Qualification and Flight Test of Non-Chrome Primers for C-130 Aircraft

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**Qualification and Flight Test of Non-Chrome Primers for C-130 Aircraft**

Qualification of Non-Chrome Primers for C-130J

LM Aero Pollution Prevention Projects

- **Water-borne (WB) Non-Chrome Primer for C-130J Outer Mold Line (OML)**
  - Project began 2003
  - Funded by: US Air Force, Aeronautical Systems Center (ASC), Acquisition Environmental, Safety & Health (ESH) Division (ASC/ENV)

- **Solvent-borne (SB) Non-Chrome Primer for C-130J OML**
  - Project began 2007
  - First phase funded by: Lockheed Martin Aeronautics Company (LM Aero) ESH organization
  - Second phase funded by: US Air Force, ASC

- **Non-Chrome Primer for C-130J Inner Mold Line (IML)**
  - Project began 2006
  - First phase funded by: LM Aero ESH organization
  - Second phase funded by: US Air Force, ASC

- **Beach Exposure**
- **Flight Testing**
Qualification of Non-Chrome Primers for C-130J

• Why
  – Reduce exposure to a known carcinogen
  – Reduce hazardous waste
  – New OSHA Limits (Effective Nov. 2006)
    • 5 µg/m³ (reduced from 52 µg/m³)
    • 25 µg/m³ for aircraft exterior paint and large aircraft parts

– LM Aero Policy
  • Continue and expand the use of non-chromium products with the goal of reducing / eliminating hexavalent chromium from our products, processes and supply chain
  • Prioritize continued research to identify additional acceptable alternatives to hexavalent chromium
  • Prioritize and apply resources to resolve corrosion issues while reducing/eliminating the use of known hazardous materials
  • Ensure that adequate qualification is completed prior to release of material change to products
Qualification of Non-Chrome Primers for C-130J

WB NCP for C-130J OML

- Qualification lab testing is complete
- Final Phase of Project – Flight testing and field evaluation
- Includes only water-borne non-chrome primer candidates
- Focuses on total finish system, not individual products
  - Similar to MIL-PRF-32239: Coating System, Advanced Performance, for Aerospace Applications
    - Surface preparation/treatment/conversion coating
    - Primer
    - Topcoat
      - For this study, Advanced Performance Coating (APC) topcoat manufactured by DEFT was used for all stack-ups
Qualification of Non-Chrome Primers for C-130J

**WB NCP for C-130J OML**

- Candidate System Stack-ups (24 candidate systems)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Product Type</th>
<th>Conversion Coating</th>
<th>Primer Product Type</th>
<th>Topcoat Product Type</th>
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<tr>
<td>1</td>
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<td>Turcoat Liquid Alumigold</td>
<td>C MIL-PRF-23377H, Ty I, Cl C</td>
<td>N 99GY001, APC</td>
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<td>4</td>
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<td>LCC1 (250 ppm Cr(^{+6}))</td>
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<td>LCC1 (250 ppm Cr(^{+6}))</td>
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<td>N 99GY001, APC</td>
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<td>6</td>
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<td>LCC2 (50 ppm Cr(^{+6}))</td>
<td>L 10PW22-8 Akzo Nobel NCP</td>
<td>N 99GY001, APC</td>
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<td>7</td>
<td>Low-Chrome</td>
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<td>N 99GY001, APC</td>
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<td>L 99GY001, APC</td>
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<td>C</td>
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<td>L 99GY001, APC</td>
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<tr>
<td>4A</td>
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<td>LCC2 (50 ppm Cr(^{+6}))</td>
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<tr>
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<td>Low-Chrome</td>
<td>L</td>
<td>LCC2 (50 ppm Cr(^{+6}))</td>
<td>L 44GN098 Deft NCP + 50 ppm Cr(^{+6})</td>
<td>L 99GY001, APC</td>
</tr>
<tr>
<td>6A</td>
<td>Low-Chrome</td>
<td>L</td>
<td>AC-131 (Sol-Gel)</td>
<td>L 10PW22-8 Akzo Nobel NCP + 50 ppm Cr(^{+6})</td>
<td>L 99GY001, APC</td>
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<td>7A</td>
<td>Low-Chrome</td>
<td>L</td>
<td>AC-131 (Sol-Gel)</td>
<td>L 44GN098 Deft NCP + 50 ppm Cr(^{+6})</td>
<td>L 99GY001, APC</td>
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<td>8A</td>
<td>Low-Chrome</td>
<td>L</td>
<td>Dorado Kote 7</td>
<td>L 10PW22-8 Akzo Nobel NCP + 50 ppm Cr(^{+6})</td>
<td>L 99GY001, APC</td>
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<tr>
<td>9A</td>
<td>Low-Chrome</td>
<td>L</td>
<td>Dorado Kote 7</td>
<td>L 44GN098 Deft NCP + 50 ppm Cr(^{+6})</td>
<td>L 99GY001, APC</td>
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</tbody>
</table>

