Pre-Coated Fasteners

Frederick Lancaster
AIR 4.3.4.6, Patuxent River NAS
# Pre-Coated Fasteners

## Abstract

Surface Finishing and Repair Issues for Sustaining New Military Aircraft Workshop, February 26-28, 2008, Tempe, AZ. Sponsored by SERDP/ESTCP.
Project Overview

• Problem
  – Military standards require permanently installed fasteners to be treated with a corrosion-inhibiting, “wet” sealant prior to installation to meet the stringent corrosion performance required by the military aerospace operational environment.
  – The process is expensive, time consuming, subject to technician error, and requires the use of an environmentally hazardous sealant.
  – Removal and replacement of “wet installed” fasteners by field and depot technicians is labor intensive, leading to increased down time for aircraft repairs.

• Objectives
  – Dem/Val laboratory and field performance of a candidate pre-coated/self-sealing fastener technology on Navy/USMC aircraft in operating environments and compare to existing practices
  – Deliver a qualified precoated aluminum fastener for fleet use
Why Wet Install?

- Prevent crevice corrosion around fastener head that leads to filiform corrosion

- History-
  - Wet installation of fasteners with a type of chromated sealant goes back to the first metal Navy Aircraft and before.....for almost 100 years.
  - Why? Because it worked in mitigating corrosion.
Project Overview

Impact to Fleet/Issues

• Equivalent to and/or improved corrosion protection from a “dry” ready-to-use fastener

• Elimination of hazardous solvents and reduction in hazardous waste

• Reduce maintenance and corrosion repair cost

• Simplifies installation (eliminate wet installation), reducing installation time and cost

• Eliminates human element of current sealant process resulting in uniform watertight seals reducing airframe corrosion

• Increase aircraft/vehicle readiness level
Evaluation Factors

- **Performance**
  - Corrosion protection
  - Visual difference
  - Neutral environmental impact

- **Cost**
  - Low impact

- **Production/manufacture**
  - High volume manufacturing

- **Logistics**
  - Shelf life
# Project Overview

## Initial Candidate Coated Fasteners

<table>
<thead>
<tr>
<th>Surface Coatings</th>
<th>Gasket</th>
<th>Hybrid w/ (Nyseal)</th>
<th>SBIR PH II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium Rich Primer - dry</td>
<td>NySeal (pre-applied uncured sealant)</td>
<td>Magni 565 &amp; Nyseal</td>
<td>SMRC-Quickseal/pre-applied non-cured sealant</td>
</tr>
<tr>
<td>Hi-Cote (phenolic based aluminum coating)</td>
<td>no coating Cr Conversion only</td>
<td>Hi-Cote &amp; Nyseal</td>
<td>METSS</td>
</tr>
<tr>
<td>Magni 565 (Zn-rich basecoat w/Al-rich topcoat)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FluorKote1 (fluoropolymer coating)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xylan 1424 (waterborne, dry-film lube with PTFE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ND Microspheres (microcapsules of epoxy resin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xylan 1020 (similar to Xylan 1424)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Test Method</td>
<td>Comments</td>
<td>Panel Sets</td>
</tr>
<tr>
<td>----</td>
<td>-------------------------------------------------</td>
<td>--------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>A</td>
<td>Salt Fog Atmosphere Per ASTM B117</td>
<td>Phase I Down Selection</td>
<td>51</td>
</tr>
<tr>
<td>B</td>
<td>Salt/SO2 Fog Atmosphere Per ASTM G85-A4</td>
<td>Phase I Down Selection</td>
<td>51</td>
</tr>
<tr>
<td>C</td>
<td>Beach Exposure Testing</td>
<td>Long Term Observation to Correlate to Salt &amp; SO2</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID</th>
<th>Coating/Installation Method</th>
<th>Comments</th>
<th>NSF</th>
<th>SO2</th>
<th>Beach</th>
<th>Total Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A Wet install – current method</td>
<td>Baseline</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>B Primer Mag Rich - Dry</td>
<td>Dry installed</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>C Hi-Kote 1</td>
<td>Phenolic based aluminum coating</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>D FluorKote1 (blue)</td>
<td>Fluoropolymer coating</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>E Xylan 1070 (black)</td>
<td>similar to 1424</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>F Xylan 1424 (blue)</td>
<td>Waterborne, dry-film lube with PTFE</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>G Magni 565</td>
<td>Zn-rich basecoat w/Al-rich topcoat</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>H ND Microspheres (yellow)</td>
<td>Unknown - waiting recommendation</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>K NySeal (green)</td>
<td>Preapplied sealant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>J NySeal &amp; Magni 565</td>
<td>Hybrid</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>I NySeal &amp; Hi-Kote</td>
<td>Hybrid</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>L NySeal &amp; Xylan 1424</td>
<td>Hybrid</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>M SMRC Product (gray)</td>
<td>Preapplied sealant 2001</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>N METSS Product (brown)</td>
<td>Preapplied sealant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>O Contro, Plain Rivets</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>P Plastisol</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>17</td>
<td>Q AvDEC tape seal</td>
<td>Sandwich the AvDEC tape</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

