic corrosion, caustic corrosion and acidic corrosion. To combat each type of corrosion, different methods are used, such as pH control (see pH section), use of corrosion inhibitors, effective monitoring, and system water control.

There are many corrosion inhibitors available today. However, for closed loop hydronic heating systems, only two types are recommended. Molybdate and nitrite corrosion inhibitors are film forming inhibitors and protect against all forms of corrosion. Molybdate is preferred over nitrite because it is required at lower concentrations, it is less toxic, and does not promote the growth of bacteria. Nitrite corrosion inhibitors work by reacting with ferrous hydroxide and forming a passive layer of magnetite. Molybdate corrosion work by converting "red rust" into a passive layer of magnetite. *Fernox F1, Rhomar Pro-tek 922, and Sentinel x100 protector* are recommended Molybdate inhibitors. The concentration of Molybdate inhibitor should be between 100-150ppm (parts per million). Concentrations above 150ppm Molybdate are not a concern and can be used as an effective pre-operational cleaner if a side stream filter is in use.

As mentioned above, doubling the Molybdate corrosion inhibitor concentration to approximately 300ppm, in conjunction with a side stream filter, is an effective pre- and post-operational cleaner. The Molybdate will bind oils and minor debris forming larger debris that the side stream filter will collect. Without the filter, the cleaning properties of this method will not be effective.

pH

A pH measurement is a logarithmic determination of the hydrogen ion concentration. The lower the pH reading the more acidic the solution; the higher the pH the more basic the solution. The pH scale ranges from 1 to 14 with a pH of 7 being neutral.

The pH of heating system water has a huge effect on the life of the heating system. Variations in pH may indicate a variety of problems and cause damage to the system components. The ideal pH is between 7 and 9. A low pH will promote steel corrosion, and a high pH will promote copper and brass corrosion and accelerate magnetite and iron scaling. Buffers in corrosion inhibitors help maintain the proper pH range. A drop in pH may indicate a bacterial infection or a degradation of glycol if it us used. A bacterial infection produces acidic by-products which drop the pH of the system water. Bacterial infections can be combated with a biocide (see Bacteria/Mold section). As glycol degrades, it produces acidic by-products dropping the pH. System pH can be maintained with regular monitoring and a pH meter. Check with the glycol manufacturer for the correct pH for that product.

Conductivity

Conductivity is an indirect measurement of Total Dissolved Solids (TDS). To approximate total dissolved solids from conductivity multiply by 0.62 (TDS = 0.62 x Conductivity). Conductivity is a test of how easily the water conducts an electric current. The more dissolved solids in the solution the higher the conductivity. Domestic tap water has a conductivity of around 300µS/cm, with variances depending on region. Conductivity can also be used as a secondary indication of the amount of chemical treatment. For example, the concentration of nitrite inhibitor in a solution should account for 1/3 of the conductivity reading.

The conductivity in closed loop hydronic heating systems should be under 300µS/cm if no corrosion inhibitors are used. The addition of glycol, nitrite, and even soft water will increase conductivity readings. Conductivity above 300µS/cm, not attributed to known water treatments, indicate a high level of dissolved solids and is not suitable for use in hydronic heating systems. In systems where the conductivity is approaching or above 300µS/cm the system should be flushed and refilled with fresh water, glycol (if required) and corrosion inhibitors.

Hardness

Water hardness is a term that describes the amount of calcium and magnesium bicarbonate in the water. These ions will precipitate out of water as calcium carbonate and magnesium carbonate when the water is heated. This can be seen daily if you have a white/yellow scale on your kitchen sink faucet. These precipitated particles can cause leaks by getting behind O-rings and allowing water to escape. Also, the precipitation of these substances onto mechanical parts can cause improper functioning of the part.

Hardness is usually measured in “Grains of Hardness” (grains/USG) or in parts per million. Converting between the two units is simple using the ratio of 1 grain/USG = 17.1ppm. We will be using ppm in our discussion.

The ‘old school’ thought on water quality recommended the use of all soft water in closed loop systems. The latest recommendation is that some hard water *can be used* in closed loop systems. The reason for the change is that softened water has the natural mineral balance disturbed. The disturbed water will try to re-balance itself by leaching the required minerals from the metals back into the water; this leaching of minerals will cause a higher rate of corrosion. To help combat the precipitation of carbonates without softening the water, dispersants are included in the corrosion inhibitor mixtures that keep the carbonates in suspension. Water hardness will vary depending on the region you live. For example, water in Saskatchewan, Canada has a hardness of about 490ppm and Nova Scotia has a hardness of about 45ppm.

Water with a hardness above 120 ppm can lead to scale build up, even with the use of corrosion inhibitors, and should not be used.

