AFRL Update on Status of Cr-Free Coating Systems

ASSETS Defense
29 August 2012

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
29 AUG 2012		**00-00-2012 to 00-00-2012**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
AFRL Update on Status of Cr-Free Coating Systems	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Research Laboratory,AFRL/RXSSO,Wright Patterson AFB,OH,45433**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
ASETSDefense 2012: Sustainable Surface Engineering for Aerospace and Defense Workshop, August 27-30, 2012, San Diego, CA. Sponsored by SERDP/ESTCP.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**27**	

Presentation Outline

Public Affairs release # 88ABW-2008-0909

- 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

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

Authorized for use under a Chrome Primer

- **Qualified Non-Chrome Primers**
  - MIL-PRF-85582 Class N Primers
    - Type I, EWDY048
    - Type II, EEAE118

    } PRC DeSoto
    - 44-GN-098, Deft
  - MIL-PRF-23377 Class N Primers
    - 16798-TEP, Hentzen
    - 02-GN-083
    - 02-GN-084

    } Deft

Qualified over a Chrome Conversion Coating

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

Issues with Non-Chrome

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- 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

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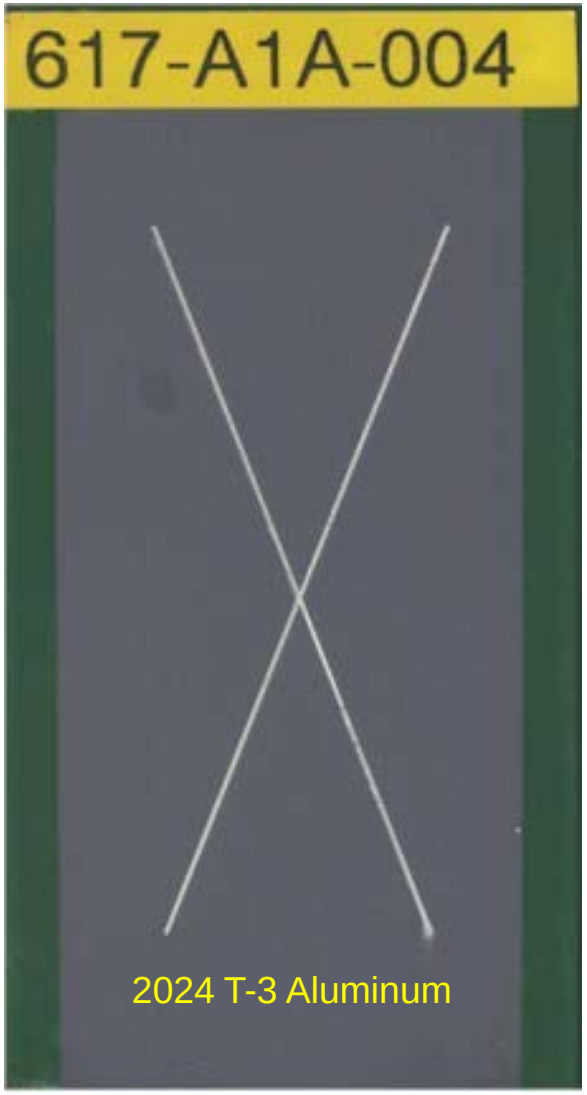