*NOTE: C = Chromated L = Low-Chrome N = Non-Chrome

Reduced-chrome = NCP on chromate conversion coating

Low-chrome = ≤ 250 ppm Cr\(^{+6}\) in stack-up

Lockheed Martin Aeronautics Company
Qualification of Non-Chrome Primers for C-130J

WB NCP for C-130J OML QUALIFICATION TESTING

- Surface Appearance
- Salt Spray (3000 hours)
- Adhesion: Wet Tape and Cross Hatch
- Filiform
- Weather Resistance: Xenon Arc (3000 hours) and QUV-B (1500 hours)
- Flexibility: Impact and Low Temperature
- Humidity Resistance (30 days)
- Heat Resistance (4 hours @ 220°F)
- Solvent Resistance
- Tape Resistance
- Fluid Resistance
- Strippability
- Galvanic Corrosion (aluminum:gr/ep)
Qualification of Non-Chrome Primers for C-130J

WB NCP for C-130J OML

- 3000 Hour Salt Spray Results

**System 1:** Alumigold-23377-APC (chromated control)

**System 3:** Alumigold-Deft 44GN098-APC (reduced chrome)

**System 7:** LCC2 (50ppm Cr+6)-Deft 44GN098-APC (low-chrome)

**System 13:** AC131-Deft 44GN098-APC (non-chrome)
Qualification of Non-Chrome Primers for C-130J

WB NCP for C-130J OML LAB TEST CONCLUSIONS

a) No total non-chrome system demonstrated acceptable performance
   - Best performing total non-chrome system
     • AC-131 + Deft 44GN098 + APC (System 13)
       » Several total non-chrome solvent-borne (SB) systems are outperforming this system
       » No plans to implement this system

b) Low-chrome systems (50 or 250 ppm Cr⁶⁺ added) also failed to show consistent improvement
   » No plans to implement these systems

c) Reduced-chrome system (System 3) - Alumigold chromated conversion coating + Deft 44GN098 (NCP) + Deft APC topcoat consistently provided acceptable results (similar to control data)

   • ESH benefits of implementing (c) reduced chrome system
     – Significant hexavalent chrome reduction in finish system
     – Potential exposure level of spray applied chromated conversion coating not as high as when spraying chromated primers
     – Rework (sanding) of finish systems containing NCP greatly reduces risk of exposure
Qualification of Non-Chrome Primers for C-130J

SB NCP for C-130J OML

- Utilized same test requirements as WB NCP for C-130J OML project
- Two of three qualification lab test stages complete
- Includes newly developed SB NCP candidates
  - Typically provide improved performance compared to WB
  - More forgiving at application
- Focuses on total finish system (similar to MIL-PRF-32239)
  - Surface preparation/treatment/conversion coating
  - Primer
  - Topcoat
  » For this study Advanced Performance Coating (APC) topcoat manufactured by DEFT was used for all stack-ups
# Qualification of Non-Chrome Primers for C-130J

## SB NCP for C-130J OML

- Candidate System Stack-ups (34 candidate systems)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Conversion Coating</th>
<th>Primer</th>
<th>Topcoat</th>
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<tbody>
<tr>
<td>S1</td>
<td>Chromated Control</td>
<td>Turcoat Liquid Alumigold C</td>
<td>Akzo Nobel 10-P20-13 C 99GY001, APC</td>
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<tr>
<td>S2</td>
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<td>Turcoat Liquid Alumigold C</td>
<td>Akzo Nobel Aerodur 2100 MgRP N 99GY001, APC</td>
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<td>S3</td>
<td>Reduced-Chrome</td>
<td>Turcoat Liquid Alumigold C</td>
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<tr>
<td>S4</td>
<td>Reduced-Chrome</td>
<td>Turcoat Liquid Alumigold C</td>
<td>Deft 02GN084        N 99GY001, APC</td>
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<td>S5</td>
<td>Reduced-Chrome</td>
<td>Turcoat Liquid Alumigold C</td>
<td>Hentzen 16708TEP    N 99GY001, APC</td>
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<tr>
<td>S6</td>
<td>Reduced-Chrome</td>
<td>Turcoat Liquid Alumigold C</td>
<td>PRC-Desoto RW-3899-64 N 99GY001, APC</td>
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<td>S7</td>
<td>Reduced-Chrome</td>
<td>Turcoat Liquid Alumigold C</td>
<td>PRC-Desoto RW-4057-64 N 99GY001, APC</td>
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<td>S8</td>
<td>Reduced-Chrome</td>
<td>Turcoat Liquid Alumigold C</td>
<td>Sherwin Williams CM04813787 N 99GY001, APC</td>
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<tr>
<td>S9</td>
<td>Reduced-Chrome</td>
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<td>S10</td>
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</table>

*NOTE: C = Chromated       L = Low-Chrome       N = Non-Chrome*
Qualification of Non-Chrome Primers for C-130J

SB NCP for C-130J OML

- 3000 Hour Salt Spray Results

S1 Control: Alumigold-23377-APC (chromated)

S2: Alumigold-MgRP-APC (reduced chrome)

