

## Courage Against Corrosion

By James McDonald, PE, CWT,  
Technical Support Manager

After a restless, fretful night of tossing and turning, the plant manager wakes up in a cold sweat and calls out in confusion, "My plant...the world...is corroding away around me, and there's nothing I can do to stop it!" The manager's spouse grumbles awake and murmurs, "Go back to sleep. You're just having a bad dream..."

Either this is an over dramatization, or the plant manager is in drastic need of a deep psychological evaluation, but there is truth to worrying about corrosion. Corrosion has been happening since the Big Bang as the primordial soup of energy congealed to matter, stars were born and went supernova, and heavier molecules such as oxygen, iron, and copper formed.

Pure metals and alloys like steel, copper, brass, stainless steels, etc. do not exist in nature. They exist as mineral ores instead, and nature is on a continual quest to return these refined metals to their original mineral ores. This includes the metals in process equipment.

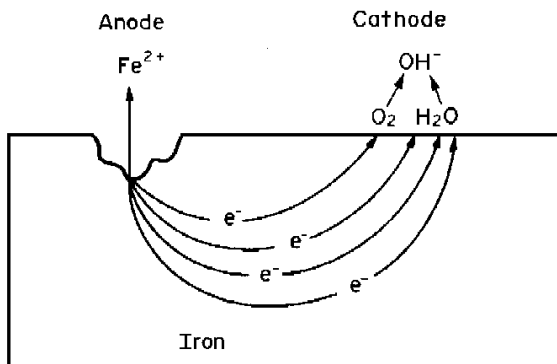


Figure 1: Corrosion Mechanism

You will **never** be able to rest soundly at night knowing that you have **completely** eliminated all corrosion in your plant because nature will simply not allow that to happen. If the job is done correctly, you **will** be able to rest soundly at night knowing you have **minimized** corrosion.

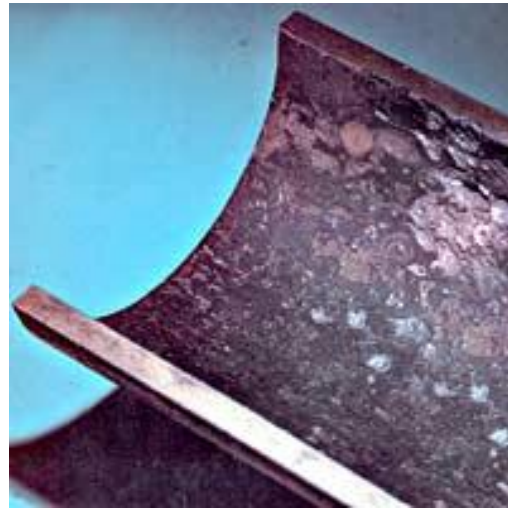


Figure 2: Corrosion

### What is Corrosion?

Corrosion is an electrochemical process where metal loss occurs at the anode and electrons flow to the cathode. If left unchecked, corrosion can destroy metal components and/or cause fouling due to corrosion byproducts. Figure 1 illustrates the corrosion mechanism.

### Minimizing Corrosion

How is corrosion minimized? It is minimized by eliminating the cause, inhibiting the process, or redirecting the focus.

### Eliminating the Cause

Components such as oxygen, carbon dioxide, ammonia, chlorides, sulfates, erosion, low pH, and high pH instigate corrosion. Eliminating these corrosion sources is one way to minimize corrosion.

Deaerators are used to remove oxygen, carbon dioxide, ammonia, and other noncompressible gases from boiler feedwater to prevent corrosion. Sodium sulfite and bisulfites are fed to neutralize oxygen, chlorine, and other oxidizing agents. Biocides are used to control microbiological activity that can lead to “microbiologically influenced corrosion” or MIC. Undersized piping and components are upgraded to reduce erosion corrosion. System pH’s are adjusted to minimize corrosion. Neutralizing amines are used to adjust condensate pH to less corrosive ranges. Pretreatment equipment such as reverse osmosis and dealkalizers are used to remove corrosive components before they enter the water system. Another way to eliminate the cause of the corrosion is to change the metallurgy to a more corrosion resistant metal or nonmetal. All these are examples of how the sources of corrosion are eliminated, neutralized, or minimized.

## Inhibiting the Process

The corrosion reaction itself can be chemically inhibited at the anode, cathode or both. Adding chemistries such as phosphates to passivate the surface will reduce corrosion. Other chemistries lay down protective coatings to block the corrosion reaction, such as polyphosphates or zinc. Painting or galvanizing a surface are also methods impeding or inhibiting the corrosion reaction.

Figure 3 shows the effects of city water on mild steel corrosion coupons. The coupon on the right is in untreated city water and already shows signs of corrosion after only **four hours** of exposure. Notice the discoloration of the water and the corrosion byproducts on the bottom of the flask. The coupon on the left is treated with a corrosion inhibitor and shows no visual signs of corrosion.



**Figure 3: Corrosion Inhibition**



**Figure 4: Sacrificial Anodes in Chiller Endcap**

## Redirecting the Focus

When dissimilar metals such as mild steel and copper are in contact with each other in a wetted environment, galvanic corrosion can occur. The less noble metal will corrode (in the case of mild steel and copper, the mild steel will corrode). While galvanic corrosion can be hard or impossible to stop chemically with corrosion inhibitors, the corrosive force can be redirected to preferentially corrode less noble, easier to replace components such as sacrificial anodes. Figure 4 illustrates magnesium sacrificial anodes installed in a chiller endcap to protect the mild



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steel components in contact with the copper tubes. The magnesium sacrificial anodes corrode instead of the mild steel and are easily replace during routine maintenance.

## Conclusion

Fighting corrosion is an ongoing process as system dynamics change and technologies improve. By understanding the corrosion process and using the correct tools to fight it, you and your water management professional can have courage to face corrosion and minimize it.

## References

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Crown Solutions Co., LLC  
945 South Brown School Road  
Vandalia, OH 45377

(937) 890-4075

[www.crownsolutions.com](http://www.crownsolutions.com)