2014 Service Technician Training Program

Closed Loop Systems

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Closed Loop Cooling and Heating

- The Closed Loop Cooling Advantages
  - High Efficiency Chillers , Heat Exchangers, and Hot Water Recirculating Boilers Need Clean Water
  - Chiller Condenser Tube and boiler heat exchange surface Fouling is Minimized
  - System Operates at Maximum Efficiency
  - Minimal Water Treatment Requirement
  - Reduced Cooling and Heating System Maintenance Costs

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Closed Loop Cooling

- Closed Cooling Loops Operating Benefits
  - Water Treatment Costs are Reduced
  - Reduced Potential Pump Problems
  - Free Cooling as an Operating Strategy

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CLOSED LOOPS

A closed system refers to a recirculating water system in which there is negligible water loss – 1% to 5% per day

The water is either heated or cooled through a heat exchanger

Water may be kept in the system from weeks to years

Operating temperatures vary in closed systems, from 40° to 50° F to as high as 350° – 400° F

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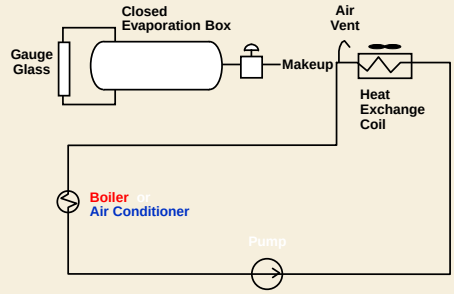
A TYPICAL CLOSED WATER SYSTEM



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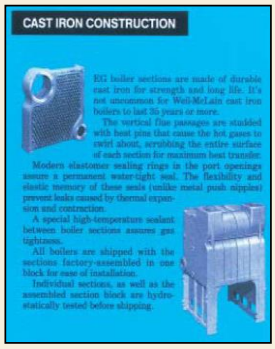
Cast Iron Sectional Boilers



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MAJOR PROBLEMS

Microbiological

Corrosion

Oxygen

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Microbiological Activity

- **Decreases Corrosion Inhibitor**
- **Decreases Heat Transfer Efficiency**
- **Increases Corrosion**

Microbiological Activity

- **Bacteria can occur in systems operating at temperatures of -0° to 160° F.**
- **Aerobic organisms can flourish in closed loops if oxygen is present.**
- **Anaerobic organisms, such as sulfate reducers, can lurk under deposits or in oxygen-free systems.**
- **Bacteria thrive the best in 90° F water, in static conditions, and in low flow areas**

Microbiological Control

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Corrosion

- **By-Products increase plugging and fouling**
- **Reduces heat transfer efficiency**
- **Wears pump seals and impellors**
- **By-Products Can Cause Erosion**

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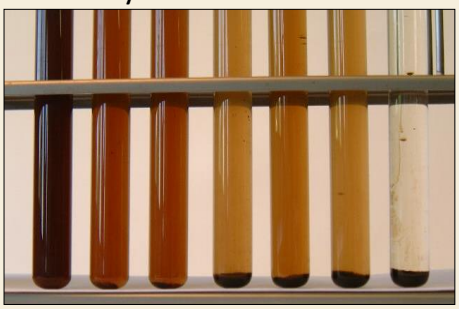
What Happens Over Time With Corrosion By-Products?



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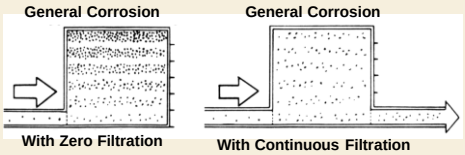

Letting Filtration Reduce The Concentration

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Filtering Contaminants

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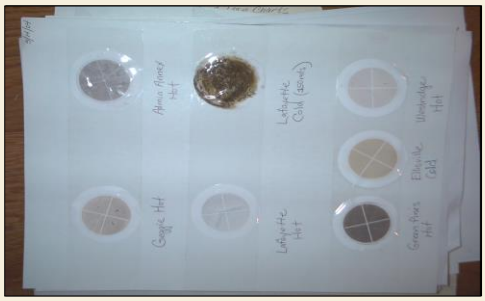
Closed Loop Corrosion

Filtered Iron Results From Several Loops



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How Can We Instantly Test The Closed Loop To See If We Have Corrosion?

