Aluminum-Rich Primer Development

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Need

- Current qualified non-chromate primers are acceptable for some applications but do not perform equivalently to chromate primers.
- Chromate primers have limited ability to protect aluminum from galvanic and filiform corrosion, stress-corrosion cracking and corrosion fatigue.
- Other improvements to primers are desired to improve painting and ESOH properties.
Approach

• Development occurring in parallel paths:
  • Promising, mature compositions are being scaled up, demonstrated and validated for targeted applications
  • Research and development continues to:
    • Enhance performance for each application
    • Expand applications
    • Reduce cost

• Partners
  • Users and authorizers
  • Licensees and suppliers
  • Universities
  • Sponsors
## Al-rich (lab) vs Aluminum Primer Goals

<table>
<thead>
<tr>
<th>Prioritization</th>
<th>Requirement</th>
<th>Minimum</th>
<th>Threshold</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corrosion</td>
<td>Filiform corrosion</td>
<td>MIL-PRF-23377/85582</td>
<td>No filiform beyond 1/8” from scribe and majority less than 1/16” long</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galvanic corrosion</td>
<td>Equal to MIL-PRF-23377/85582 Class C control</td>
<td>Better than Class C control by 10% (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scribed panel corrosion</td>
<td>Equal to MIL-PRF-23377/85582 Class C control</td>
<td>Better than Class C control by 10%</td>
</tr>
<tr>
<td>2</td>
<td>VOC</td>
<td>340 g/L</td>
<td>250 g/L</td>
<td>100 g/L</td>
</tr>
<tr>
<td>3</td>
<td>Flammability/Flash Point</td>
<td>n/a</td>
<td>100 F</td>
<td>150 F</td>
</tr>
<tr>
<td>4</td>
<td>Chemical Strippability</td>
<td>MIL-PRF-23377/85582, 90% stripped by either Method A or B</td>
<td>50% stripped with TT-R-2918</td>
<td>90% Stripped with TT-R-2918 or equivalent to Methylene chloride based paint stripper</td>
</tr>
<tr>
<td>5</td>
<td>Drying time</td>
<td>MIL-PRF-23377 (5 hr/8 hr)</td>
<td>3 hr/8 hr</td>
<td>1 hr/6 hr</td>
</tr>
<tr>
<td>6</td>
<td>IR reflectance</td>
<td>MIL-PRF-23377/85582</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>7</td>
<td>Fluid resistance</td>
<td>MIL-PRF-23377/85582</td>
<td>Minimal adhesion loss with Skydrol exposure</td>
<td>Current resistance + Skydrol</td>
</tr>
<tr>
<td>8</td>
<td>Application</td>
<td>MIL-PRF-23377/85582 @ 1.5 mils</td>
<td>MIL-PRF-23377/85582 @ 1.0 mils</td>
<td>MIL-PRF-23377/85582 @ 1.0 mils</td>
</tr>
<tr>
<td>9</td>
<td>Solvent Resistance</td>
<td>MIL-PRF-23377/85582</td>
<td>100 double rubs</td>
<td>200 double rubs</td>
</tr>
<tr>
<td>10</td>
<td>Thickness Tolerance</td>
<td>n/a</td>
<td>2x thickness (2-3 mils)</td>
<td>4x thickness (4-6 mils)</td>
</tr>
<tr>
<td>11</td>
<td>Application Method</td>
<td>Bulk spray (HVLP)</td>
<td>Brush</td>
<td>Aerosol spray</td>
</tr>
<tr>
<td>12</td>
<td>Packaging</td>
<td>1K or 2K</td>
<td>1K or 2K</td>
<td>1K &amp; 2K</td>
</tr>
</tbody>
</table>

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Filiform Corrosion

Completed filiform test (1000 hrs.) per MIL-PRF-23377. Right-hand panel in each set shows chemically stripped scribe area.
Galvanic Corrosion

- Panels were chemically stripped after 500 hours in Cyclic Corrosion Testing
- 2024-T3 aluminum with Type II conversion coating; topcoat on right half of coupons

