**Why Effective MIC Control is Still a Major Challenge for many Oil and Gas Assets?**

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**Introduction**

Microbiologically influenced corrosion (MIC) still remains as a major integrity threat and cause of failure for many upstream, midstream and downstream oil and gas assets – in spite of the continuous technological advances in the areas of oilfield microbiology, metallurgy and chemicals.

Extensive field experience from both the UK’s North Sea Sector and the Persian Gulf Region indicates that the main root cause of the encountered MIC leaks, failures and issues has been either the total lack of or inadequate knowledge and expertise in relation to bacterial and MIC basics and fundamentals among the pertinent personnel. Simultaneously, it has also been observed that oil and gas assets who successfully managed and controlled the MIC integrity threat were the ones whose relevant personnel possessed adequate MIC competency; mainly due to MIC training they had received.

While MIC incompetency remains the main root cause of bacterial and MIC problems; timely, practical and adequate MIC training is regarded as the main solution and way forward for tackling the existing MIC issues for the oil and gas assets concerned.

**What is MIC?**

MIC can be defined as corrosion influenced by the presence or activity of microorganisms (Ref. 1). Such microorganisms can cause corrosion problems for various oil and gas assets either directly or indirectly. The corrosion damage inflicted by them is considered direct when they create or further increase the environment’s corrosivity (e.g., by acid production through their metabolism). The damage is considered indirect when they attack, deteriorate or weaken a corrosion control measure already in place; thus further promoting corrosion. Such affected corrosion control measures include surface coatings and some corrosion control chemicals such as certain types of oxygen scavengers.

Microorganisms are divided into different types, of which bacteria are the most prevalent type encountered in the oil and gas industry. Bacteria themselves are further divided into various categories or families and sulphate-reducing bacteria or SRB remain the most predominant and insidious category.

MIC rates, provided that suitable nourishment and growth conditions exist for bacteria, can be up to several millimetres per year; which is quite severe, compared to other corrosion mechanisms often encountered in the oil and gas industry.

Locations or systems most susceptible to bacterial contamination and MIC include, but are not limited to:

* Sea water injection
* Fire water
* Drains
* Cooling water
* Sandwash water (where treated sea water is used to wash the sand accumulated in various pressure vessels)
* Water displacement systems (where treated sea water is used to empty a product storage tank)
* Wet product transfer pipelines
* Wet product storage tanks

The important caveat regarding MIC is that prevention is always better than cure, because microbial control once lost, may take years to restore, if at all!

**The MIC Mitigation Process**

The bacterial and MIC mitigation process as depicted in Figure 1 refers to a cyclic—and continuous—process composed of three stages (Ref.2):

* Bacterial and MIC monitoring stage—The necessary sampling (both liquid and biofilm [or sessile]) is done along with the pertaining inspections and corrosion rate monitoring activities are carried out (in order to produce the required input data for the assessment stage).
* Bacterial and MIC assessment stage—The input data produced in the first stage are evaluated, trended, processed, analysed, and interpreted to determine bacterial types, their associated populations, and the concentration of various ions and molecules consumed or produced by the bacteria. The input data are also used to estimate or calculate the associated MIC corrosion rates.
* Bacterial and MIC control stage—In this stage, various activities are carried out to reduce the existing bacterial populations, and also to decrease the associated corrosion rates due to MIC.

In other words, the bacterial and MIC mitigation process is composed of three stages and each stage is composed of two components: one component pertaining to bacteria, and the other to MIC. Table 1 provides the associated description and justification for each of the pertaining components.

**Why MIC still Remains a Predominant Cause of Failure?**

Extensive field experience from the North Sea’s UK Sector and also from the Persian Gulf Region has demonstrated that the majority of the observed or studied MIC cases were due to poor, erroneous, impractical or late decisions and activities associated with the existing bacterial and MIC issues. Some of such erroneous decisions and activities included:

* Selecting sampling locations where no water was present
* Not capping or sealing the filled sample bottles
* No chlorination at the sea water inlet
* Intermittent chlorination at the sea water inlet
* Increasing chlorination injection rate significantly to kill sessile bacteria and also to remove biofilms
* Using biocide chemicals only effective against planktonic bacteria and incapable of killing sessile bacteria
* Not coordinating sampling activities with biocide treatments (hence, not being able to determine biocide effectiveness)
* Injecting biocide upstream of the oxygen scavenger injection point
* Using chemicals which act as nourishment for the exiting bacterial types

However, the masterpiece MIC case belongs to a sea water treatment site which stopped biocide injections for two years. Such decision induced numerous MIC leaks with an associated repair and replacement cost of more than 100 million dollars, just for the first year! Their justification for doing so was that because the bacteria were too tiny to be seen with naked eyes, then the integrity threat they posed was accordingly insignificant and negligible; hence no need for any bacterial and MIC mitigation via biocide chemical treatment!

**MIC Incompetency under Closer Scrutiny**

The above examples clearly demonstrate that lack of or inadequate knowledge and expertise in regard to bacterial and MIC basics and fundamentals has been the root cause of the majority, if not all of the observed MIC issues across many oil and gas assets.

In other words and more precisely, MIC incompetency has been the main culprit behind the encountered MIC leaks and failures. In general, the observed MIC incompetency can be divided into the following four subject areas:

1. Bacterial nourishment and growth conditions
2. Bacterial and MIC monitoring
3. Bacterial and MIC assessment
4. Bacterial and MIC control

The last three items when are incorporated with each other comprise the overall bacterial and MIC mitigation process, as was mentioned earlier. Therefore, any shortcomings in properly carrying out any single one of them, could adversely affect the overall bacterial and MIC mitigation process, leading to more MIC issues and problems.

**Conclusions**

* MIC remains as one of the most prevalent and insidious corrosion deterioration mechanisms across many oil and gas assets.
* MIC incompetency has been the main culprit behind the observed MIC leaks and failures.

**Recommendations**

* Timely, proper and practical bacterial and MIC training is absolutely required for the pertinent personnel and managers.

**References**

1. Standard Test Method: Field Monitoring of Bacterial Growth in Oil and Gas Systems, TM0194-2014, NACE International, 2014, ISBN 1-57590-192-7
2. A. Morshed, A Practical Guide to MIC Management in the Upstream Oil and Gas Sector, AMPP, 2023, ISBN 978-1-57590-424-5

Figure 1- Bacterial and MIC mitigation process and its three stages.

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| **Stage** | **Components** | **Justification** |
| Stage 1: Bacterial and MIC Monitoring | Bacterial Monitoring | To produce both liquid and biofilm (or sessile) samples for the next stage (assessment stage).  |
| MIC Monitoring | To produce predominantly wall thickness inspection and corrosion rate monitoring data for the next stage (assessment stage). |
| Stage 2: Bacterial and MIC Assessment | Bacterial Assessment | To determine types (i.e., metabolism) and populations of the bacteria encountered in the system, along with the concentration of ions and molecules consumed and produced by the bacteria. |
| MIC Assessment | To determine whether or not the encountered wall losses or corrosion rates are due to MIC, and also to estimate or calculate the encountered MIC rates. |
| Stage 3: Bacterial and MIC Control | Bacterial Control | To use methods to either kill bacteria or retard their activity. |
| MIC Control | To use methods to reduce or totally arrest the encountered corrosion rates due to MIC. |

Table 1- The components associated with each stage of the bacterial and MIC mitigation process and their associated justifications (Ref. 2).