Totals: 51 51 17 119
Testing Summary

- Phase I: Initial Screening testing
  - Corrosion only
  - Various coatings, tapes, surface treatments for dry installation
    - Evaluate using Aluminum Countersunk Rivets
  - Current chromated primer/pretreatment used for evaluation
- Downselect
- Phase II: Final Screening testing
  - Retest using non-chrome pretreatment and non-primer panel setup
    - Nonchrome fastener
  - Fluids compatibility
  - Physical/mechanical testing
  - Leak Testing
  - On-Aircraft testing
- Phase II A:
  - Start steel, Hi-lok™ & titanium fasteners
Phase I Screening Test Flowchart

1. Physically prepare 3x5 panels/drill/countersink
2. Pretreat Panels (Alodine 1200S)
3. Prime Top Surfaces (MIL-PRF-85582D type II Cl 1, min DFT 0.3 mils)
4. Scribe Rivet Heads/Panels
5. Prime All Surfaces (MIL-PRF-85582D type II Cl 1, min DFT 0.3 mils)
6. Stamp Identification on Each Panel
7. Rivet/Fasten Panels Together
8. Coat Top Surfaces and edges (MIL-PRF-85285 Type I, Class H Color 36375 Flat Gray DFT 1.2 mils avg) & Artificial Aging (2 Weeks Ambient – 70F)
9. Seal Mating Edges with 8802 non-chrome sealant
10. Scribe Rivet Heads/Panels
11. Place Panels in Neutral Salt Fog & SO2
12. Cross Section panels & Photograph
13. Photograph Panels & Rate
14. Evaluate
15. Control panels: wet installation present system
16. Panel weight
17. Measure thickness/record
18. Measure thickness/record
19. After Aging, Perform Paint Adhesion Test on select panels. Measure thickness
20. NSF 3000hrs/failure
21. SO2 1000hrs/failure
22. Photograph

Options:
- Option 1: Apply AvDEC tape between panels
- Option 2: Apply 3M tape on Rivet line

Panel weight 3000hrs/failure SO2 1000hrs/failure
Test Panel Preparation/Pretreatment

Fasteners – Al 2117-T4 (chromated)

Top Panel - Al 2024-T3
Bottom Panel - Al 7075-T6

Note A: Top Panel 2024-T3, Dimensions 3in wide x 5in length x 0.25in thick, Countersink 0.25 in 5 Places, starting center at 0.5 inches from short side edge – 1 inch in from long side edge, then drill 1 inch apart on center. Drill through after counter sink 0.1875 inch diameter.

Note B: Bottom Panel 7075-T6, Dimensions 3in wide x 5in length x 0.25in thick, 5 Places, starting center at 0.5 inches from short side edge – 1 inch in from long side edge, then drill 1 inch apart on center, drill through each 0.1875 inch diameter.

Note C Pretreatment: Pretreat all surfaces IAW MIL-DTL-5541, Type I, Class 1A (Alodinetm 1200s). 40-70mg/sqft

Note D: 1st Prime coat, all top surfaces as shown and edges one (1) coat each to each panel of average thickness of 0.3 mils of MIL-PRF-85582 Type II, Class C1. Measure thickness after priming & record.

Material: Top Plate Al 2024-T3 3inx5inx0.25in thick, Bottom Plate Al 7075-T6 3inx5inx0.25in thick.

Grain direction parallel to short dimension.
Note A: Assemble Plate A (top) to Plate B (bottom) flush, using MS20426AD5-12 3/16 inch diameter fasteners. Top Plate A, countersink/coated side facing up when assembling. Bottom plate B orientation – coated side up. Coated top of bottom plate B will mate with the uncoated (not painted) bottom side of Plate A.