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Scribed Panel Corrosion

- Al-rich primer performance over 2024-T3 aluminum with Type II conversion coating

2000 hours in ASTM B117, left, and 2000 hours in cyclic GMW 14872, right.
Outdoor Exposure

Commercial Al-rich on 2024-T3 with TCP and topcoat - 7 months on deck of USS Wasp (test ongoing)

1st Gen lab Al-rich on 2024-T3 with Alodine 1200S and gloss white topcoat - 38 months at KSC beach front site

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Prior research has identified a way to inhibit the initiation and propagation of pitting and cracks due to intergranular corrosion (IGC) and intergranular stress-corrosion cracking (IGSCC). For 5XXX alloys, the potential “target” is approximately -0.90 to -1.10 volts versus standard calomel electrode (SCE).
SCC Results - Lab Al-rich primer

- Impact of Al-rich primer on fracture strength and ductility.

Al 5083 SSR in Salt Water
Effect of Dwell Time and Gap on Al-rich Primer

- Uncoated, in Air (25°C room temp.)
- Uncoated, in 3.5% NaCl solution, pH=7.3
- LP4-FQ5, no gap, 24 hr dwell
- XP1-FQ, .156" gap, 0 hr dwell
- LP4-FQ3, no gap, 0 hr dwell

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Ongoing R&D

- Lab compositions are continually being optimized to achieve peak performance for each application
- Examples:
  - Left: latest leading lab composition for mixed metals after 30 cycles of GMW 14872 (steel) and 1000 hours B117 (aluminum) (spec durations)
  - Right: Newest application is inorganic Al-rich for facility and high temp applications - as painted
• Intellectual property licensed to private industry
• For the licensees
  – NAWC-AD is assessing commercialized versions of the primer and treated pigment
  – Some licensees are focusing on pigment supply only
  – To date, NAVAIR has tested multiple primer samples from two companies and provided them with feedback to assist in modifying and optimizing their Al-rich primer formulations
  – Primers from additional licensees expected in next 12 months
  – Pigment from three licensees tested and validated.
Commercial Scale Up

- Supply and cost reduction of metal pigment is main need
- ONR Advanced Topcoat System project will support scale-up of pigment and pigment passivation technology as well as primers
  - Beginning in FY17 and planned for 4 years
  - Will include work via BAA and Navy labs/engineering
  - Key outputs are 100+ gallon quantities and technical improvements
Dem/Val Progress

- Spray out demonstration of commercial product completed at Cherry Point paint hangar, December 2015
- Validated ease-of-use, dry-times, handling, curing, adhesion, etc.
Dem/Val Progress

- NASA C-130 and P-3 panels (l): primer applied at Pax River lab in August 2016 and returned to NASA Wallops Island for installation
- Coast Guard H-60 tail boom and pylon (r): primer applied at Elizabeth City repair facility by CG artisans in September 2016
Other Progress

• Mixed metals (aluminum and steel)
  – Working with Army Research Lab (ARL) to develop a new MIL-DTL-53022 “Type VI” that will have higher performance than Type IV

• Grit blasted steel
  – Working with ARL to develop primer(s) to meet requirements of MIL-PRF-32550
  – Potential for ~40% weight savings compared to zinc-rich primers and eliminate zinc aquatic toxicity risk

• Wet installation
  – Developing a TT-P-1757 alkyd-based variant for OEM and repair applications, especially threaded fasteners
Other Progress

• High temperature (engine)
  – Developing an inorganic Al-rich as potential alternative to Alseal & Sermetel type coatings
  – Potential is for lower cost processing/room temperature curing, similar sacrificial performance as an original or repair coating, and no chromate

• Facilities (with NASA)
  – Developing an inorganic Al-rich as potential alternative to inorganic zinc-rich (IOZ) products
  – Potential for similar corrosion resistance, ~40% weight reduction and much higher operating temperature than IOZ products (600 vs 450 C)
  – Potential option to flame sprayed aluminum
Questions?

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