Field Repair of IVD Aluminum Coatings on High-Strength Steels Using Kinetic Metallization™

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Sacrificial Coatings for High-Strength Steels

- **Cadmium & Chromate Conversion Sealants**
  - Historical corrosion protection coatings
  - Environmentally Hazardous
    - EO13148
      - All Federal Agencies
      - Toxic Chemicals, Hazardous Substances, and Pollutants
        Reduced by 50% by 12/31/2006
Cd Alternatives

- Ion Vapor Deposition (IVD) of Aluminum
  - Class I, Type II chromate conversion sealant
  - IVD process is **NOT** applicable for field repairs
- Alumiplate$^\text{SM}$ (toluene based plating)
  - Primarily applicable to fasteners
  - Alumiplate$^\text{SM}$ is **NOT** applicable for field repairs
- Electroplating
  - Zn, Zinc-Ni & Zinc-Sn
  - Brush plating for field repairs
Technology
Search for
Environmentally Sustainable Field Repair of IVD-Al Coatings
Field Repair Process for IVD-Al

- NAVAIR SBIR Solicitation - N04-023
  - Field repair technology development for IVD-Al
  - Meeting current environmental laws/regulations
  - Performance requirements at Navy Maintenance levels
- **Kinetic Metallization™** NAVAIR Funded Project
  - Phase I SBIR - 2004 (KM feasibility project)
  - Phase IIA SBIR - 2005 (field repair development)
    - Al based coating formulations using KM process
    - Portable KM handheld gun & spraying techniques
  - Phase IIB SBIR - 2006 (JTP-2003 Qualification Testing)
What Is Kinetic Metallization™?
Impact Consolidation Process
- Feed-stock: fine powder,
- Accelerant: inert light gas

Solid-state Consolidation
- No melting
- No liquid chemicals

KM Sonic Nozzle
- Friction compensated
- Low pressure (50 psig)
- Low gas flow (7.5 SCFM)
- Environmentally Innocuous
- No hazardous substances
KM Flow Path

Helium Storage System

Powder Fluidizing Unit

Thermal Conditioning Unit

Deposition Nozzle

Heat Energy

Kinetic Energy
Field Repair Techniques using Handheld Kinetic Metallization™ Gun
Handheld KM Gun

- Portable KM System
  - Enable Field Repairs
Portable KM Gun

- Handheld Gun
- Real Time
- 1-cm Standoff
- 5-mm Stripe
- Overlapping Strokes
- Multi-layers
KM
Al-Trans®
Properties
&
Performance
KM Al-Trans®

- Aluminum + Transition Metal Composite
  - Blended Powder Feedstock
    - Transition Metal Admixtures - Cr, Ni, Co, V, Ti, Cu
    - Admixture Concentration: 25-30% by Volume
- Al-Trans® (Cr) Formulation Developed 1999
  - Electrically conductive coating for telecommunication racks
  - Replacement of Zn-Chromate conversion coatings
  - Improved coating adhesion compared to CP-Al for KM process
KM Al-Trans®

- Al-Trans®
  - Aluminum
  - Chromium

- Adhesion
  - Steel, ASTM B571
  - Paint, ASTM D2794, 120 ft-lb

- Corrosion
  - ASTM B117, 5000 hours
TEM

Tight Al-Cr interface
Superb cohesion
Upper image 140,000X original
Nano Al-Trans®
- Proprietary blend of nano & micro-size Al
- Chromium admixture
- 4130 steel substrate

Nano Al-Trans®
Surface Preparation Effects on Adhesion

Adhesion Strength: nano-AlTrans Formulations
Epoxy Strength = 9.3 +/- 1.4 (ksi) Bare Stds
IVD Strength = 7.8 +/- 2.0 (ksi)

Adhesion Strength (ksi)

- SiC
- Al2O3
- GB Peen
- Sanded
Neutral Salt Spray - 3000 Hrs
ASTM B117

nano-Al-Trans®/Cr

nano-CP-Al
SO$_2$ Salt Spray
G85- 500 Hrs
Patch Preparation Areas
IVD-Al with Epoxy Primer Topcoat
KM Al-Trans®/Cr Patch Repairs with Feather IVD-Al Border
KM Al-Trans®/Cr Repair of IVD-Al Patch Ares after Topcoat of Epoxy Primer
Neutral Salt Spray
1000 Hrs ASTM B117

Handheld KM Gun
Spray 1.0-1.5 mils
Al-Trans®/Cr Coating
on 4130 Steel
Handheld KM Gun
Spray 1.0-1.5 mils
Al-Trans®/Cr Coating
on 4130 Steel
KM Al-Trans® Future

- Qualification and Development
  - NAVAIR SBIR Phase IIB Award May 2006
    - IVD and Alumiplate\textsuperscript{SM} repair process
    - Portable Kinetic Metallization unit
    - Coating qualification per JTP-2003
  - Market Portable KM Units
    - Repair kit for commercial aircraft
      - Al-Clad, IVD and Alumiplate\textsuperscript{SM} repairs
    - Repair unit for industrial applications