2000 hours Salt Spray

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

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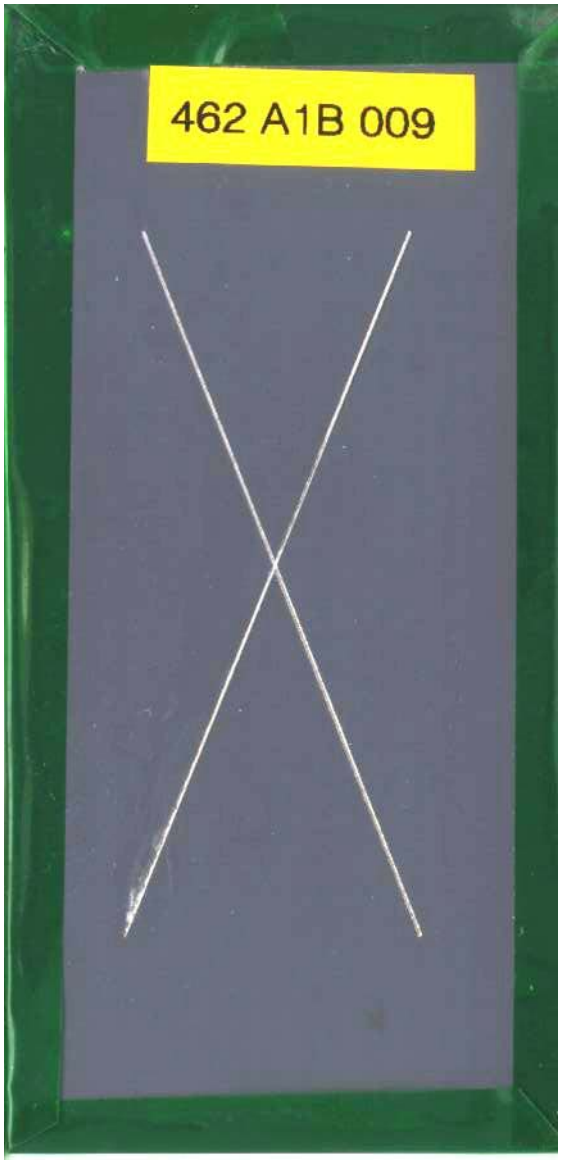

4032 hours Salt Spray

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

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- 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

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- **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

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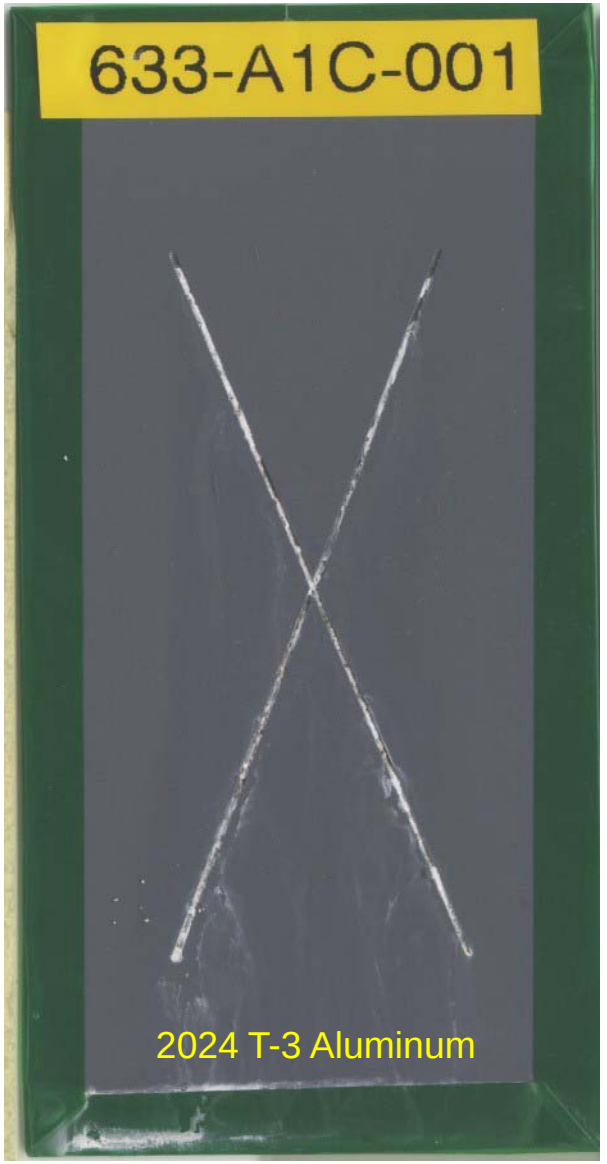
3000 hours Salt Spray

