Field-level Assessment of Mg-rich Primer

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**Field-level Assessment of Mg-rich Primer**

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Presentation Overview

- Project Team
- Objective and Purpose
- Technical Approach
- Results of Laboratory Testing
- Results of Field Testing
- Conclusions
- Planned Future Activities
- Questions
Project Team

• COTR – Thomas J. Lorman, 77AESW (ASC/ENVV)

• Primary Project Stakeholders
  – Mike Spicer, AFRL/CTIO
  – Joel Johnson, AFRL
  – MSgt. Mike Ramsey, Florida Air National Guard

• Additional Stakeholders
  – AFRL/CTIO, F-22 SPO, F-35 SPO, FANG, Boeing, Akzo-Nobel Aerospace Coatings (ANAC), NAVAIR Pax River, Hill AFB, NASA - Kennedy Space Center
  – Battelle’s Florida Materials Research Facility
Objective and Purpose

Objective

• Validate an environmentally friendly coating system through laboratory coupon tests and outdoor exposure tests on select non-chromate coating system stack-ups for use on legacy, as well as the F-22 and F-35 aircraft

Purpose

• Testing will serve to validate the chemical and physical performance requirements specified in T.O. 1-1-8 and other applicable T.Os referenced for approved Air Force coating systems

• Data gathered from this project will be provided to F-22 and F-35 SPO for possible application of the non-chromate stack-up to metallic and composite structures
Technical Approach

• Scope
  – Conduct controlled “round-robin” laboratory tests to assess performance of Prekote pretreatment, Mg-rich primer, and Aerodur 5000

• Deliverables

  Demonstration Test Plan
  – Integrate testing and analysis protocols with Boeing-Long Beach, AFRL/CTIO, Akzo-Nobel Aerospace Coatings, NAVAIR Pax River, Hill AFB, NASA Kennedy Space Center
  – Test Plan included testing protocols, articles, substrate matrices, surface treatments, primers, and topcoats
  – Test Plan complements Round Robin Test Plan drafted by UDRI and provided to Battelle May 2008

  Technical Data Package
  – Literature survey, technical review and reporting on components contained in non-chromate coating systems being investigated for project
Mg-rich Coating Formulations

- **Prototype university formulation (2004)**
  - Utilized 100+ mm Mg particles and five component resin system
  - Performance in B-117 and cyclic salt spray very good

- **Akzo-Nobel Aerospace Coatings (ANAC) licenses technology (2004)**
  - Worked to resolve surface roughness, compliance, and “usability” issues

- **PD374-165 (2005)**
  - First formulation with viable smaller Mg particle; utilization of a two component resin system
  - Performance in B-117 marginally good

- **PD406-35 (2005)**
  - Modification of resin system; VOC compliant using exempt solvents; performance in B-117 good

- **XP405-110 (2006)**
  - Optimized Mg pigment volume concentration (PVC)
  - Performance excellent over bare and PreKote panels, some adhesion loss over fresh Alodine 1200
  - Some samples prepared with an “active” lot of Mg powder; excess of fines created blistering

- **XP417-183 (2007)**
  - Resin system modified to improve flexibility and performance over Alodine 1200
  - Improved overall performance as reported by ANAC

- **XP455-30 aka “Aerodur 2100” (2007-2008)**
  - Inclusion of green pigment for contrast ratio; reported to have no adverse effect on performance
XP417-183
Most Reported Results Good

ANAC (2,000 hrs. B117)

AFRL (HH-60)

NAVAIR
5,000 hrs B117 AA2024-T3
Primer Only  Topcoated

MIL-DTL-81706 Ty I pretreatment

Cr Control
XP405-110
XP417-183

Equal to Cr
Not as good as Cr
Technical Approach Phase I – Laboratory Assessment - Status

- ASTM B-117 Exposure Testing of Coated Test Panels
  - Required 3,000 hour or 125 day exposure period with visual assessments every 504 hours
  - ANAC and AFRL coated panels (Aerodur 2100)
  - First exposure test terminated after ~650 hours by AFRL/CTIO because of test protocol issues (i.e., X-scribe morphology and test environment)
Technical Approach Phase I – Laboratory Assessment - Status

- Must seriously address the issue of scribe morphology on potential performance in B-117 test environment
  - Growing body of evidence showing that “rough” scribes can have a serious impact on performance, even for Cr controls

ANAC generated scribe variability on Cr controls; same topcoated, Cr-primer system, four different scribe methods after 650 hours of B-117
Scribe Morphology (cont.)

