Environmentally Friendly Corrosion Protection in Cleaning Systems for United States Coast Guard Aircraft

By: Cliff Cracauer
Cortec Corporation
Presented by: Anna Vignetti
Outline

• Introduction
• Experimental
• Results
• Discussion
• Conclusions
Introduction
Scope

• US Coast Guard desired a cleaner incorporating corrosion inhibitors

• To be used as a preventative maintenance product
The Problem

• Corrosion on Aircraft
  – Caused by contamination
  – Can occur even on painted surfaces
The Solution

• Development of a Maintenance Cleaner
  – Used to remove various contaminants
  – Should include corrosion inhibitors
  – Must meet specified criteria
Performance Criteria

• Cleaning Ability

• Corrosion Protection

• Must Meet Mil-C-87973
Cleaning Properties

- No standardized testing to evaluate cleaning properties
- Field testing implemented based on comparative analysis
  - Rate of removal
  - Foaming properties
  - Water break-free surface
Cleaning Properties

• Must Remove Contaminants
  – Dirt
  – Grease
  – Oils
  – Exhaust
  – Salts
New VCI Cleaner Tested
Corrosion Prevention

- VCI Cleaner needs to provide short-term protection
- Part of a preventative maintenance program
- Areas of concern include
  - lap joints
  - flange areas
  - landing gear
Incorporating VCI’s

VCI

Metal

Anode

Cathode

Dissolved VCI ions

Molecules of VCI in gaseous phase
Experimental
Material Compatibility

• Rubber Compatibility Testing
  – ASTM D 2240
  – 25% VCI cleaner solution used
  – Specimens fully immersed for 30 minute interval
Material Compatibility

• Stress Crazing of Acrylic Plastic
  – ASTM D 484-83
  – Test specimens placed under bending stress
  – Test interval depends on the type of plastic
Material Compatibility

• Effects of VCI Cleaner on Unpainted Surfaces
  – ASTM F 485-90
  – Specimen fully immersed
  – 24 hour testing period
Material Compatibility

• Effect of VCI Cleaner on Painted Aircraft Surfaces
  – ASTM F 502
  – Measures a change in pencil hardness of the coating
  – Visual inspection for any staining
Corrosion Testing

• Low-Embrittling Cadmium Plating
  – ASTM 1111-88
  – Specimens totally immersed
  – Evaluated quantitatively by weight loss
Corrosion Testing

• Sandwich Corrosion
  – ASTM F 1110
  – Specimens sandwiched using saturated filter paper
  – Cyclic test between warm ambient air and warm humid air
  – Seven day testing period
Corrosion Testing

• Total Immersion Corrosion
  – ASTM F 483
  – 24 hour testing period
  – Evaluated quantitatively by weight loss
Corrosion Testing

- Half Immersion Corrosion
  - ASTM G 31-72
  - Specimens partially immersed in closed container
  - 30 day testing period
  - Used to test VCI ability of cleaner
Environmental

- Biodegradation
  - EPA 28-day BOD/COD Test
Results
Compatibility Results

• Rubber Compatibility Test (ASTM D 2240)
  – Two types tested
    • AMS 3204
    • AMS 3209
  – No change in Shore A hardness
Compatibility Results

- Acrylic Plastic Compatibility Test (ASTM F 484-83)
  - Three types tested
    - MIL-P-5425
    - MIL-P-83310
    - MIL-P-25690
  - No Crazing Evident
Compatibility Results

• Effects of VCI Cleaner on Unpainted Surface (ASTM F 485-90)
  – Two Alloys Tested
    • Aluminum 7075-T6
    • Titanium 6 AI-V4
  – No Staining
  – No Residue
Compatibility Results

- Effects of VCI Cleaner on Painted Aircraft Surfaces (ASTM F 502)
  - Test panels done in duplicate
  - No change in pencil hardness was found
    - Rated 4H before
    - Rated 4H after
  - No streaking, discoloration, or blistering
Corrosion Testing Results

- Corrosion of Low-Embrittling Cadmium Plate (ASTM F 1111-88)
  - Average weight loss of 10.6 mg
  - Within acceptable limits
Corrosion Testing Results

• Sandwich Corrosion Test
  – VCI Cleaner passes 7 day test
  – No visible corrosion after testing period
Corrosion Testing Results

• Total Immersion Corrosion (ASTM F 483)
  – Five substrates tested
    • AMS 4037 Bare Al; anodized per MIL-A-8625
    • AMS 4037 Bare Al
    • AMS 4911 Ti (MIL-T-9046)
    • AMS 5045 Grade 120 Steel
    • AMS 5504; 410 SS, silver plated per QQ-S-365
# Corrosion Testing Results

## Table 7
Total Immersion Corrosion (ASTM F 483)

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Weight Loss (mg) After 24 hrs</th>
<th>Weight Loss (mg) After 168 hrs</th>
<th>WGT Loss mg/cm²/24hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS 4037 Bare Al; anodized per MIL-A-8625 Type 1</td>
<td>&lt;0.1</td>
<td>+0.2</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AM 4037 Bare Al</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AMS 4911 Ti MIL-T-9046</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AMS 5045 Grade 1020 steel</td>
<td>0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AMS 5504; 410 SS, silver plated Per QQ-S-365 Ty II, Grade B</td>
<td>0.6</td>
<td>0.4</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Note: No visible corrosion on any panel*
Corrosion Testing Results

• Half Immersion Corrosion (ASTM G 31-72)
  – Two substrates tested
    • 1010 Carbon Steel
    • 3041 Bare Al

• Panels tested with VCI cleaner contained no corrosion during testing period
• Test panels evaluated by visual inspection
• Control fails in less than 24 hours
## Corrosion Testing Results

### Half Immersion Corrosion (ASTM G 31-72)

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Time Before Corrosion (Days) Control</th>
<th>Time Before Corrosion (Days) VCI Cleaner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1010 Carbon Steel</td>
<td>&lt;1</td>
<td>&gt;30</td>
</tr>
<tr>
<td>3041 Bare Al</td>
<td>&lt;1</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>
Biodegradability Results

• VCI Cleaner Passes 28-day Test
  – Tested undiluted
  – BOD/COD ratio is 0.66
Discussion
Discussion

• VCI Cleaner Passes Field Trials
  – Easy-to-use
  – Removes all contaminants
  – Provides corrosion protection
Discussion

• VCI Cleaner Passes Material Compatibility
  – Rubber compatibility
  – Acrylic plastics
  – Unpainted aircraft surfaces
  – Painted aircraft surfaces
**Discussion**

- VCI Cleaner Passes Corrosion Testing
  - Low-embrittling cadmium plating
  - Sandwich corrosion
  - Total immersion
  - Half immersion
Summary
Summary

• VCI Cleaner Passes Field Cleaning Tests

• VCI Cleaner Provides Desired Corrosion Protection as a Maintenance Product

• VCI Cleaner Conforms to MIL-C-87973
VCI Cleaner Implemented