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



Results of Changing Components

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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

Results of Changing Components

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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

Lab Results vs Real World

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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

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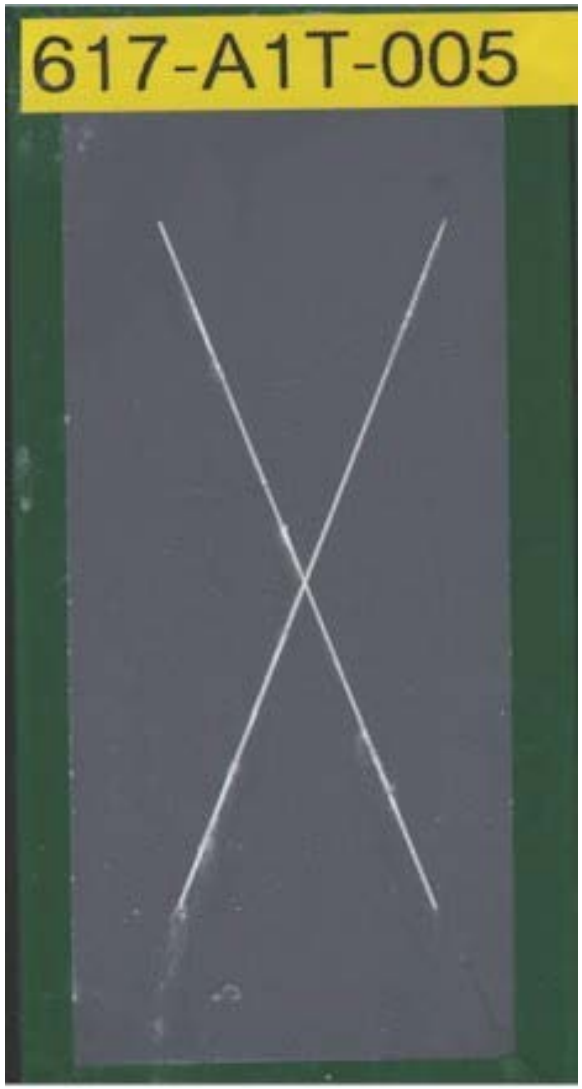
Laboratory Salt Fog 2000 hrs



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

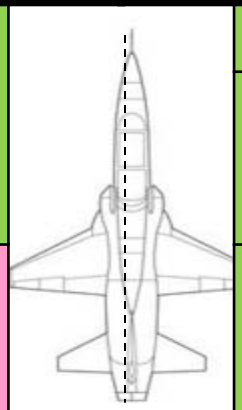
Alodine 5200
Sicopoxy 577-630
Deft 03GY310
(MIL-PRF-85285 Ty 1)

AFRL Chromium-free Coating Systems Integration Plan Efforts

Public Affairs release # 88ABW-2008-0909

"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>
<tr><th>Chromium Control</th><th colspan="2">Chromium-free</th></tr>
<tr><td rowspan="2">PreKote
(3 Step Process)</td><td rowspan="3">  </td><td>Brulin 815GD Cleaner</td></tr>
<tr><td>Alodine 5700
Non-chrome
Conversion Coat</td></tr>
<tr><td>MIL-PRF-23377 Primer
Sherwin Williams
E90-G-203</td><td>ANAC 577-630
Non-Chrome Primer</td></tr>
<tr><td colspan="3">Topcoats
Deft MIL-PRF-85285 (03-GY-308 and 03-GY-277)</td></tr>
</table>

AFRL Chromium-free Coating Systems Integration Plan Efforts

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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)

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- 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

