



Reducing Corrosion & Iron Closed Loop Chiller

Summary:

Excessive corrosion (> 10 MPY mild steel general corrosion as well as pitting) and resulting corrosion products (Fe and FeOH) were resulting in increased approach temperatures, reduced PUE, excessive cleaning costs and system damage in a data center.

Each 1 degree in approach temperature gain over design, in a 1,000-ton chiller, equals about \$10,000 / Yr in increased operating cost.

In addition to electrical cost increase, excess cleanings (weekly) were needed to keep the heat exchangers and strainers online.

Each 3-day cleaning required 2 men, 8 hours each, \$150.00 per hour all in labor cost. Annualized cost = \$125,000.

Your Water Dr. was retained to determine root cause and return the system to proper operating conditions.

The root cause of the challenge was the addition of chlorine bleach into the closed loop in an effort to control a biological challenge.

Your Water Dr. identified root cause(s), corrected the missteps, cleaned the system on line and returned the system to proper operation within 6 months eliminating \$150,000 in annual cost and terminating system damage.

Background:

A closed loop cooling system was facing continued biological challenges. Biological populations were frequently found to be in excess of 100,000 CFU/ml with occasional tests showing 1,000,000 CFU/ml for both total aerobic plate count and Pseudomonas. Agreed performance upper limit was 1,000 CFU/ml.

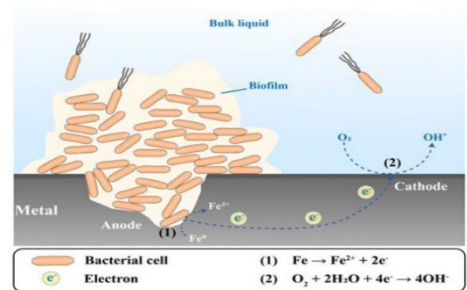
The water treatment company selected chlorine bleach as the biocide to be used to control the excess population and added it to the system.

The bleach addition was not effective in controlling the biological population. The bleach did however increase corrosion, which increased corrosion products, which plugged the system screens and plate and frame heat exchangers ultimately raising approach temperatures and increasing cost of operation in the system.

Discussion:

1. Most closed loop systems operate
 - a. At an elevated pH.
 - i. 9.5 is a typical closed loop pH
 - ii. **The pH was found to be low in this system.**
 - iii. **The pH was increased to proper levels**
 - b. Use a corrosion protection agent
 - i. Nitrite and Molybdate are commonly used inorganic agents.
 - ii. **Anticorrosion agent dose was found to be low in this system**
 - iii. **The anticorrosion agent was increased to proper levels**
2. Control of microbiology is critical as the insulating and MIC properties of bio-slime deposits are well documented

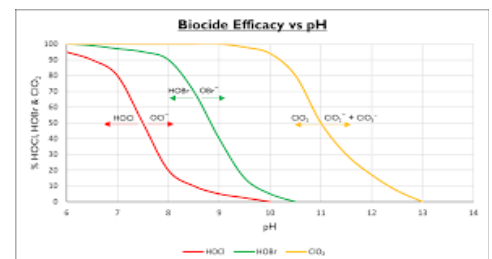
- a. Microbial Induced Corrosion MIC is a type of corrosion in which the deterioration of metals is facilitated by the presence and activity of microorganisms. It is estimated that about 10% of all corrosion to metals and non-metals are caused by microbial activity.



- b. One significant example of microbial-induced corrosion is the anaerobic corrosion of iron and steel. MIC is almost always associated with biofilm formation. A biofilm can be described as a gel-like substance composed of a mixture of about 95% water, extracellular polymeric substance EPS and a suspension of cells and inorganic matter.

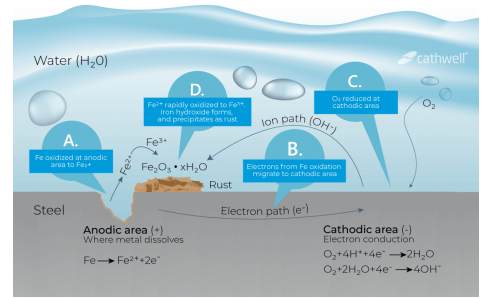
- i. **Microbiological populations were found to be 10 – 1,000 times recommended levels.**

3. Chlorine was selected as the biocide to be applied to gain control of the biological population.
 - a. **Chlorine is not an effective biocide at elevated pH. At pH 9.5 only 5% of chlorine fed is an effective biocide.**



4. Bleach is an oxidizer meaning it will increase corrosion in a system. This is especially true in high concentration and long exposure times.
 - a. **Bleach has been disallowed as an option for biocide in the systems**
 - b. **A proper treatment was used in place of bleach which returned the biological populations to below upper control limits**

5. The first step in corrosion is the formation of Fe⁺ ion
 - a. Fe⁺ testing was started
 - b. As Fe⁺ reading dropped we could verify actions were effective in stopping new corrosion
 - c. Test results dropped from 20 to < 0.2 ppm**
6. As corrosion increases, so do corrosion by-products.
 - a. Corrosion by products deposit in the system setting up further corrosion – under deposit corrosion – due to lower oxygen levels under deposits and higher oxygen levels on clean metal.
 - b. An on-line filtration system with the capability of various filtration ranges from 1000 micron down to 0.5 micron was selected and installed.**
 - c. Particle size analysis and particle count testing was performed.**
 - d. Post filter start up particle size in the water mirrored filter sizing.**
 - i. 100, 50,25,10,5,1, 0.5 all the way down**
 - e. Particle count dropped by > 99%.**
7. Yellow metals such as copper and brass need special protection in a closed loop system. This protection is generally accomplished with an Azole such as BZT or TT.
 - a. The closed loop was found to have little to no Azole leaving the system susceptible to corrosion of yellow metals
 - b. Yellow metal ions in the close loop were 3 – 10 times what they should be
 - c. BZT was added to the system to proper levels and testing was instituted lowering the yellow metal test results to under allowable levels**



Conclusion:

Close loop, chilled water systems are common and critical in HVAC or process cooling systems. When cared for properly:

1. Establishment of
 - a. Lower control limits
 - b. Operating targets
 - c. Upper control limits
2. Testing
 - a. Frequency
 - b. All critical parameters
3. Making adjustments with correct chemicals and tools
4. Retesting to assure corrections were effective

Closed loop cooling system operate efficiently. When improperly cared for, the closed loop cooling system has the potential to loose system life, decrease capacity, operate inefficiently (increasing operating cost) or even cease functioning all together.



Conclusion Cont.

The closed loop was returned to proper operating conditions resulting in operating cost reductions and system life extension.

Excesses were eliminated:

1. Corrosion
 - a. Mild steel
 - b. Yellow Metals
2. Biological counts
 - a. Total
 - b. Slime formers
3. Operational spend
 - a. Chemicals
 - b. Cleanings
4. Energy Use
 - a. Approach / PUE

Critical operating parameters include:

1. pH
2. Dosage of anticorrosive agents
 - a. Steel
 - b. Yellow metals
3. Biological population
 - a. Total plate count
 - b. Slime formers
 - c. Legionella
4. Dissolved Fe and Cu
5. Approach Temperature
6. Particle count
7. Particle size