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Understanding microbiologically influenced corrosion

Microbiologically influenced corrosion (MIC) describes corrosion caused by acidic byproducts from the metabolic activity of biological organisms thriving under deposits. In refinery and petrochemical plants, MIC is a common cause of waterside corrosion and failure of heat exchangers, and it often occurs in combination with abiotic corrosion processes.

The actual mechanisms of many MIC processes are complex and difficult to model. A fundamental requirement for MIC is a biofilm (*slime*) that effectively isolates the metal surface from bulk water. Systems with high concentrations of suspended solids or high rates of corrosion increase the likelihood of accumulating deposits that will shield bacteria in biofilms from bulk water.

Microbiological monitoring. Direct measurement of MIC is difficult because it is a localized phenomenon. The creation of biofilm is dependent on the specific operating conditions in a heat exchanger such as the linear flowrate and velocity profile near the heat-exchanger surface.

Typically, water treatment professionals measure the planktonic or "free floating" bacteria populations in the bulk water using cultured media (dip slide)and attempt to derive a correlation between these measurements and the risk of sessile bacteria or biofilms. Dip slides do not evaluate the bacteria involved in MIC—sessile bacteria. Sessile bacteria exist as biofilms on heat-transfer surfaces, a location impossible to sample in operating equipment.

Several methods are available to measure sessile bacteria, including mesh coupons and linear polarization resistance electrodes. *Mesh coupons* are semi-quantitative methods to measure the risk of MIC. Plant personnel typically install a mesh coupon in the first pass of a conventional corrosion-coupon rack and examine the coupon for biofilm by rubbing a finger across the surface.

Installing a mesh coupon typically reduces the corrosion rates of downstream-test coupons. Removing the variable of localized under-deposit corrosion should improve the correlation of the corrosion coupon rates with system reliability. Unfortunately, there are no industry standards for mesh-test coupons or consensus on the proper interpretation of the results.

Linear polarization is a standard online corrosion measurement technique that measures changes in electrochemical properties for in-situ probes. The sensor promotes biofilm formation by polarizing test electrodes on a daily basis and tracking the differential between applied and generated currents. A demonstration project is underway at the E. I. duPont Nemours' Sabine River Works facility in Orange, Texas.[1,2]

Risk Management. The greatest risk factor for MIC is deposition. Once deposits form and trap bacteria on the heat-transfer surface, few effective on-line corrective actions are available.

Preventing MIC requires a clear understanding of the operating conditions of highest risk and proper mitigation procedures. High populations of planktonic bacteria correlate with high populations of sessile bacteria and a high risk of MIC. Typically, plant personnel feed oxidizing and nonoxidizing biocides to control planktonic bacteria and a bio-dispersant to remove biofilm. Table 1 shows the risk factors for MIC. The risk of MIC following process leaks is particularly high in cooling water systems that have new or recently cleaned heat exchangers.[3]

TABLE 1. Risk factors for MIC.

Risk factor	Root causes	Mitigation
High concentrations of suspended solids	• Poor quality make-up for cooling system • Post-precipitation of cold lime softened make-up water	• Improve clarification procedures • Inject acid or change chemistry of pre-treatment
High iron corrosion rate	• Inadequate chemical corrosion control program	• Improve corrosion control chemical treatment program
	• Process leak	• Isolate leaking heat exchanger and/or increase concentration of corrosion inhibitors
High planktonic bacteria population	• Insufficient biocide concentrations	• Increase oxidizing and non-oxidizing biocide concentrations

Actions. MIC is a major source of heat-exchanger failures and unplanned outages. Tools to monitor biofilm are under development. Because most plant personnel use indirect measurements that are poorly correlated to biofilm, understanding the risk factors is the best method to prevent operating conditions conducive to biofilm creation and MIC. HP

LITERATURE CITED

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