Fasten per PS19000

Insert and fasten using rivet gun & bucking bar

Fastened rivet back should be approximately 1-1/2 times the diameter of the rivet, evenly mushroomed.

Note B: Fastened rivet back should be approximately 1-1/2 times the diameter of the rivet, evenly mushroomed.

Seal edges between panels
Orient panels 15 degrees from vertical.
NSF & SO2 Evaluation

Evaluate per ASTM D 1654-05

Neutral Salt Fog B117– Duration 3000 hours
  • Check weekly until 1000 hours
  • 1000 hours plus, check every 2 weeks, rate and photograph.
  • If a failure occurs – remove, rinse, and photograph or scan panel, and determine the final rating – record.
  • Run sets 2800 hours, 5000 hours, & 10,000
  • photograph, rate, and scan. Record all data.

SO2 ASTM G35– Duration 1000 Hours
  • If a failure occurs – remove, rinse, and rate, then photograph or scan panel
  • At 1000 hours remove 1 set of panels, rate/record, photograph and scan.
  • At 2800 hours remove 1 set of panels, rate/record, photograph and scan.
  • Run remaining set to 5000 hours.

168 hours = 1 week/7 days
1000 hours = 41.5 days
3000 hours = 125 days~4 months
Accomplishments to Date

Mar-June

- Panels assembled with candidate fasteners
  - Photographic & Visual documentation
- Panels placed in SO2 and Salt Fog
- Panels shipped for beach exposure testing.

June-Oct

- 1000 Hr SO2 Panels completed, cut for examination and under evaluation
  - SEM analysis performed on Control (current wet install) and Plain (non-coated fastener).
- Panels placed on beach
- 2800 Hr SO2 Panels completed - evaluated
- 1000 Hr B117 panels complete

Oct-Feb

- 2800 Hr B117 Complete – sectioned/being evaluated
- 5000 Hrs SO2 Complete - sectioned/being evaluated

Feb ->

- 5000 Hrs B117
- 10,000 Hr B117
SO2 (G85) Evaluation
1000 Hrs
2856 Hrs
1000 Hours Control- Plain Rivets

17 Weeks Control- Plain Rivets
1000 Hrs SO2 Wet Install

17(2,856 Hrs) weeks Wet Install
Good
1000 Hours Wet Install with Primer Mag Rich

17 Weeks Wet Install with Primer Mag Rich

17 Weeks Control- Plain Rivets
Note: Product was precured at time of fastening, fasteners did not seat properly, still performed well-present chromated formulation
Fair
1000 Hours ND Microspheres

17 Weeks ND Microspheres

17 Weeks Control- Plain Rivets
1000 Hours METSS Product

17 Weeks METSS Product

17 Weeks Control- Plain Rivets
1000 Hours NySeal & Magni 565

17 Weeks NySeal & Magni 565

17 Weeks Control- Plain Rivets
Worse
1000 Hours NySeal & Hi-Kote

17 Weeks NySeal & Hi-Kote

17 Weeks Control- Plain Rivets

Fastener Head Eaten Away
1000 Hours Hi-Kote 1

17 Weeks Hi-Kote 1

17 Weeks Control- Plain Rivets
1000 Hours NySeal & Xylan 1424

17 Weeks NySeal & Xylan 1424

17 Weeks Control- Plain Rivets

Fastener Head Eaten Away
1000 Hours NySeal (Green)

17 Weeks NySeal (Green)

17 Weeks Control- Plain Rivets
1000 Hours Xylan 1424

17 Weeks Xylan 1424

17 Weeks Control- Plain Rivets
1000 Hours FluorKote 1

17 Weeks FluorKote 1

17 Weeks Control- Plain Rivets
1000 Hours Magni 565

17 Weeks Magni 565

17 Weeks Control- Plain Rivets
Preliminary Observations

• 1000 hour B117 did not tell much
• From Samples taken out of SO2 & 1000 & 2800 Hours
  – Fasteners with a coating of said min thickness mitigate crevice corrosion Need some type of corrosion inhibitor over fastener
    • Coating must fill gap during fastening to mitigate crevice corrosion
  – Thinly coated products do not mitigate crevice corrosion
  – Fasteners without a corrosion inhibitor included in coating
    • Heavy corrosive attack, usually resulting in degradation of the fastener head.

  – It appears as if the dry coating fastener approach may produce candidates perform as well or nearly as well as the current wet installation.