Glycol Freeze Protection

Propylene Glycol, (PG), is used to prevent the freezing of systems that are exposed to low temperature environments, such as snowmelt systems. If glycol is required in a system, it is recommended that the concentration of glycol be above 20% and no more than 35%. Below 20%, glycol becomes a nutrient for the growth of bacteria, which can infect the system. Once a bacterial infection gets into a system, it is very difficult to remove. Glycol concentrations above 35% make the water too viscous and may cause damage to system components. High glycol concentration reduces heat transfer and decreases efficiency; this decrease is most noticeable in mixtures above a 50% concentration. A 50% glycol mixture should only be used in snow melt applications. Propylene Glycol can last up to 9 years. It is important to inspect glycol systems to detect degradation in glycol over time.

Addition of glycol to a system will cause a drop in pH (see pH section). Buffers are usually mixed with the glycol to combat the drop in pH. When glycol breaks down it forms acidic products which lower pH. Inhibited glycol will typically have a pH of 8-9 when mixed at a 30-50% concentration with water, check with the glycol manufacturer for the proper pH level. The use of UV water filters in glycol systems is not recommended because UV radiation will degrade glycol.

Bacteria and Mold

Different types of bacteria can infect a heating system. Bacterial infections are rare but happen occasionally. As previously mentioned, bacteria can thrive in a glycol environment in concentrations below 20%. This is because at a low concentration, the glycol is no longer toxic to the bacteria and the bacteria can feed off it. The bacteria can leave a slime residue that interferes with proper operation of the system (the excrement of the bacteria can be highly corrosive, often indicated by "pin-hole" leaks in the heating system).

Microbiological organisms can enter a system through the make-up water. They can also enter the water through air dissolving into the water. Testing for bacterial and mold infections can be done using agar dip slides. If an infection is found, the easiest way to remove the organisms is to add dispersants and biocide to the system. Both products can be purchased through pool supply stores.

System Cleaning

Existing and new heating systems must be cleaned with a hydronic system cleanser such as the recommended products below. System cleaners must be drained and thoroughly flushed from the system with clean water to remove any residual cleaner, prior to installing a new boiler. NEVER leave a system cleaner for longer than recommended by the manufacturer of the cleaner. Always follow the instructions provided by the system cleaner manufacturer.

• Noble Noburst Hydronic System Cleaner

• Fernox F3 Cleaner

• Rhomar Hydro-Solv 9100

• Sentinel X400

The following scale conditions may occur when the recommended guidelines are not followed:

Scaling in Hot Water Boilers

Scale is a general term used to describe mineral deposits formed from dissolved minerals in water. These deposits restrict flow in the boiler and heating system, reduce efficiency and damage system components. Scale formation in hydronic heating systems has three main causes, use of hard water, aerated hydronic systems, and poorly maintained heating systems. Three common types of scale found in boilers are, lime scale, magnetite, and hematite.

Lime scale is a chalky off-white material commonly found in kettles, shower heads and boilers. Lime scale is formed when naturally occurring calcium carbonate, magnesium hydroxide, and calcium sulphite, found in most ground water supplies, is heated, and precipitates onto the boiler or system piping. Tests for water hardness measure the level of calcium carbonate and magnesium hydroxide in a water sample. Hardness is typically measured in grains per gallon (gpg), parts per million (ppm), or milligrams per liter (mg/L).

Magnetite scale is a hard, brownish-black material that is found in closed loop heating systems. Magnetite is formed when iron corrodes in a closed loop water system and the dissolved oxygen in the water is limited. It is normal for some magnetite to occur in heating systems where iron is present. Corrosion inhibitors work by creating a passive layer of magnetite on iron components. The initial water fill will always contain some dissolved oxygen which will react with exposed iron and create magnetite. In Closed loop systems there is a limited amount of dissolved oxygen available and magnetite formation will be negligible. Free magnetite in heating systems can be reduced with the use of magnetic filters. Magnetite will not be detected by a harness test but will evidence itself in total dissolved solids, conductivity, or iron specific tests.

Hematite or rust scale is reddish-brown in color and is found wherever unprotected iron is exposed to moisture and oxygen. Rust will form in heating systems when there is too much oxygen present. Oxygen is introduced in heating systems from inadequate air elimination, non-oxygen barrier components, and excessive make up water. Rust formation in a heating system requires immediate action to prevent system damage. Systems with evidence of hematite formations must be thoroughly cleaned and the water in these systems should be monitored closely for the several months to ensure that pockets of rust do not come loose and contaminate the fresh system water. Hematite is nonmagnetic and will not be picked up with magnetic filters.