AFRL Update on Status of Cr-Free Coating Systems

ASSETS Defense
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**AFRL Update on Status of Cr-Free Coating Systems**

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**Approved for public release; distribution unlimited**

Presentation Outline

• Approved Non-Chrome Coatings
• Issues with Non-Chrome Coating Systems
  – Unclear Requirement
  – Problems Developed
    • Non-Chrome not as Robust as Chrome
    • Lab Results don’t Translate to Real World
    • Not All Aircraft are Created Equal
• AFRL Path Forward
• PreKote/Mg-Rich Coating System
• Current Field Testing
USAF Approved Non-chrome Coatings

• **Authorized Non-chrome Pretreatments**
  – PreKote approved – T.O. 1-1-8

• **Qualified Non-Chrome Primers**
  – MIL-PRF-85582 Class N Primers
    • Type I, EWDY048
    • Type II, EEAE118
    • 44-GN-098, Deft
  – MIL-PRF-23377 Class N Primers
    • 16798-TEP, Hentzen
    • 02-GN-083
    • 02-GN-084

Authorized for use under a Chrome Primer

Qualified over a Chrome Conversion Coating

Result: **NO QUALIFIED COMPLETE NON-CHROME COATING SYSTEM**
(Pretreatment/Primer/Topcoat)
Issues with Non-Chrome

• Chrome Inhibitors are a Technology
  — Much Characterization before Specifications
    • Pretreatment MIL-PRF-81706
    • Primer MIL-PRF-23377 or MIL-PRF-85582
    • Topcoat MIL-PRF-85285
  — Robust could mix and match with little variance in performance
Unclear Requirement

2000 hours Salt Spray
Complete Chrome System

MIL-DTL-81706
MIL-PRF-23377, Class C2
MIL-PRF-85285

MIL-DTL-81706
MIL-PRF-23377, Class C2
Deft APC
Unclear Requirement

4032 hours Salt Spray
Complete Chrome System

MIL-DTL-81706
MIL-PRF-23377, Class C2
MIL-PRF-85285

MIL-DTL-81706
MIL-PRF-23377, Class C2
Deft APC
Unclear Requirement

• First Versions of MIL-C-23377
  – No Salt Fog Test
  – Formula Specification – Specified Amount of Chrome

• Blistering of MIL-C-23377
  – Added Humidity Test
  – Added Salt Fog Test – 1000hrs

• Acquisition Reform
  – Push to go to Performance Specifications
    • Removed Specified Amount of Chrome Requirement
    • Salt Fog Test – 2000hrs
      – Engineering Rule of Thumb – Double Requirement
Unclear Requirement

• Non-Chrome is **NOT** a Technology
  – Each Non-Chrome Coating System is a Technology
    • New technologies require characterization, sub-system field test, full up field test, etc
    • Then specifications built around that technology
  – But, that is **not** what happened
    • If pass salt spray, 2000hrs, then good to go
    • Chrome Coating Specifications modified to include a type for Non-chrome
  – **Problems developed**
    • Changing components of the system yielded big differences
    • Success in **lab tests did not translate** to outdoor exposure
    • Some success with **JGAPP primers** on F-15 but failure on KC-135
      – Pre-existing corrosion on OML of KC-135
Results of Changing Components

3000 hours Salt Spray

MIL-DTL-81706
MIL-PRF-23377, Class C2
Deft APC

Complete Chrome System

MIL-DTL-81706
Deft 02-GN-084
Deft APC

Non-Chrome Primer

2024 T-3 Aluminum

2024 T-3 Aluminum
Results of Changing Components

3000 hours Salt Spray

MIL-DTL-81706
Deft 02-GN-084
Deft APC

Non- Chrome Primer

PreKote
Deft 02-GN-084
Deft APC

Complete Non- Chrome System

2024 T-3 Aluminum
Results of Changing Components

3000 hours Salt Spray

MIL-DTL-81706
Deft 02-GN-084
Deft APC

Non- Chrome Primer

BoeGel
Deft 02-GN-084
Deft APC

Complete Non- Chrome System

Blisters in Field
Lab Results vs Real World

2000 hours Salt Spray

MIL-DTL-81706
MIL-PRF-23377, Class C2
Deft APC

Complete Chrome System

Alodine 5200
Sicopoxy 577-630
Deft APC

Complete Non-Chrome System
Lab Results vs Real World

Laboratory Salt Fog 2000 hrs

Outdoor Exposure After 3+ Years At Daytona (Failure <1 year)

Alodine 5200
Sicopoxy 577-630
Deft 03GY310 (MIL-PRF-85285 Ty 1)
“Sicopoxy” Flight Test with T-38 at Randolph AFB (2008-2009)

- Conduct a field test to evaluate the capabilities of the selected non-chrome coating system against the standard coating system

<table>
<thead>
<tr>
<th>Chromium Control</th>
<th>Chromium-free</th>
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<tbody>
<tr>
<td>PreKote (3 Step Process)</td>
<td>Brulin 815GD Cleaner</td>
</tr>
<tr>
<td>MIL-PRF-23377 Primer Sherwin Williams E90-G-203</td>
<td>Alodine 5700 Non-chrome Conversion Coat</td>
</tr>
<tr>
<td>Topcoats Deft MIL-PRF-85285 (03-GY-308 and 03-GY-277)</td>
<td>ANAC 577-630 Non-Chrome Primer</td>
</tr>
</tbody>
</table>
AFRL Chromium-free Coating Systems Integration Plan Efforts

