PENFLEX

ENGINEERING BULLETIN #149

An Introduction to Microbially Influenced Corrosion (MIC)

THE COST OF CORROSION

Since the mid-1900s governments around the world have sought to determine the economic impact of corrosion. The most recent figures, released by NACE International in its 2016 IMPACT study, put the global cost of corrosion at an estimated US $2.5 trillion, equivalent to 3.4 percent of global GDP (2013).[1]

The costs are significant and incurred across nearly all industries. And while the challenges facing these and other industries are considerable, the report went further to state that 15-35 percent of the cost of damage, or between US $375 – $875 billion, could be saved annually through corrosion prevention best practices.

It's becoming better and better understood that Microbially Influenced Corrosion (MIC) plays a role in contributing to the corrosion wreaking havoc on systems and processes globally with the potential to increase rates of corrosion by two or three orders of magnitude.[2]

With a proper understanding of factors leading to MIC and designing, manufacturing and maintaining piping systems in response, its impact can be checked.

MICROBIALLY INFLUENCED CORROSION

Some microbes found in water and soils can metabolize nutrients using oxygen or various other chemical compounds like sulfur or iron to produce corrosive agents. Others can change the electrochemical conditions at the metal surface without producing corrosive agents themselves.

These changes can lead to direct localized corrosion, an increase in general crevice corrosion, or possible corrosion inhibition. In any of these scenarios, MIC—also called microbiologically induced corrosion, bacterial corrosion, or biocorrosion—should be considered as a possible contributing factor.

1 "Economic Impact," NACE International, http://impact.nace.org/economic-impact.aspx.
2 "ATI Alloy AL-6XN," ATI Allegheny Ludlum, last modified 2010, https://www.atimetals.com/Products/Documents/datasheets/stainless-specialty-steel/superaustenitic/al-6xn_tds_en_V2.pdf.

Sulfate reducing bacteria (SRB), iron and manganese bacteria, and sulfur oxidizing bacteria are the three types of microbes commonly associated with MIC. SRB is responsible for most instances of accelerated corrosion damage to ships and offshore steel structures while iron and manganese oxidizing bacteria are most often associated with the corrosion of stainless steels.[3]

Given water is requirement for microbe growth, MIC is a problem in industries using seawater, surface water, municipal reclaim water, grey water and well water. Water treatment, power generation, oil and gas, marine, and pulp and paper are industries especially prone to MIC.

COMMON MIC SCENARIOS IN OIL & GAS

Incidences of biocorrosion resulting in, among other things, oil reservoir souring and pipeline and process equipment corrosion have been reported in oilfield operations where water is present.[4] MIC may be responsible for as much as 40% of internal corrosion within the oil and gas industry.

Sulfate reducing bacteria present in crude oil or injection water often attaches to the internal surfaces of pipelines and injection lines. SBRs covert sulfate into highly corrosive hydrogen sulfide and even the low concentrations of water in crude oil or condensed water in gas pipelines can be sufficient to allow them to multiply. The presence of biofilms and localized pitting corrosion could be indications of MIC.

It’s imperative that oil and gas piping systems are designed using the optimal alloy—the austenitic stainless steels are suitable options; carbon steel should likely be avoided—and geometry to minimize MIC’s impact.

For instance, flow velocity is an important consideration given the increased likelihood that microbes will adhere to the piping surface with slow media flow. Engineers need to keep this in mind when determining the inner diameter of pipes and hoses.

MICROBIALLY INFLUENCED CORROSION IN POWER GENERATION

The significant amount of water required to generate electricity typically gets recirculated many times over and may be left stagnant for periods of time. Trapped gases, minerals and impurities make the water increasingly corrosive while biofilms can more easily develop under these conditions.

Power plants are thus susceptible to MIC. Often, it’s stainless and carbon steel tanks and piping that see this kind of corrosion. When it comes to metal hose and expansion joints, steps to maintain a material’s corrosion resistance—like purging welds and keeping surfaces clean and unscratched—will help to delay the onset of Microbially Influenced Corrosion.

Of course, the design and manufacture of piping components can only go so far to limit the impact of MIC. Regular mechanical cleaning and employing chemical treatments with biocides to prevent bacterial population growth would help curb its impact on piping once in service.

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[3] “ATI Alloy AL-6XN,” ATI Allegheny Ludlum, last modified 2010, https://www.atimetals.com/Products/Documents/datasheets/stainless-specialty-steel/superaustenitic/al-6xn_tds_en_V2.pdf.
[4] Videla, Héctor A. and Liz Karen Herrera Quintero, “Biocorrosion in oil recovery systems. Prevention and protection. An update,” Technical Journal of the Faculty of Engineering, http://www.tjfeonline.com/admin/archive/919.09.20141411133274.pdf.

HIGH LIKELIHOOD IN WATER TREATMENT

Water treatment sees some of the highest levels of MIC, and challenges laid out previously in this bulletin are often compounded by the age of many sewage systems and water treatment facilities. Protective coatings, whether physical barrier coatings or sacrificial coatings, are increasingly being used to mitigate the effects and delay the advance of MIC.

Given the wide variety of culprits and the varying ways in which they can accelerate corrosion, MIC is difficult to predict and its impact a challenge to estimate. As the subject gets more attention, that will likely change but it's worth remembering that many factors are in play—from design and manufacture through to operation and maintenance—when it comes to reducing the impact of and minimizing costs associated with MIC.

We hope to have given some context and insight into this topic with our bulletin and encourage you to contact us with any questions.