Kinetic Metallization™

A Repair Process for Damaged IVD-Al Coatings, Mg, and Al Alloy Components

NAVAIR Ph II SBIR Briefing
12 May 2009
Ralph Tapphorn, PI
Problem - Field Repair of Damaged IVD Aluminum Coatings

- Used on Landing Gear and HS Steel Aircraft Components
- No Al coating field repairs
- Brush plating of cadmium
- Naval Aviation Depot (NADEP)
  - F/A-18, E-6B, H-1, V-22, F-35
- Air Force Depot Facilities
  - Tinker and Hill AFB Depots
Aircraft - Dimensional Restoration
Mg and Al Alloy Parts

- Transmission Gearboxes, Housings, Generators
- Rotary Aircraft (AH-64, AH-1W, AH-1Z, CH-53, HH-1N, MH-53E, SH-60, UH-60)
- Fixed Wing Aircraft (P-3, F-35)
- Mg Alloys (AZ80A, AZ91C, AZ91E, ZE41, AEZ33A, WE43B-T6, AZ92-T6, HC32A-T5, QE22A-T6)
- Al Alloys (7075, 7050)
Introduction to Kinetic Metallization™ (KM)

- Metal deposition through particle impact
- Low-temperature << melting point
- High particle velocity > 500 m/s
- Gas velocity below Mach 1
  - He, 300K, 980 m/s
  - GN2, 300K, 330 m/s
Potential Energy

Heat

Powder

Deposition Nozzle

Gas Storage System

Powder Fluidizing Unit

Thermal Conditioning Unit

Kinetic Energy

Nozzle

Fluidizing Unit

Powder
KM-MCS
IVD-Al Repair

- KM-Mobile Coating System
- Handheld KM Spray Gun
- Portable cart
- Brush-sieve powder fluidizing unit

Al-Trans® Coatings
- Aluminum-Transition Metal
- Corrosion resistant transition metal blend (Cr or Ni Alloys)
Al-Trans®
HSS Alloy Development

Dimensional Restoration
HSS Alloy Components

Corrosion Control
HSS Alloy Components

Amorphous Powder

Cr-Based Admixture
Ni-Based Admixture

CP-Al
Qualification Panels
Brush-Cd and Al-Trans®
KM Repair Sequence for IVD-Al

- IVD-Al Removed
- Feather Edges
- KM Al-Trans® Repair
ASTM B-117 Salt Fog Testing

Brush Cd Control Samples

KM Al-Trans® Repair Specimens
Scribed Salt Fog Testing
ASTM B-117
Scribed Cyclic $\text{SO}_2$ Salt Fog (ASTM G85 annex 4, B117/$\text{SO}_2$)
## JTP-2003 Performance Specifications

<table>
<thead>
<tr>
<th>General &amp; Galvanic Test</th>
<th>JTP</th>
<th>Acceptance Criteria</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip-ability</td>
<td>3.1.3</td>
<td>Removal with 2 Hrs MIL-S-5002D</td>
<td>Pass</td>
</tr>
<tr>
<td>Open Circuit Potential</td>
<td>3.1.4</td>
<td>OCP Steady State &lt; 1 Day</td>
<td>Pass</td>
</tr>
<tr>
<td>EIS/Tafel Analysis</td>
<td>3.1.4</td>
<td>Steady State Corrosion Rate</td>
<td>Pass</td>
</tr>
<tr>
<td>Visual Exam</td>
<td>3.1.4</td>
<td>No pitting/crevice corrosion</td>
<td>Pass</td>
</tr>
</tbody>
</table>
## JTP-2003 Performance Specifications

<table>
<thead>
<tr>
<th>Reparability Test</th>
<th>JTP</th>
<th>Acceptance Criteria</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>3.1.1 3.7.1</td>
<td>Smooth Continuous Coating</td>
<td>Pass</td>
</tr>
<tr>
<td>Bend Adhesion</td>
<td>3.2.1 3.7.1</td>
<td>No loss of adhesion per MIL-STD-870B</td>
<td>Pass</td>
</tr>
<tr>
<td>Paint Adhesion Solvent Primer</td>
<td>3.2.2 3.7.1</td>
<td>ASTM D 3359 MIL-PRF-85582</td>
<td>Pass</td>
</tr>
</tbody>
</table>
### JTP-2003 Performance Specifications