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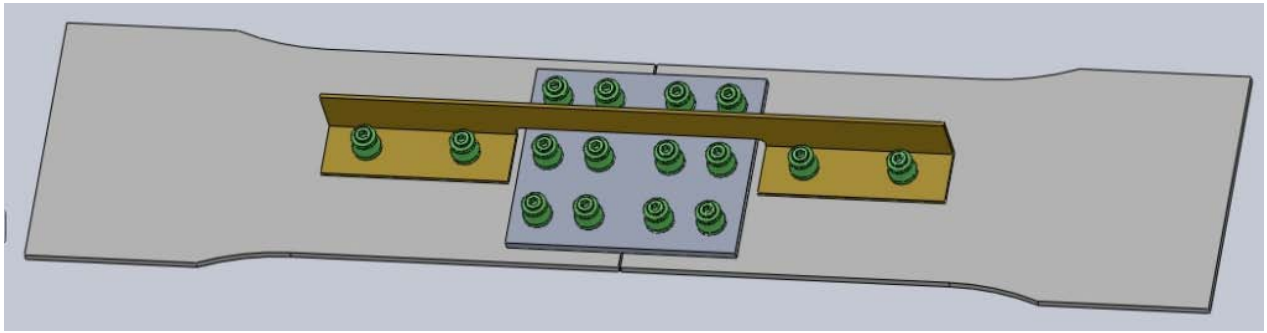
- **Coating System Specification - MIL-PRF-32239 (Outer Moldline Only)**
  - Eliminates issues with mixing components of a coating system
- **Develop Better Laboratory Test Methods – 3 Prongs**
  - Better Salt Fog Cabinet – Include UV
  - Family of Test Coupons to Represent Aircraft Structures and Loads
    - Initial Focus is KC-46 Fuselage
  - Evaluation Techniques – NDI, Corrosion Modeling – Feeds ASIP Models



AFRL Path Forward

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- **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

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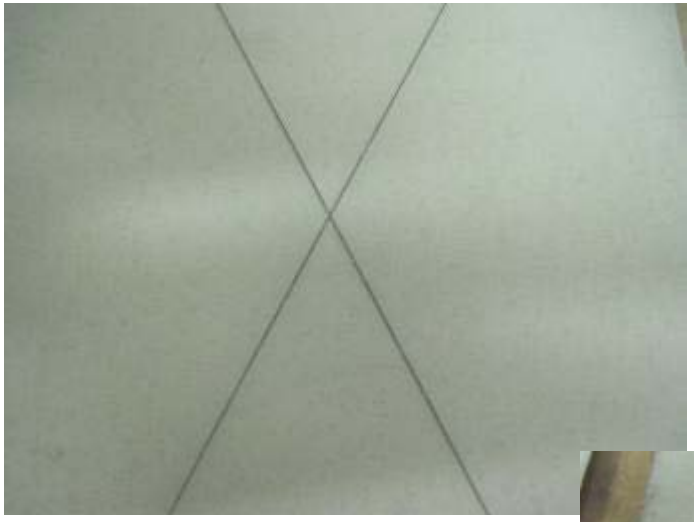
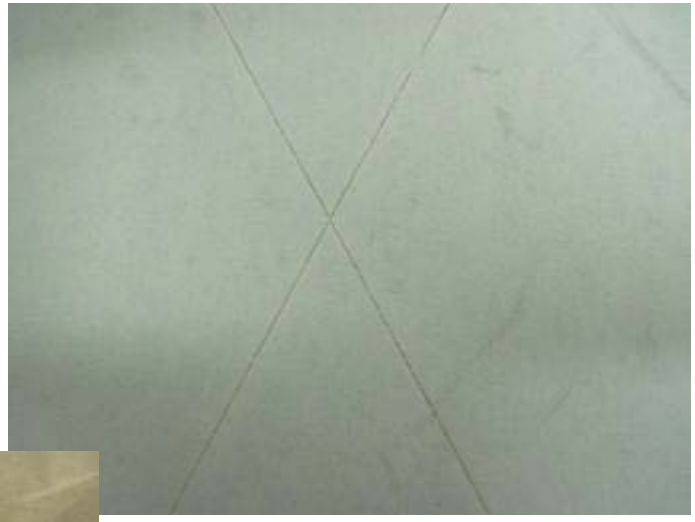
Painted 2024 Al Panels After 3+ Years At Daytona



