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WATER TREATMENT SPECIALISTS

Technical Data Sheet

CORROSION MONITORING

Corrosion is to some degree inevitable in most water utility systems. The goal is to minimize corrosion and allow the utility system to achieve the intended useful life for all critical components. Critical components may include heat exchange equipment (i.e., chiller and condenser bundles, air handling coils, process coolers, boilers and cooling towers, etc.) and distribution piping. Acceptable values will vary depending on the system type and desired life expectancy. One might expect it is easier to achieve an excellent performance level in a light heat duty HVAC system as compared to heavy heat duty industrial plant. One might expect it is easier to achieve an excellent performance level in a continuously operating system as compared to an intermittently operating system. So performance expectations must also be weighed based on system duty and operating conditions. No matter what the system, if corrosion potential is a real or primary threat to system reliability, then corrosion monitoring should be implemented. Corrosion can be monitored in various ways: 1) by testing for corrosion by-product in the bulk water, 2) by using corrosion coupons to assess metal loss and 3) by using corrosion rate probes to assess metal loss real time. Testing for corrosion by-product is reasonable, but typically only offers snap shots into performance and does not quantify actual metal loss measurement. Corrosion coupons provide a composite overview of corrosion by summarizing metal loss over time, but do not give you insight as to whether and when short term events had occurred. Corrosion probes can offer both short term and long term assessment and quantify corrosion rate, but typically requires a fair investment in equipment. Generally, bulk water corrosion measurement and corrosion coupons are used in combination offering a good compromise to corrosion probes. However, corrosion probes should always be considered where corrosion is a chronic problem and/or where the tolerance for corrosion is extremely low.

Corrosion By-product(s) in The Bulk Water

Measuring corrosion by-product in the bulk water should consider: 1) what metal materials exist in the system (i.e., test for iron if an all steel system, test for copper and iron if cuprous and ferrous metals are present, etc.), 2) sampling at a representative point in the system, (i.e., typically downstream of critical equipment or as the water returns from the system), and 3) sampling at a frequency to account for the anticipated variability in corrosion by-product (i.e., closed recirculating systems turn over less frequently than do open recirculating system, or sampling after the feed of a halogen, etc.).

Determination of excessive or problematic corrosion by-product levels requires some understanding of system operation and materials of construction. Guidelines exist for desired maximum levels of metals oxides in cooling and boiler systems and these guidelines can be used to help assess the likelihood of corrosion and fouling problems. However, bulk water testing often must be supplemented with additional data analysis and trending in order to draw accurate conclusions and determine problem solutions. For example, in open cooling loops one should consider the metal oxide in the makeup as well as the bulk recirculating water. In a closed loop, high metal oxide levels do not necessarily relate to active corrosion, but could be the result of past corrosion problems.

Corrosion Coupons

The most important thing to understand about corrosion coupon testing is that the data is a composite and does not show short term events and the data may not be absolutely transferable to actual metal loss, but provides a useful trend, i.e., consistently bad coupon results will usually confirm a performance problem (of some sort) or a sudden change in coupon result should be closely scrutinized. Below are some key considerations to getting representative data to use.

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 days or less usually will have higher corrosion rates compared to coupons remaining in the rack for a longer 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 60 to 90 days. However, the real key is to have consistency in the time of exposure from coupon to coupon.

Coupons should be placed in the corrosion rack so 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 and skew results compared to actual system corrosion potential. Water flow through a coupon test rack should be 3 - 5 feet per second or 3 - 5 gpm in a 1” coupon rack (see CTI reference).

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. Ideally, the coupon should be exposed to the hottest water (i.e., the system return line water). However, often in HVAC systems the supply water is sent through the corrosion rack as a matter of convenience - this may bias the results some due to the colder water. As it relates to coupon positioning, flowrate and temperature, one must consider the objective of coupon testing. It may make perfect sense to setup these noted conditions to most accurately represent the actually system conditions. The key again is consistency in what is done and to look at trends and relate coupon results to other performance data such as bulk water testing and visual inspections.

