Microbiological Influenced Corrosion

Margaret Gorog
• MIC is localized corrosion under biological films
• Bacteria are not necessary for corrosion but appear to be increasing in activity
• They do not consume the metal but produce films and acids that assist or accelerate pitting and underdeposit corrosion
• They are anaerobic or aerobic and can interact together
• They survive in a variety of conditions, sometimes harsh
• Sulfate reducing bacteria and manganese oxidizing bacteria are common
Where does MIC occur?

• Bacteria need water and nutrients to survive
  • Fire water piping
  • Water side of heat exchangers, condensers, coolers
  • Bottom of storage tanks, low flow or stagnant zones in piping
    • Brown stock filtrate
    • Warm water
    • White water
    • Starch solution
    • Hydrotest water
• Slimes in alkaline white water can be a quality issue
• Carbon steel corrodes under corrosion deposits
• Stainless steel pits mainly on or near welds. Scratches, roughly ground surfaces also provide sites for corrosion
How to identify MIC

• It’s difficult to fully prove
• Would corrosion occur anyway?
• Pit shapes are not exclusive to MIC
• Look for a combination of factors that indicate MIC
• Watch out for
  • Unexpected, rapid corrosion
  • Untreated water
  • Black deposits
  • Foul smell
  • Corrosion deposits high in sulfur, low in chlorides
  • Manganese deposits on stainless steel
• Use modern molecular methods (MMM) to identify bacteria
Sulfate Reducing Bacteria

• Most common MIC
• Sulfate reducing bacteria prefer anaerobic conditions and collect under deposits and in stagnant zones.
• Differential oxygen concentrations between the bulk environment and area under the deposit causes the pitting
• SRB’s are not required for pitting but can accelerate the rate of attack because they produce hydrogen sulfide which in turn produces acid.
• If sulfur has concentrated in black corrosion deposits and there is an absence of chlorides suspect MIC with sulfate reducing bacteria
• Stress corrosion cracking is possible
Manganese Deposition

• Pitting of stainless steel has been linked to waters containing manganese. It is usually in connection with bacteria oxidizing manganese to manganese dioxide. Pitting then occurs under the MnO2 deposits.

• The MnO2 deposit is oxidizing and in the presence of chlorides can aggressively pit stainless steel.

• If Manganese is greater than 50 ppb the risk of deposition due to biological or chemical oxidation is high. Lower levels however do not rule out the chance for deposition.1

• Manganese deposits are dark brown or black and tend to coat the metal surface.

• To prevent pitting, remove manganese to minimize deposition or eliminate bacteria with biocides. Remember oxidizing biocides in excess can also cause stainless steel to pit

Prevention and Control

- Keep surfaces clean, remove deposits, maintain flow
- Pickle and passivate SS welds, minimize scratching, gouging
- Drain, store dry when not in use (hydrotesting, HEX’s)
- Biocides, water treatment
- Material selection is of limited value
- Susceptibility of stainless steel follows pitting resistance
  - Austenitic (304L/316L) not resistant
  - Duplex (2205) an improvement but not immune
  - Super austenitic (6% Mo SS) or super duplex considered resistant
    - Titanium and nickel alloys considered resistant
- Be aware of MIC research and detection methods
Evaporator surface condenser

Pitting along the tube seam
Pitting close-up
Black deposit in a pit
Cross section
Hemispherical pit
High sulfur, no chlorides detected
Chromium/iron corrosion deposit
Carbon steel sprinkler pipe
Tuberculation/barnacles
After cleaning

Notice the seam running along the length of the tube
Leak
Round, multileveled pits
Cross section, note weld on right
Unusual preferential corrosion

Weld thickness ~ 0.102”
Remaining wall ~ 0.062”
Schedule 10 pipe = 0.109”
Barnacle corrosion deposit with sulfur
Warm water tank
Pit near a ground weld
Cuts for metallography

Cut past pit on outside
Weld cross-section
Lengthwise section

Tunneling along the weld
Rust deposit near a pit

The deposit contains iron/chromium corrosion products and a small amount of sulfur. Chlorides aren’t detected.
304L White liquor tank

3 weeks after hydrotesting with water containing 120 ppm chlorides
Pit tunneling in a weld
Pit Measurement (5% sampling)

<table>
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<th></th>
<th>Nominal (inch)</th>
<th>Avg Depth</th>
<th>Avg Diam</th>
<th>No P</th>
<th>Avg Plate</th>
<th>No H</th>
<th>Avg HAZ</th>
<th>No W</th>
<th>Avg Weld</th>
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<td>Floor</td>
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<td>0.115</td>
<td>0.183</td>
<td>14</td>
<td>0.097</td>
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<td>0.076</td>
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<td>1</td>
<td>0.058</td>
<td>11</td>
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<td>3</td>
<td>0.039</td>
<td>16</td>
<td>0.068</td>
<td>6</td>
<td>0.098</td>
</tr>
</tbody>
</table>

More pits at the bottom and in the HAZ. Deepest at the bottom and in the weld.
MIC is not the likely cause of pitting

ID deposit contains concentrated chlorides, no sulfur is detected
Warm water tank manganese deposits
Barnacles along/near welds

“Muddy” deposits
Barnacle close-up
Rough grinding below a barnacle
Deposit composition

Wall Deposit high in manganese

Barnacle Deposit contains corrosion products, sulfur and chlorides
Summary

Condenser – SRB possible
Steel pipe – Mainly corrosion
Water tank – SRB possible
Liquor tank – Chloride pitting
Water tank – Manganese
Stock tank – SRB possible

Questions?