Kinetic Metallization™

Repair of IVD Al Coatings and Mg Alloys Aircraft Components Using Portable Kinetic Metallization Systems

NAVAIR SBIR Ph I & II Contract #N68335-05-C-0296
NAVAIR SBIR Ph I Contact #N68335-07-C-0448

SERDP/ESTCP Session-6 “Cd Replacements”
Inovati
Ralph Tapphorn, VP of Technology
Feb. 27, 2008
Report Documentation Page

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Standard Form 298 (Rev. 8-98)  
Prescribed by ANSI Std Z39-18
Problem - Field & Depot Repair of Damaged IVD-Al & Mg Alloys

**Aircraft Components**
- Landing Gear & HS Steel
- Mg Alloy Gearboxes
- IVD-Al field repair

**Customer Requirements**
- On aircraft carriers & depots
- Environmentally sustainable
- Meets Navy JTP-2003
- **Portable system & Handheld spray gun**
- Robotic deployment for OEM Applications
Organizations & Platforms with Needs for Coating Repairs

- NADEP Facilities
  - PEO(T)        F/A-18, EA-18G
  - PMA-271       E-6B
  - PMA-276       H-1
  - PMA-275       V-22
  - JSF JPO       F-35 Lightning II
- Air Force Depot Facilities
  - F-22
  - C-17
- Commercial Aircraft
  - A380 & B787
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
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- He, 300K, 980 m/s
- GN2, 300K, 330 m/s
Helium Storage System

- Powder
- Heat Energy
- Kinetic Energy
Helium Storage System

Powder Fluidizing Unit

Heat Energy

Kinetic Energy
Kinetic Energy

Helium Storage System

Powder Fluidizing Unit

Thermal Conditioning Unit

Kinetic Energy
Helium Storage System

Powder Fluidizing Unit

Thermal Conditioning Unit

Deposition Nozzle
Kinetic Metallization Systems
- Low temperature & Pressure (1 MPa)
- KM-CDS, KM-PRO, & Portable KM
- Customers Worldwide (US, Japan, Australia, China)
- 4 units delivered to Japan last year

KM Coatings
- Al-Trans® corrosion resistant
- WC-Co & Cr$_3$C$_2$-NiCr wear/corrosion resistant
- MCrAlY wear/oxidation resistant
## KM Compared to CS & HVOF

<table>
<thead>
<tr>
<th></th>
<th>KM</th>
<th>CS</th>
<th>HVOF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max. Temp.</strong></td>
<td>400°C</td>
<td>800°C</td>
<td>1650°C</td>
</tr>
<tr>
<td><strong>Heat Source</strong></td>
<td>2.5kW Integral</td>
<td>47kW Remote</td>
<td>Combustion</td>
</tr>
<tr>
<td><strong>Accelerant Gas</strong></td>
<td>He, N₂, He/N₂</td>
<td>He, N₂, He/N₂</td>
<td>Explosive Comb.</td>
</tr>
<tr>
<td><strong>Bonding Mechanism</strong></td>
<td>Metallurgical</td>
<td>Metallurgical</td>
<td>Mechanical</td>
</tr>
<tr>
<td><strong>Powder Size</strong></td>
<td>0.5 to 45µm</td>
<td>&lt; 100 µm</td>
<td>+15µm, -44µm</td>
</tr>
<tr>
<td><strong>Powder Dispenser</strong></td>
<td>Brush-Sieve</td>
<td>TS Feeder</td>
<td>TS Feeder</td>
</tr>
<tr>
<td><strong>State of Deposition</strong></td>
<td>Solid</td>
<td>Solid</td>
<td>Liq./Semi-solid</td>
</tr>
<tr>
<td><strong>Gun Pressure</strong></td>
<td>&lt;1MPa</td>
<td>&gt;4MPa</td>
<td>&lt;1 MPa</td>
</tr>
<tr>
<td><strong>Gun/Nozzle Mass</strong></td>
<td>1 kg</td>
<td>20 kg est.</td>
<td>&gt; 4 kg</td>
</tr>
</tbody>
</table>
Al-Trans® Kinetic Metallization

- Portable KM System
  - Handheld KM spray gun
  - Cartridge powder canisters
- Al-Trans® Coating
  - Aluminum-Transition Metal (Cr)
  - Superior corrosion resistant
  - Replaces IVD-Al and Cd
  - Replaces liquid-based plating

Qualification of Portable System for Repair of Damage IVD-Al Coatings
Laboratory Model of Handheld KM Gun

KM Al-Trans® Repair Coupons - 1.5±0.3 mils
Al-Trans® Kinetic Metallization Qualified per JTP-2003

<table>
<thead>
<tr>
<th>General &amp; Galvanic Test</th>
<th>Reparability Test</th>
<th>Reparability Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip-ability</td>
<td>Appearance</td>
<td>Unscribed Salt Fog</td>
</tr>
<tr>
<td>Open Circuit Potential</td>
<td>Bend Adhesion</td>
<td>Scribed Salt Fog</td>
</tr>
<tr>
<td>EIS/Tafel Analysis</td>
<td>Paint Adhesion</td>
<td>Unscribed SO$_2$ Salt Fog</td>
</tr>
<tr>
<td>Visual Exam</td>
<td>Scribed Painted Coating</td>
<td>Scribed SO$_2$ Salt Fog</td>
</tr>
</tbody>
</table>
3500 Hrs Neutral Salt Fog
KM Al-Trans®

3500 Hrs Neutral Salt Fog
Brush Cd - Cr6+
Control Specimens
1300 Hrs Neutral Salt Fog Scribed KM Al-Trans®

1300 Hrs Neutral Salt Fog Scribed Brush Cd - Cr6+ Control Specimens
168 Hrs Cyclic SO$_2$ Salt Fog
Brush Cd - Cr6+
Control Specimens

500 Hr Cyclic SO$_2$ Salt Fog
KM Al-Trans$^\text{®}$
# JTP-2003

## Al-Trans® Kinetic Metallization

<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 3.7.1</td>
<td>200 Hr/75% ASTM F519</td>
<td>Pass</td>
</tr>
<tr>
<td>Hydrogen Re-Embrittlement</td>
<td>3.6.1 3.7.1</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>
</tbody>
</table>
Al-Trans® Kinetic Metallization
Repair Demo IVD-Al on F-18 Axle
NAVAIR Ph I SBIR - 2007
KM Fillet Repair CP-Al on ZE41A Mg Alloys
Other Coating Applications Using Kinetic Metallization Systems

Highly Dense KM Coating on 304-SS
WC-10%NiCrCo
Hv = 1615±164

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