Problems

Fouling and Plugging

Because most closed systems retain water a long time, any corrosion can result in a gradual buildup of metals in the system causing severe fouling and plugging.

Oxygen pitting

Air can seep into the closed system through valves, unions, elbows, and pumps in addition to dissolved oxygen in makeup water.

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Deposit Control

- **Water added to a closed loop does not evaporate so a deposit control program often is not required.**
- **Polymers or surfactants sometimes are incorporated into closed-loop programs to act as dispersants.**
- **Polymers and surfactants can be effective in cleaning up systems that have been previously abused and contain high-suspended solids of metal oxides or hydroxides.**
- **Side-stream filtration is used in conjunction with these chemicals. When cleaning up, it is important to have bled the system so that the cleaned deposits can be removed from the system.**

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Oxygen

O_2 (Oxygen) can enter a system in two ways:

1. Seep through valves, unions, elbows, pumps, faulty air separators.
2. It also enters as dissolved oxygen in makeup water.

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Expansion Tanks

- **They compensate as water expands with rising temperature and permit addition of makeup water.**
- **They may be "open" or "closed".**
- **Open tanks release air to the atmosphere. They are located on the suction side of the pump at the highest point in the system.**
- **Closed expansion tanks are most commonly used in high-temperature hot water boilers, high-temperature systems, and chilled-water loops.**

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Closed Loops

Air Separators

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Closed Loops

Mechanical Pump Seals

- **Seals are designed to permit minor leaks of water.**
- **Excessive water loss results if they are not maintained**
- **High levels of inhibitors can crystallize in the seal, causing mechanical degradation**

Foulants such as iron can wear mechanical seals

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Closed Loop Monitoring

Monitoring should include:

- Testing for the inhibitor – nitrite, molybdate, etc.
- pH
- Iron levels
- Copper levels
- Suspended solids

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Types of Closed Loop Inhibitors

- **Nitrite**
- **Molybdate**
- **Borate**
- **Nitrate**
- **Silicates**
- **Phosphates**
- **Azoles**
- **Sulfites**

Nitrite

- Interfere with the corrosion mechanism by putting down a film or barrier on the steel surface
- Typically utilized at 500 to 1,500 ppm at pH>7.5
- Formulated with several other inhibitors and buffers such as borate, nitrate, azole, or molybdate
- Used in chilled water loops to hot water boilers
- Residuals must be maintained to constantly repair gaps in the film barrier
- Nitrifying and de-nitrifying bacteria use nitrite for their food/metabolism and if present contribute to the production of nitrate, ammonia, and nitrogen in the system

Molybdate

- Molybdate (MoO_4) is an anodic metal passivating agent
- Used at concentrations of 80 to 500 ppm as Mo at high pH (>8.5).
- Not recommended soley in hot water systems
- Molybdate treatments are expensive and require high concentrations in high sulfate and chloride water
- Calcium molybdate precipitation can occur in high-hardness waters

Borate

- It is used to buffer the water to a pH above 8.5 or higher.
- Used most often used with nitrite-based programs.

Nitrates

- Nitrates at 100 to 200 ppm provide protection to aluminum.
- Aluminum must be controlled in the 7.5 to 8.5 range.
- A pH above 9.0 will produce severe corrosion of aluminum.

Silicate

- Effective corrosion inhibitor for both steel and aluminum
- Produces an adsorbed silicate film on the metal surface that is stable over a temperature range of 80° to 140° in low hardness or soft water
- Used at concentrations of 20 to 60 ppm as SiO_2
- Can be used alone or with phosphates.
- Are preferred treatments for systems with high water losses.

Phosphates

- Phosphate can be used alone or with silicate in systems with high water loss
- Used where economics prohibit the use of alternate programs
- Exercise extreme caution when using phosphates to avoid the precipitation of calcium phosphate.

Azoles

- Add benzotriazole and tolytriazole to closed system treatments for the protection of yellow metals (copper & brass)
- Dosages vary from 10 to 20 ppm
- Azoles form a thin, impervious, adsorbed, organic film on yellow metals, acting as a chemical and physical barrier to corrosion.

