Standards for Corrosion Rates

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The following has been produced by the AWT Technical Committee under the direction of the Cooling Water Subcommittee Head, Bennett P. Boffardi, Ph.D., FNACE.

The values obtained from the gravimetric evaluation of corrosion using coupons depend upon many factors. These factors include but are not limited to:

- Type of industry
- Duration in a coupon test rack
- Coupon placement
- Orientation of the coupon
- Flow characteristics passing over the coupon
- Temperature of the water passing through the corrosion rack
- Water quality
- Process contamination
- Level of treatment
- Coupon rack

Acceptable values from a HVAC system may not be achievable in a refinery of chemical plant. Industrial plants may not be able to achieve the some degree of protection as those found in institutional or commercial sites.

The length of time the coupons is in the coupon rack, with flowing water over the coupon can influence the final result. Short-term duration of 30-day or less usually will have higher corrosion rates compared to coupons remaining in the rack for long term of 90 days. The reason for the differences is that with short term, the coupon surface is active and has not acclimated to its environment, resulting in greater metal loss from the coupon, or higher corrosion rate. With long-term duration, the initial high metal loss from the coupon becomes a small percentage to the overall weight loss. Also, as the metal coupon corrodes, the corrosion products can act as a barrier reducing the rate of further attack.

The recommended time frame using coupons placed into a corrosion test rack is approximately 90 days.

Coupon placement into a corrosion rack should follow the galvanic series in seawater. The most active metal or alloy must be placed in the number one position, which is the first position downstream of the water. Other coupons should follow the galvanic series in seawater with the last coupon being the most noble metal or alloy. This procedure prevents the more noble metal or alloy from cathodically depositing on the active metal or alloy. For example, carbon steel must be placed in the corrosion rack ahead of copper alloys. This protocol prevents copper ions from depositing onto the steel.

Copper ions deposit onto the steel can form a galvanic cell, stimulating attack on the steel in the form of pits.

Coupons should be placed in the corrosion rack such that water flows from the back of the coupon where it is attached to a coupon holder. The coupon should be orientated with the broad face in a vertical position. This reduces the accumulation of debris onto the face of the coupon, which can accelerate corrosion.

Water flow through a coupon test rack should be 3 - 5 feet per second. High velocities can cause erosion on soft alloys such as copper-based materials. Lower water velocity can cause particulate matter to settle onto the coupon resulting in underdeposit attack. Water being discharged from the rack should be open to the atmosphere, eliminating any back pressure.

Normally, the corrosion rack is connected to the riser to the cooling tower, because the water is the hot. Connections to the supply line will bias the results because of the lower water temperature.

Water quality has a strong impact on corrosion. pH, temperature, conductivity, dissolved and suspended solids will influence the rate of attack on the coupons.

Process contaminations can accelerate attack. Sour hydrocarbon leaks will increase corrosion due to sulfide attack on copper or carbon steel. Ammonia leaks can decrease attack on carbon steel due to higher pHs. However, ammonia will accelerate attack on copper.

The level of chemical treatment will influence corrosion rates on coupons. Using unpassivated coupons in a rack with a maintenance level of chemical treatment will have higher corrosion rates compared to using passivated coupons. Unpassivated coupons can be used if the chemical treatment at a level to passivate the system.

The corrosion rack should not be coupled to a brass valve nor made of galvanized steel. Both the conditions will bias results. The brass valve will cause copper ions to deposit onto the steel accelerating corrosion. Galvanized corrosion rack will release zinc ions, which will act as a synergist with the chemical treatment providing improved protection compared to carbon steel.

Following the constraints, acceptable corrosion rates for carbon steel and copper alloys in open recirculating cooling water systems are listed in *Table 1*. Corrosion rates for closed cooling water systems are listed in *Table 2*.

Table 1

Quantitative Classification of Corrosion Rates for Open Recirculating Cooling Water Systems

Corrosion Rates (mpy)

Description	Carbon Steel	Copper Alloys
Negligible or Excellent	Less than or equal to 1	Less than or equal to 0.1
Mild or Very Good	1 to 3	0.1 to 0.25
Good	3 to 5	0.25 to 0.35
Moderate to Fair	5 to 8	0.35 to 0.5
Poor	8 to 10	0.5 to 1
Very Poor to Severe	>10	>1

Table 2

Quantitative Classification of Corrosion Rates for Closed Recirculating Cooling Water Systems

Corrosion Rates (mpy)

Description	Carbon Steel	Copper Alloys
Excellent	Less than or equal to 0.2	Less than or equal to 0.1
Good	0.2 to 0.5	0.1 to 0.25
Moderate	0.5 to 0.8	0.25 to 0.35
Poor	0.8 to 1	0.35 to 0.5
Very Poor to Severe	Greater than or equal to 1	Greater than or equal to 0.5

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