Institute of Corrosion Working Day and Symposium - 26 May 2015
Corrosion Aspects of Asset Integrity Management and Lifetime Extension
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Oilfield Microbiology

Legend:
1. Crude Oil: Sourcing/Corrosion
2. Pipeline: Corrosion
3. Crude Oil: Corrosion
4. Diesel Oil: Contamination/Corrosion
5. Lubricating Oil: Contamination
7. Crude Oil: H₂S Gas/H₂SO₄
8. Production System: Corrosion
9. Water Injection System: Corrosion
10. Water Filled Leg: H₂S Gas/Corrosion
11. Drilling Mud: Corrosion/Seabed Pollution
12. Oil Spills: Microbial Breakdown
13. M.E.O.R
14. Sourcing/Plugging
15. Down Hole: Corrosion
16. Fuel Oil: Acid Corrosion
The aim of the oilfield microbiologist is to generate useful and appropriate data in order to:

- predict which locations, vessels, pipework, systems are under particular threat from microbiologically influenced corrosion (MIC)
- prioritise areas for treatment according to budget and time restraints
- apply and monitor appropriate strategies to mitigate against the effects of MIC
Microbiologically influenced corrosion (MIC) is the deterioration of metal under a biological influence

• surface associated microbial growth (biofilms) influence the physico-chemical interaction between the metal and the environment

• biofilms consist of cells and their metabolic products, extracellular polymeric substances and adsorbed organics, plus inorganic precipitates and volatile compounds

• in a marine environment the presence of a biofilm can accelerate corrosion of carbon steel by several orders of magnitude
• Systems:
  Production
  Water Injection
  Produced Water Reinjection (PWRI)
  Ballast water
  Seawater Cooling
  Cooling/heating
  Firewater
  Diesel storage and distribution

• Samples:
  Planktonic – water, crude, diesel, cooling medium

  Sessile – biofilm from coupons, bio-sidestreams and/or other intrusive devices.
Sessile Samples - Coupons

Direct system exposure

Sessile Microbial Samples and Weight Loss analysis
Testing for:
- sulphate-reducing prokaryotes (SRB)
- general heterotrophs
- acid-producing bacteria
- nitrite-reducing bacteria
- bacteria and fungi in diesels
- nitrate-reducing bacteria
- sulphate-reducing archaebacteria (SRA)
- archaebacteria
- methanogens

Techniques:
- traditional viable counts (MPNs)
- molecular techniques – qPCR, FISH, DAPI

Chemistry:
- pH, sulphide, bisulphite, Volatile Fatty Acids (VFAs),
- chlorine residuals, iron, nitrite, nitrate etc
Microbiological issues prevalent in systems on ageing assets

Water Injection

High levels of microbes (and macro-organisms) are found in seawater - from psychrophiles to extreme thermophiles. Main control regime is chlorination and filtration, with organic biocide treatments into or downstream of the deaerator.

On aging assets, often find poor quality water containing high populations of a diverse microflora, not only causing problems topsides, but being injected into the reservoir = reservoir souring.

KPIs often inappropriate.
Production

Originally relatively clean but now contaminated with indigenous reservoir micro-organisms, contamination from injected seawater and from contaminated drilling muds etc.

Those microbes most suited to the environment will attach and grow, with different populations thriving depending on the temperature (and the pH, pressure and salinity) of each environment.

With aging assets, there is often a high water cut and well established biofilms.
Produced Water Reinjection (PWRI)

The mixing of seawater and produced water may bring several issues due to changes in temperature, salinity and the nutrient status.

**Ballast water, seawater cooling, firewater**

Adequate chlorination essential

**Diesel storage and distribution**

Sediment and slime at the bottom of storage tanks with anaerobic conditions. Difficult to test, difficult to clean. Water will settle out in low lying areas, leading to perforations.
Oilfield Microbiology

Biocide application:
  • strategies
  • monitoring programmes
  • optimisation

Lab and field based biocide trials against planktonic/sessile bacteria
Data Trending and Interrogation

• All data should be graphed/trended on a regular basis – pipelines, drains, deaerator tower etc

• Trending of data pre and post biocide applications – especially if a long term project

• Biocide treatments can then be optimised

• Monitoring essential
Import SRB by Enumeration Pre & Post Biocide Doses

Legend:
- mSRB (pre)
- mSRB (post)
- tSRB (pre)
- tSRB (post)
- htSRB (pre)
- htSRB (post)
SRA Numbers by qPCR Pre & Post Biocide Doses
<table>
<thead>
<tr>
<th>WORKSCOPE</th>
<th>Current status</th>
<th>Actions required</th>
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<tbody>
<tr>
<td><strong>PRODUCTION</strong></td>
<td>Moderate to high planktonic SRB, low to moderate sessile SRB with low corrosion and moderate pitting rates. Risk of MIC.</td>
<td>Regular kill dose of biocide required. Post biocide planktonic samples should sent in for analysis.</td>
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<tr>
<td><strong>WATER TREATMENT VESSELS</strong></td>
<td>Moderate thermophilic SRB at Vessel B water outlet, low numbers at the remaining locations. Low sulphide levels. SRB growth and activity still occurring across vessels with a high risk of MIC.</td>
<td>Close monitoring required as early intervention may be required to ensure control is maintained.</td>
</tr>
<tr>
<td><strong>DRAINS</strong></td>
<td>Low thermophilic SRB in Closed Drains, moderate sulphide levels measured. Low risk of contamination being recirculated and of MIC.</td>
<td>No immediate action currently required. Regular monitoring should be maintained.</td>
</tr>
<tr>
<td><strong>WATER INJECTION</strong></td>
<td>Low planktonic and sessile SRB numbers, sulphide levels below detection limit. Moderate to high corrosion and pitting rates. Risk of microbial proliferation and MIC</td>
<td>System currently under reasonable control. Further investigations required to determine the cause of the high pitting measured at CC-XOX-017. The use of molecular techniques such as qPCR should be used to confirm or eliminate the role of MIC.</td>
</tr>
<tr>
<td><strong>DIESEL SYSTEM</strong></td>
<td>Low aerobic bacteria, yeast and mould enumerated from all the tanks sampled. Low particulate contamination, fungal fragments and water content.</td>
<td>No immediate action is required as the diesel tanks are currently under good control and water content is at a minimum. Regular monitoring should be maintained.</td>
</tr>
<tr>
<td><strong>FIREWATER SYSTEM</strong></td>
<td>No SRB, but high GHB measured in all the hydrants sampled. No residual chlorine, high potential risk of biofouling.</td>
<td>A regular firewater ring main flushing routine should be implemented to prevent stagnation and bring in freshly chlorinated water.</td>
</tr>
</tbody>
</table>

**Legend:**
- **Green**: Good Control, Low Risk, No Immediate Action Required
- **Yellow**: Requires Careful Monitoring/Possible Early Intervention
- **Red**: Risk Of MIC, Urgent Action Recommended
Thank you for your time
Any Questions?