- In nearly all cases, significant amounts of corrosion product is seen on the rough “conventional cut” side of the scribe and very little on the smooth “climb cut” side.
- Reduced Chromate Control
  - PreKote / Deft 02-Y-40 / Deft 99-GY-001 (color 36173)

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Sample 799-A1D-016
2024-T3 Bare

Sample 799-D1D-016
7075-T6 Bare
Round Robin Results – 650 hours
Chromated Controls

AFRL

ANAC
Round Robin Results – 650 hours
Mg-rich Primer (Aerodur 2100)

AFRL

ANAC
Technical Approach Phase I – Field Assessment - Status

- Exposure Testing of Coated Test Panels
  - 12-month Exposure Tests
    - Commenced June 25, 2008 at FMRF
    - Commenced October 9, 2008 at FANG
  - Nine month FMRF exposure conducted on March 18, 2009
    - No significant change in scribe rating
    - Undercutting detected on select panel sets
    - Blistering on “blank” test panels (no primer)
    - No major chalking, gloss or color changes ($\Delta E < 1$)
Technical Approach Phase I – Field Assessment - Status

9-month Exposure Results
- no visual changes noted (typical)
## Technical Approach Phase I – Field Assessment (9-months)

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<tr>
<th>Set ID</th>
<th>Panel ID</th>
<th>Surface Treatment</th>
<th>Primer</th>
<th>Topcoat</th>
<th>Scribe Corrosion</th>
<th>Undercutting</th>
<th>Blistering</th>
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<td>MEK/Brulin GD815/Phos. Acid/1200 S</td>
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Technical Approach
Phase II – Field Assessment

- Test two non-chromate stack-ups on static A/C at Florida ANG (125th Fighter Wing), Jacksonville, FL

- Additional exposure testing of coated panels and sensors at FANG and FMRF for data correlation purposes

- Sections of a/c painted include: upper/lower wing, lower fuselage

- Coordination between ANG and AFRL/CTIO
Technical Approach
Phase II – Field Assessment

• Stack-ups included:
  – PreKote/Aerodur 2100 primer/Aerodur 5000 topcoat
  – Alodine 5200/ANAC 577-630 primer/Aerodur 5000 topcoat

• Initial scuff-sand operations conducted during July 2008

• Weather-related delays (i.e., temperatures and rainfall) in completing application of primer and topcoat materials to test sections of all aircraft

• Decision was made by Battelle and FANG to postpone painting of aircraft until fall

• Final strip & painting of test sections and all surfaces of static aircraft completed October 10, 2008
F-102 Test Sections (2 of 4)

RH-side Fuselage
System #1

System #2

LH-side Upper Wing
System #2
System #1
F-106 Test Sections (2 of 4)

LH-side Fuselage

RH-side Lower Wing

Primer #1

Primer #2
T-33 Test Sections (2 of 4)

RH-side Fuselage

Primer 1

Primer 2

RH-side Upper Wing

Primer 1

Primer 2
F-15 Primed and Topcoated

Primer Coated

Topcoat Completed
The “Crew”
Conclusions

- Initial laboratory testing of Mg-rich primer systems delayed as a result of scribing morphology and test environment compatibility with “novel” coating system
- ASTM B117 is not appropriate test method for Mg-rich primer
- 9-month outdoor exposure data confirms excellent performance of Prekote/PRC 7233/PRC 9311 and control systems. Aerodur 2100 primer performing well
- AFRL to determine next iteration of laboratory testing
- 2-year field exposure panel test results (Abbott), 6-18 month flight testing (H-60, P-3 and AH64A) of coated sensors (Abbott) and 9-month panels from subject project yield good results for Mg-rich primer stack-up
- NAVAIR results with Mg-rich primer are very encouraging
- Next generation of Mg-rich primer coating performance better than all previous generations
- Future need to address alternative polymeric backbone chemistries (i.e., flexible primers and multiple stack-up combinations)
Planned Future Activities

- Continued quarterly monitoring of field exposure test panels (FMRF and FANG)
- Preparation for next 3,000-hour laboratory test exposure
- Obtain color/gloss/chalk and corrosion assessments from four static aircraft