T-38, Randolph AFB (Sep 2008)

Control Side

Test Side

✓ Aircraft looked good - no visual difference between control and test side
✓ Dry film thicknesses (3.06 mils test side, 3.96 mils control side), color, and gloss were taken
✓ Witness panels with both processes were taken for laboratory testing

No difference between Chrome system and Non-Chrome system Sept 2010
Issues with JGAPP NCr
(Chrome can Arrest Existing Corrosion)

- JGAPP – KC-135 Field Test
  - Hickam AFB
  - Half & Half
    - Chrome/Non-Chrome

- Corrosion in Center of Skins
  - Existing Corrosion Pits
  - NCr Could NOT Prevent

- Sent Back to Depot
  - Out of Cycle = Big Dollars
AFRL Path Forward

- **Coating System Specification - MIL-PRF-32239 (Outer Moldline Only)**
  - Eliminates issues with mixing components of a coating system

- **Develop Better Laboratory Test Methods – 3 Prongs**
  - Better Salt Fog Cabinet – Include UV
  - Family of Test Coupons to Represent Aircraft Structures and Loads
    - Initial Focus is KC-46 Fuselage
  - Evaluation Techniques – NDI, Corrosion Modeling – Feeds ASIP Models
AFRL Path Forward

• Under Secretary of Defense, Mr. Young Letter
• Defense Acquisition Regulations System, 48 CFR Parts 223 and 252
• Non-Chrome Characterization Effort – Need to Reduce Risk
  – 9 Non-Chrome Coating Systems
  – Laboratory Testing to MIL-PRF-32239
  – Extensive Outdoor Exposure Testing
    • 2024 and 7075 Scribed Panels
    • Pre-Corroded Panels
    • Fresh Anodized Panels
    • C-5 Skins – Anodized, Partial Primer
    • Panels with Fasteners
    • Battelle Sensors
  – Sea Water Spray and Without – Overhang (3X)
Outdoor Exposure

Painted 2024 Al Panels After 3+ Years At Daytona

Prekote/
AE 2100/
85285 Ty IV AE 5000

Chrome Control
81706/
23377, Cl C2/
85285 Ty I Deft 03GY310

Alodine 5200/
Sicopoxy/
85285 Ty I Deft 03GY310 (Failure <1 Year)
Galvanic Test Samples Exposed at Daytona

2024-T3 Al with Cd Plated Steel Screws
Proven Very Effective In Discriminating
Among Paint Systems and Quickly
Failures <1 Year

System 2; Prekote/AE 2100/85285 Ty IV AE 5000 NC/NC; 2 Years

System 4 5541/23377, Cl C2/85285 Ty I 03GY310 C/C; 2 Years
Outdoor Exposure

System 6  Prekote/Americoat/85285 Ty I NC/NC; 2 Years

C130 Matrix; 5541/85582 Cl N/85285 Ty IV C/NC; 1 Year

C130 Matrix; 5541/AE 2100/85285 Ty IV C/NC; 1 Year

NOTE: AE 2100 requires good conductivity with substrate.

AE 2100 NOT recommended over conversion coating.
Outdoor Exposure

KC-135 Upper Wing Skins; Painted and Scribed; 2+ Years; Daytona

**System 4;** C/C/85285, Ty IV
Middle

**System 5;** Alodine 5200/Sicopoxy/85285, Ty IV
Lower

**System 2;** PreKote/AE 2100/85285, Ty IV
Upper

**System 4;** C/C/85285, Ty IV
Lower
Outdoor Exposure

Magnified view of fasteners (2+ Years)

System 2; PreKote/AE2100/85285, Ty IV Deft ELT

System 4; C/C/85285, Ty IV Deft ELT
Mg-Rich Implementation

• Norwegian Air Force – Jan 2012
  – Performed best of all non-chrome tested
  – Approved for use

• Germany Approval – May 2012
  – Specification TL8010-0046
  – Used on Tornado and P3-C Orion

• Italian Air Force – July 2012
  – 30 C-130 to be painted
First Norwegian C-130

After application of the Aerodur 2100MgRp

C130 AMI “VEGA 58” Completely Painted
C-130 Field Testing

• 5 Aircraft Scheduled
  — Complete coverage of aircraft with test coating
  — 2 Complete
    • 20 Aug 2011 -- WR-ALC – Elmendorf AI
      — PreKote/ANAC Aerodur 2100/ANAC Aerodur 5000
    • 7 May 2012 -- WR-ALC – Hurlburt FI
      — RECC 1015 (DeOX)/RECC 3021 (Pretreat)/Deft 02-GN-093/Deft 99-GY-XXX ELT
F-16 Field Testing

• In Planning Stage
• 5 Aircraft
• 4 Test Coatings, 1 Control
  – 4 - Pretreatments and Primers
  – 1 - 5541/23377
• Standard F-16 Topcoat
  – MIL-PRF-85285 Ty IV
• Coatings Rotate to Different Locations
• Test Duration = PDM Cycle
  – 6 Years