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)

Outdoor Exposure

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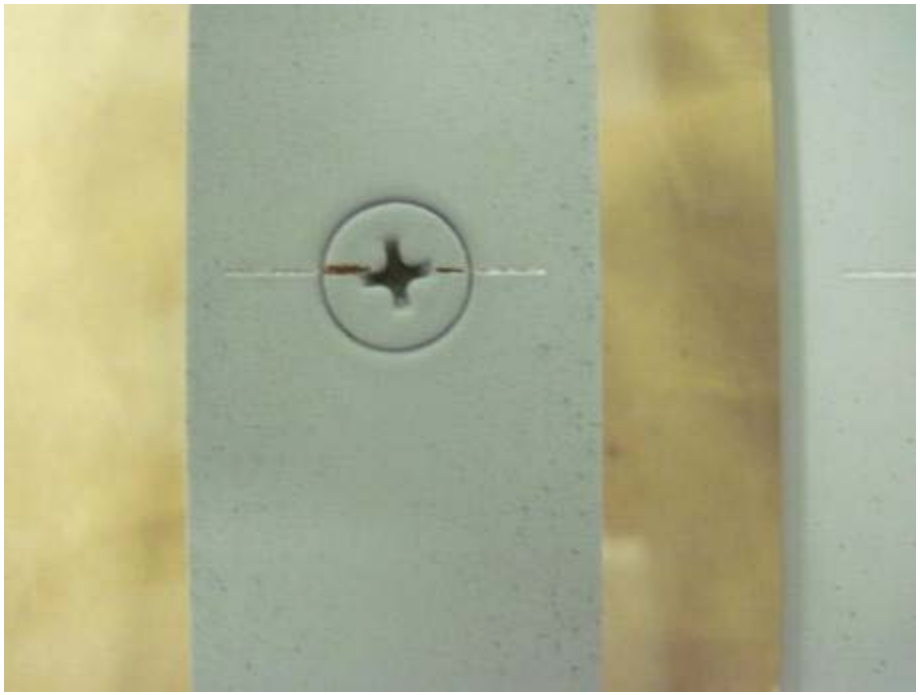
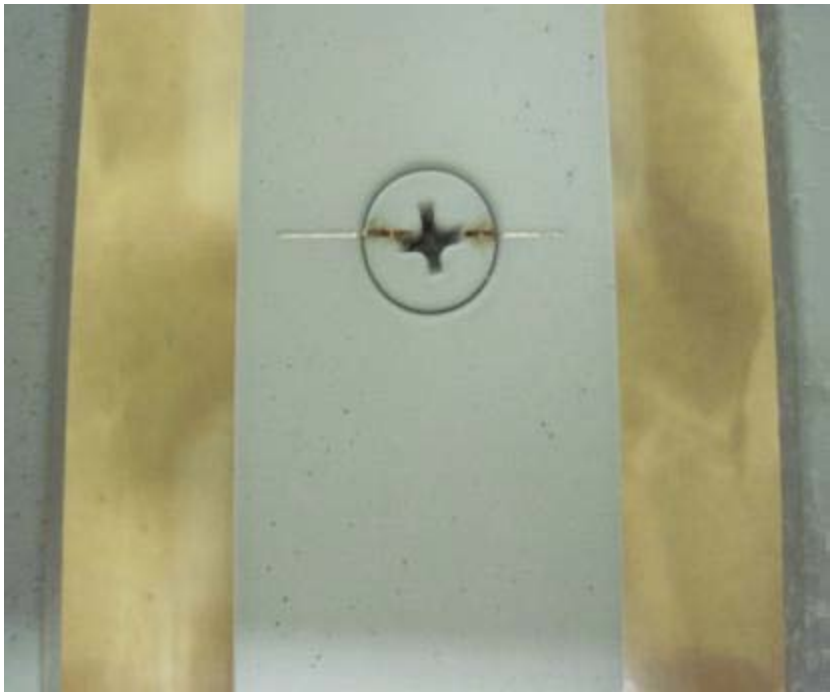
Galvanic Test Samples Exposed at Daytona