Coupon placement into a corrosion rack should follow the galvanic series. 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 with the last coupon being the most noble metal or alloy. This procedure prevents the more noble metal (i.e., copper in a HVAC system) from cathodically depositing on the active metal (i.e., steel in a HVAC system). If copper oxide deposits onto the steel a galvanic cell can form, stimulating attack on the steel in the form of pits.

Using unpassivated coupons in a rack when treating the system with a maintenance level of chemical treatment will yield higher corrosion rates compared to using passivated coupons. Unpassivated coupons can be used if the chemical treatment is 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. Generally, PVC and Teflon components are used in cooling systems, while steel is used in hot systems.

Assessing Coupon Results

Generally, the performance targets are as follows: 1.0 to 3.0 MPY on steel and <0.1 to 0.2 MPY on copper in open loops and 0.1 to 0.5 MPY on steel and <0.1 to 0.2 MPY on copper in closed loops. These performance targets are based on an extensive database gathered from hundreds of industrial systems. There are two considerations for corrosion rate assessment: 1) MPY relates to metal thickness loss and life expectancy of pipe, exchanger, etc. and 2) fouling potential, which can also be assessed using bulk water testing of corrosion by-product(s). Reported “general” corrosion, particularly in a closed loop, will typically represent a concern for system fouling short term and equipment life expectancy as a possible long term consequence. Another consideration is the degree of pitting. Reported pitting corrosion can be a greater concern as pitting can have a greater short term impact on equipment life expectancy.

Below are corrosion coupon performance criteria as reported by the Association of Water Technologies (AWT), a professional trade organization for the water treatment industry.

Quantitative Classification of Corrosion Rates for Open Recirculating Cooling Water Systems Corrosion Rates (mpy):

Description	Carbon Steel	Copper Alloys
Excellent	1.0	0.1
Very Good	1.0-3.0	0.1 to 0.25
Good	3.0-5.0	0.25 to 0.35
Fair	5.0-8.0	0.35 to 0.5
Poor	8.0-10.0	0.5 to 1
Severe	>10	>1

Quantitative Classification of Corrosion Rates for Closed Recirculating Cooling Water Systems Corrosion Rates (mpy):

Description	Carbon Steel	Copper Alloys
Excellent	0.2	0.1
Good	0.2-0.5	0.1 to 0.25
Moderate	0.5-0.8	0.25 to 0.35
Poor	0.8-1.0	0.35 to 0.5
Severe	>1.0	>0.5

Corrosion Probes

Corrosion probes assess and report on the corrosion potential of a system real time. As with corrosion coupons, the data may not match up absolutely with actual system corrosion rates, but should be viewed as a trending tool. If a corrosion rate probe is linked to a data logging component, then the corrosion probe serves both to provide real-time corrosion assessment as well as long term corrosion assessment. This enables the user to monitor the impact of short term events on corrosion potential, (i.e., assess the impact of acid feed cycles, halogen feed cycles, on/off operation, etc.).

The corrosion probe can be installed in a similar way as corrosion coupons are installed and often are installed in the same device, a corrosion by-pass rack. The same consideration that apply to corrosion coupons also apply to the corrosion probe. The performance criteria for corrosion coupons also apply to corrosion probe results.

In closing, where corrosion is a real or primary threat to system reliability, corrosion monitoring is critical. No matter how and what parameters are chosen, the results should be benchmarked to visual inspection of the system and historical experiences.

References

ASTMG31-90,"Standard Method for Conducting Corrosion Coupon Tests in Plant Equipment", Annual Book of ASTM Standards, Vol. 3.02, ASTM, Philadelphia, PA., 1993.

ASTMG1-90,"Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens", Annual Book
of ASTM Standards, Vol. 3.02, ASTM, Philadelphia, PA., 1993.

CTI Code STD-149(00). “Corrosion Testing Procedures – Corrosion Coupons Testing and Test Devices”, CTI Code Tower, October 2000.