Oxygen Scavengers

- Oxygen scavengers work well in closed-loop systems where the system is not truly closed and the pH is properly controlled.
- Maintain a sulfite residual of 80 to 120 ppm.
- In high-temperature systems, hydrazine and diethylhydroxyl amine (DEHA) are better because they are also metal passivation agents.
- DEHA residuals from 60 parts per billion to 150 ppb are used.
- DEHA is used where there are limits on conductivity.

Chemical Feeders

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Glycol Closed Loop Systems

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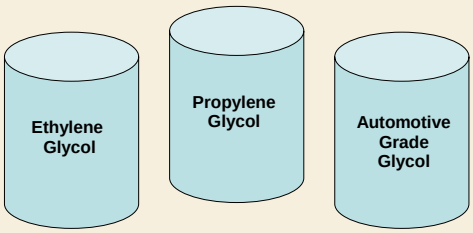
Type of Glycol

The types of glycol that are commercially available in bulk:



Type of Glycol

- **Automotive grade glycol must not be used in HVAC systems because these types of glycol contain corrosion inhibitors that are not compatible with the materials and operations of HVAC systems.**
- **Automotive grade glycols will break down quickly in a HVAC system and cause system corrosion.**

The acute oral toxicity of propylene glycol is much lower than that ethylene glycol.

Propylene glycol is the preferred choice for use in systems where accidental ingestion may occur.

- Because of its higher heat transfer rate ethylene glycol could be used in systems where accidental ingestion is not a concern.
- Some municipalities also restrict the disposal of ethylene glycol to sanitary sewers, which may further limit its use in certain applications.

Never dump any glycol to a storm sewer or a water way with out approval from the appropriate governmental agencies.

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System Cleaning

- All lines and equipment of the system should be cleaned with a cleaning solution formulated to remove oil, grease, and mill scale
- The cleaning solution must be thoroughly flushed from the system prior to the glycol addition.
- After flushing the system, the water should be tested to insure all of the cleaner is removed.
- Corrosion inhibitors added will only protect what it comes in contact with. If the system surface is dirty the inhibitor cannot contact the metal to protect it.

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SYSTEM MATERIALS

The standard materials of construction (i.e. **steel, cast iron, copper, brass, bronze, solder, and most plastics**) that are found in closed loop water systems are also acceptable for use in glycol systems.

However, **aluminum, galvanized, and zinc materials should be avoided** because the corrosion inhibitors in most glycols will not fully protect aluminum at temperatures greater than 150F (65C). The zinc and the zinc in the galvanized alloy will react with the alkaline corrosion inhibitor and start to corrode.

Fresh Make-up Water

- The use of automatic **fresh water make-up** for glycol systems must be avoided to prevent undetected dilution of glycol.
- Fresh potable water contains oxygen. The amount of oxygen is dependent on the temperature of the water.
- When glycol is added to water the chemical reaction between the two will also release oxygen.

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Fresh Make-up Water

If automatic fresh water make-up is mandated, install a water meter on the fill line to track water usage.

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Fresh Make-up Water

Prevent unintended glycol dilution by installing a glycol feed system to replace small fluid loses.

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Expansion Tanks

Bladder type expansion tanks are needed for glycol

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Expansion Tank

Due to the higher density of glycol, the expansion tank for a glycol system must be capable of absorbing approximately 4% more volume than a closed system without glycol.

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Glycol Concentration

20%Glycol ▶ Bug Poison

20% Glycol ◀ Bug Food

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Volume of Glycol

The following equation may be used to calculate the approximate amount of glycol that must be added to the system:

$$G = \frac{V \times (CD-CP)}{(100-CP)}$$

G = volume of fresh concentrated glycol to be added to the system.
V = volume of the system
CD = desired glycol concentration, vol%
CP = present glycol concentration, vol%

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Dilution Water

- The water which is used to mix and or dilute glycol must be of the highest possible quality (i.e., softened, demineralized, deionized, boiler condensate).
- Minerals in some domestic water supplies will deplete the inhibitor concentration in the glycol, thus making it corrosive.
- Many local water supplies will exceed these limits.

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Dilution Water

The following limits are representative of most glycol suppliers:

Chloride 25 ppm Max	Sulfate 25 ppm Max
Calcium 50 ppm Max	Magnesium 25 ppm Max