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

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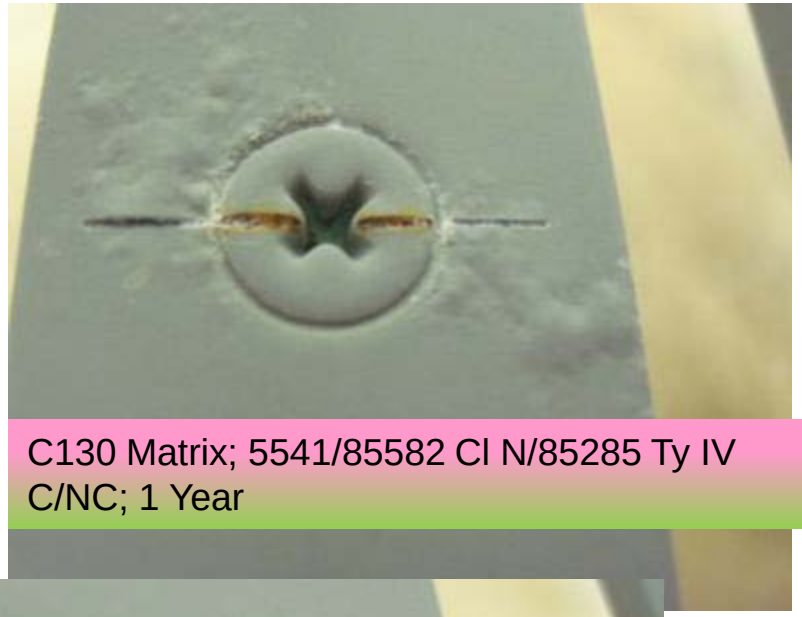
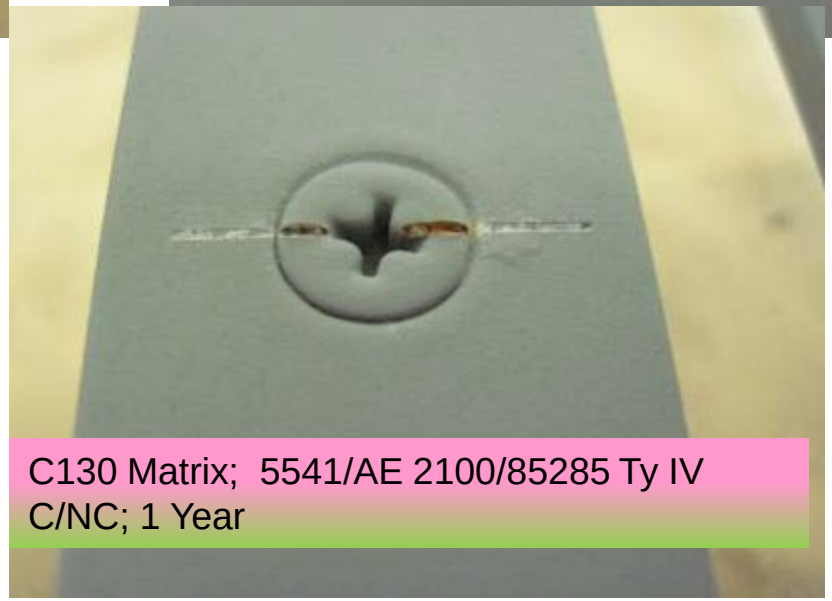
System 6 Prekote/Americoat/85285 Ty I NC/NC; 2 Years



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

NOTE: AE 2100 requires good conductivity with substrate.

AE 2100 NOT recommended over conversion coating.



