Corrosion of Electronic Control Systems in Gas Treating Environments

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Outline

• Importance of control systems and impact of corrosion damage

• Corrosive air standards

• Sulfur plant process description

• Failure of a history module
  – Use of VpCIs to reduce damage rates
  – Improved air handling systems to control damage

• Corrosion fatigue failure of field based unit

• Corrosion monitoring systems for electronic systems

• Conclusions
Airborne contaminants

- Limit particulates
- Limit temperature
- Limit humidity
- Limit reactive gases
- Location relative to the sea
<table>
<thead>
<tr>
<th>Gas</th>
<th>Concentration, ppb</th>
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<tbody>
<tr>
<td>H₂S</td>
<td>&lt;3</td>
</tr>
<tr>
<td>SO₂ / SO₃</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Cl₂</td>
<td>&lt;1</td>
</tr>
<tr>
<td>NOₓ</td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

**Table 1: ISA G1 requirements for specific gases**

Reference: ISA S71.04 - 1985
ISA ratings for electronic equipment

- G1, Mild—Corrosion is not expected to be a problem
- G2, Moderate—Corrosion may be an issue in 5 years
- G3, Harsh—Corrosion is expected to be an issue within 5 years
- GX, Severe—Corrosion will seriously impact equipment life
Case 1—Control Room

- DCS Installed in 1994 with ESD
- Multiple failures of computers, monitors, other electronic equipment
- Communications module failed
- History module failed 3 times in one year
Control room
Figure 2: View of the module circuit board, after removal of external covers.
Figure 3: Detail view of circled area in Figure 1. Note corroded pads (arrow) and uncorroded external contact pins (left)
Figure 4: Optical image of corrosion product
Figure 5: EDS X-ray microanalysis spectrum of corrosion product and corresponding BSE image in the scanning electron microscope.
Figure 6: Cabinet room results
Equipment Reliability Correlation
(ISA Standard S71.04-1985 for Copper)

- ISA Class GX: SEVERE
- ISA Class G3: HARSH
- ISA Class G2: MODERATE
- ISA Class G1: MILD
Equipment Reliability Correlation
(ISA Standard S71.04-1985 for Copper)

ISA Class GX: SEVERE
ISA Class G3: HARSH
ISA Class G2: MODERATE
ISA Class G1: MILD

Film Thickness in Å

Silver (1964 Å)
Copper (1280 Å)
Without inhibitor

With inhibitor
Equipment Reliability Correlation
(ISA Standard S71.04-1985 for Copper)

ISA Class G1: MILD
ISA Class G2: MODERATE
ISA Class G3: HARSH
ISA Class GX: SEVERE

No inhibitor

With inhibitor
Equipment Reliability Correlation
(ISA Standard S71.04-1985 for Copper)

ISA Class G1: MILD
ISA Class G2: MODERATE
ISA Class G3: HARSH
ISA Class GX: SEVERE

Film Thickness in Å
0 300 500 1000 1500 2000
Silver (95 Å) Copper (108 Å)
Improved air handling
With inhibitor
Case 2—Process Level Controller

• Sealed housing—leaked

• Corrosion fatigue failure

• Same corrosives—$S_x$
Figure 9: Plan view of four circuit boards, as received; arrows show locations of transformer lead failures.
Side view of a broken transformer lead on Board # 2 magnification approximately 2X
Figure 11: Fracture surface of broken lead, Board # 2
SEM micrograph, 200X
Figure 12: Microsection showing fine secondary cracks on broken transformer lead from Board # 2, etched 750X
Fractography—Ductile Failure
Possible Solutions

• Better housing & seals
• Relocate level switch
• Reduce vibrations
• Conformal coatings
• User applied coatings & powders
Corrosion Monitoring

• Why monitor?
• Electrical resistance type monitors
• Ease of equipment use
• Company standards require monitoring
Chemical Filter Cartridge
Deep Bed Filter
Conclusions

• Corrosion of control systems is a risk to plant operations and safety

• Corrosion can be best avoided by the design of adequate air handling systems that remove particulates, control temperature, control humidity, and remove reactive gases

• VpCIs—Vapor phase corrosion inhibitors provide protection to equipment in inadequate environments

• Corrosion monitoring is essential to track performance of the air handling system.