Environmentally Friendly Pretreatment for Department of Defense Applications

SERDP Project WP-1676

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**Environmentally Friendly Pretreatment for Department of Defense Applications**

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SERDP-1676 Technical Objectives

- Develop an environmentally friendly pretreatment system for multi-material Department of Defense applications
  - Free of hexavalent chromium (Cr$^{6+}$)
  - No volatile hazardous air pollutants (HAPs)
  - Ease of application using existing infrastructure
  - Cost effective
  - Broad substrate/topcoat compatibility
Current Zirconium Pretreatment Commercial Activity

- Over 60 general industrial lines converted to zirconium pretreatments (spray and immersion lines).
- Several major North American and European automotive OEM pretreatment lines converted to zirconium pretreatments
Zirconium Pretreatment Benefits

Performance
- Excellent corrosion resistance
- Promotes coating adhesion to substrate

Environmental
- No volatile hazardous air pollutants (HAPs)
- Reduced waste concerns
  - 80% less waste than zinc phosphate
  - No regulated heavy metal species

Processing
- Application at ambient temperature
- Milder pH than zinc phosphate and chromate pretreatments (pH = 4.5 vs. 1.5 – 3.0)
Appearance of Zirconium Pretreatment

Before Zirconium Pretreatment

After Zirconium Pretreatment

Zirconium pretreatment coatings are visible.
Zirconium-Based Pretreatment

Coating thickness: 20-200 nm.
Coatings on Cold-Rolled Steel

- Morphology and coating thickness of the zirconium pretreatments are unique when compared to zinc phosphate.
Commercial Pretreatment performance

cleaned only  Zirconium Pretreatment  Zinc phosphate

Modified GMW14872 with Electrocoat over CRS
Environemntally Friendly Zirconium Oxide Pretreatment

**Task 1:** OEM Pretreatment Development

**Task 2:** Depot Pretreatment Development

**Task 3:** Repair Pretreatment Development

immersion-applied ZrOx
Environmentally Friendly Zirconium Oxide Pretreatment

Task 1: OEM Pretreatment Development

- Evaluate commercial immersion formulae with DoD substrates and coatings - reformulate as needed (Mil-Spec testing at ARL).
Limited Mil-Spec testing at ARL: Immersion Pretreatment

• Samples submitted for accelerated corrosion testing (CRS, 2024-T3, and 7075-T6).
  − Commercial and experimental formula modifications submitted
  − B-117 and GMW-14872
  − Tested against tricationic Zn phosphate and chrome wash primer

• Two Zirconium pretreatment variations passed the 336 hr and 1000 hr B-117 outlined per MIL-DTL-53022 or MIL-DTL-53030 (not as strong as zinc phosphate after 1000 hrs)

• Same two Zirconium variations were similar to controls in 40 cycles GMW-14872

• Variations also passed wet/ dry adhesion and JP-8 fluid resistance

• Panels with passing results were sent to NASA’s Cape Canaveral beachside corrosion site

500 hours B117 MIL-PRF-53022 Type II
• Visit DoD depot facilities to benchmark application process/conditions
• Determine compatibility of immersion formula with depot equipment.
• Formula optimization, if needed
• Comprehensive Mil-Spec testing

Task 2: Depot Pretreatment Development
Benchmark Depot Application Systems

**Marine Corps Logistics Base at Albany, GA**
- Uses immersion pretreatment
- Two tanks currently not in use suitable for zirconium pretreatment

**Letterkenny Army Depot**
- Uses immersion pretreatment
- Wash primer replacement high priority
- Would need to supply immersion tank for zirconium application
Task 3: Repair Pretreatment Development

- Suitable for small areas
- Spray-Gun applied
- Wand applied
- Wipe-on

Environmentally Friendly Zirconium Oxide Pretreatment
Field repair zirconium pretreatments

- Two potential formulations are in development:
  - Spray-on/ Rinse-off application
  - Dry-in-Place application

- Both materials utilize zirconium technology and are based on prototype formulations from Task 1

- **Spray-on/ Rinse-off** formula uses an inorganic shear-thinning rheology modifier
  - Material can be sprayed on using a hand or garden sprayer, but then “gels” after application; adheres to vertical surfaces until rinsed off
  - Need to collect rinse water

- **Dry-in-place** formula is designed to be spray applied, then ambient air dried
Field repair zirconium pretreatments

• Limited Mil-spec testing by ARL:
  – Spray-on/Rinse-off passed wet/dry adhesion and JP-8 testing
  – Dry-in-Place formulation had inconsistent wet adhesion

• Further development with application conditions of Dry-in-Place formula has resulted in a more consistent pretreatment coating

1000 hours B117 (MIL-DTL-53030 Type II)
Path Forward

• Qualification to Mil specification

• Continue to develop a field application zirconium system appropriate for depot needs

• Proposal submitted to ESTCP for a demonstration/validation of immersion technology at DoD depots
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