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

Outdoor Exposure

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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

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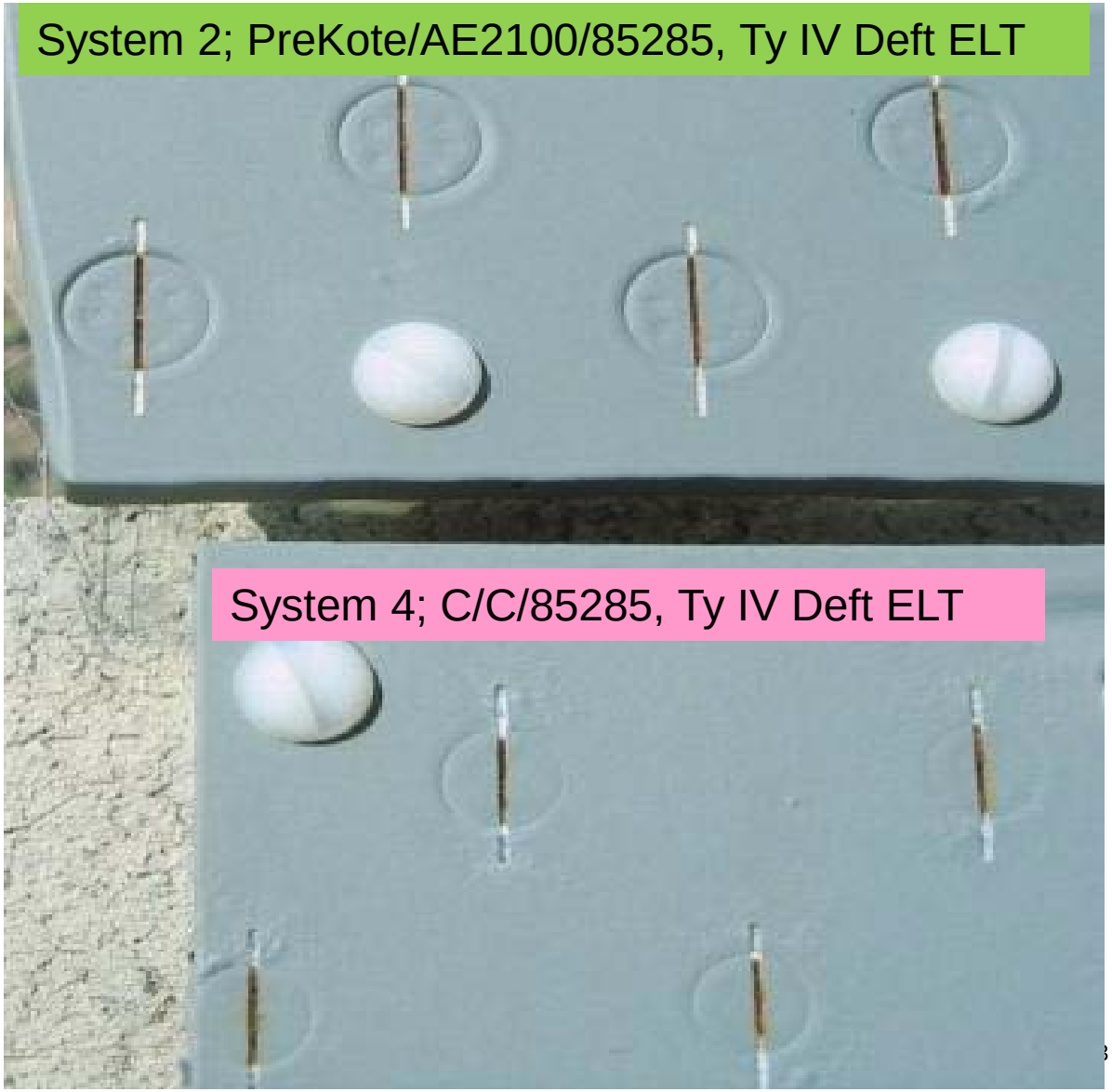
Magnified view of fasteners (2+ Years)



Mg-Rich Implementation

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- **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

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C-130 Field Testing

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

F-16 Field Testing

Public Affairs release # 88ABW-2008-0909

- 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