<table>
<thead>
<tr>
<th>Reparability Test</th>
<th>JTP</th>
<th>Acceptance Criteria</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unscribed Salt Fog</td>
<td>3.3.1</td>
<td>3000 Hrs ASTM B117-94</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>3.7.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scribed Salt Fog</td>
<td>3.3.2</td>
<td>1000 Hrs ASTM B117 94</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>3.7.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unscribed SO2 Salt Fog</td>
<td>4.1.1</td>
<td>500 Hrs ASTM G85</td>
<td>Pass</td>
</tr>
<tr>
<td>Scribed SO2 Salt Fog</td>
<td>4.1.2</td>
<td>500 Hrs ASTM G85</td>
<td>Pass</td>
</tr>
<tr>
<td>Unscribed Salt Fog</td>
<td>3.1.4</td>
<td>3000 Hrs ASTM B117-94</td>
<td>Pass</td>
</tr>
</tbody>
</table>
# JTP-2003 Performance Specifications

<table>
<thead>
<tr>
<th>Reparability Test</th>
<th>JTP</th>
<th>Acceptance Criteria</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Embrittlement</td>
<td>3.6.1</td>
<td>200 Hr/75% ASTM F519</td>
<td>Pass</td>
</tr>
<tr>
<td>Hydrogen Re-Embrittlement</td>
<td>3.6.1</td>
<td>200 Hr/75% ASTM F519</td>
<td>Pass</td>
</tr>
<tr>
<td>Corrosion Resistance 14 Fluids</td>
<td>3.3.4</td>
<td>No Coat Degradation Compared to Brush Cd</td>
<td>Pass</td>
</tr>
<tr>
<td>Stress Corrosion Cracking</td>
<td>4.3</td>
<td>SEM Fractography</td>
<td>Pass</td>
</tr>
<tr>
<td>Scribed Painted Coating</td>
<td>3.3.5</td>
<td>3000 Hrs ASTM B117 - 94</td>
<td>Pass</td>
</tr>
</tbody>
</table>
F-18 Axle
IVD-Al Repair
KM Al-Trans® Coating
Al-Trans®
Magnesium Alloy Development

Dimensional Restoration
Mg Alloy Components → CP-Al → Ni-Based Admixture
Mg Alloy Components

Ni-Based Admixture
Amorphous Powder
Al₂O₃ Admixture

Corrosion Control
Mg Alloy Components → CP-Al → Ni-Based Admixture
Mg Alloy Components

Amorphous Powder
### Al-Trans® Screening Tests
#### Powder Alloy Development

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microhardness</td>
<td>&gt; 62 R$_b$</td>
</tr>
<tr>
<td>Residual Stress</td>
<td>Compressive</td>
</tr>
<tr>
<td>Interface/Coating Cracks</td>
<td>None</td>
</tr>
<tr>
<td>Bond Strength</td>
<td>&gt; 10 ksi</td>
</tr>
<tr>
<td>Porosity</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Tensile UTS/YLD</td>
<td>32/23 Ksi (min)</td>
</tr>
<tr>
<td>Strain-to-fracture</td>
<td>&gt; 0.5%</td>
</tr>
</tbody>
</table>
KM Dimensional Restoration

- KM Portable System
  - Handheld KM Spray Gun
- Aircraft Alloy Components
  - Mg gearboxes & transmissions
  - Al stanchions & hinges
- Current NAVAIR Ph II SBIR
  - Alloy powder development
  - Portable KM System development
Al-Trans®
Aluminum Alloy Development

Dimensional Restoration
Al Alloy Components

CP-Al
7072-Al
7075-Al

Ni-Based Admixture
Amorphous Powder
Al₂O₃ Admixture

Corrosion Control
Al Alloy Components

CP-Al
7072-Al

Ni-Based Admixture
Amorphous Powder
For more information, please visit our booth #319