S20: Alodine 5700-02GN084-APC (non-chrome)

S21: Alodine 5700-16708TEP-APC (non-chrome)
SB NCP for C-130J OML LAB TEST CONCLUSIONS TO DATE

- **Top Performing Candidate Systems:**
  - **S2** - Alumigold + Akzo Nobel Aerodur 2100 MgRP + APC (reduced-chrome system)
  - **S20** - Alodine 5700 + Deft 02GN084 + APC (non-chrome system)
  - **S21** - Alodine 5700 + Hentzen 16708TEP + APC (non-chrome system)

- Several other systems demonstrating reasonable performance and will continue with additional lab testing

- Generally SB NCP systems performed better than WB NCP systems
Qualification of Non-Chrome Primers for C-130J

NCP for C-130J Inner Mold Line

- Screening and qualification lab testing complete
- Includes both WB and SB NCP candidates
- NCPs tested with chromate conversion coating only
  - More difficult to observe corrosion on IML parts
  - IML parts conversion coated by immersion process – lower exposure levels
- Testing based on MIL-PRF-23377 and MIL-PRF-85582 requirements
Qualification of Non-Chrome Primers for C-130J

NCP for C-130J Inner Mold Line
- **Candidate Matrix (6 Candidate NCP’s)**

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<tr>
<th>ID</th>
<th>TYPE</th>
<th>PRODUCT NAME</th>
<th>MANUFACTURER</th>
<th>TYPE</th>
<th>COLOR</th>
<th>CANDIDATE OR CONTROL</th>
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<td>C1</td>
<td>Primer</td>
<td>10-PW20-4</td>
<td>Akzo Nobel</td>
<td>Water-borne</td>
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<td>Control</td>
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<td>Control</td>
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<td>Primer</td>
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<td>Deft Coatings</td>
<td>Water-borne</td>
<td>Green</td>
<td>Candidate</td>
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<td>P2</td>
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Note: Color number per Fed-Std-595
Qualification of Non-Chrome Primers for C-130J

NCP for C-130J Inner Mold Line Qualification Testing

- Viscosity
- Solvent Content
- Condition in Container
- Surface Appearance
- Drying Time
- Lifting
- Adhesion, Cross Hatch
- Solvent Resistance
- Salt Spray (2000 hours)
- Pot Life
- Impact Flexibility
- Water Resistance
- Humidity Resistance (30 days)
- Filiform
- Fluid Resistance
- Aged Conversion Coating Compatibility
- Reactivation Compatibility
- Galvanic Corrosion
- Storage Stability
Qualification of Non-Chrome Primers for C-130J

NCP for C-130J Inner Mold Line

- 2000 Hour Salt Spray Results (conversion coating & primer only, no topcoat)

Chromicoat L-25 - Hentzen 16708TEP (non-chrome solvent-borne primer)

Chromicoat L-25 - PRC-Desoto RW-3899-64 (non-chrome solvent-borne primer)

Chromicoat L-25 - Akzo Nobel Aerodur 2100 MgRP (non-chrome solvent-borne primer)
Qualification of Non-Chrome Primers for C-130J

NCP for C-130J Inner Mold Line

- 2000 Hour Salt Spray Results (conversion coating & primer only, no topcoat)

Chromicoat L-25 – Akzo Nobel 10-PW20-4 (chrome water-borne primer)

Chromicoat L-25 – Deft 02GN084 (non-chrome solvent-borne primer)

Chromicoat L-25 – Deft 44GN098 (non-chrome water-borne primer)
NCP FOR C-130J INNER MOLD LINE LAB TEST CONCLUSIONS

- **Top Performing Candidates**
  - Akzo Nobel Aerodur 2100 MgRP
  - Deft 44GN098
  - Deft 02GN084

- Deft 44GN098 WB and 02GN084 SB NCPs performed similarly

- Briefed AFCPO and C130 SPO Engineering in 2008 on results of all lab testing performed (WB NCP, SB NCP, and IML NCP).

**Recommendations/Outcome:**

» 24-month beach exposure (completed)

» 3-year flight testing (on-going)
NCP Beach Exposure

24 Month Inspection
Little difference seen between MgRP reduced chrome and full chrome control panels. 44GN098 panels showing small blisters along scribes.
24 Month Inspection

16708TEP panels began showing blisters at 3 months. 02GN084 panels showing a few small blisters along scribes.
### NCP Beach Exposure

#### 24-Month beach exposure results summary

<table>
<thead>
<tr>
<th>PRIMER</th>
<th>Scribe</th>
<th>PITS</th>
<th>OXIDATION</th>
<th>BLISTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
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<tr>
<td>44GN098</td>
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</tr>
<tr>
<td>MgRP</td>
<td>s</td>
<td></td>
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<tr>
<td>02GN084</td>
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<tr>
<td>16708TEP</td>
<td>s</td>
<td>red</td>
<td></td>
<td>red</td>
</tr>
</tbody>
</table>

- **s**: superficial
- **red**: several
- **yellow**: few
- **green**: none
Qualification of Non-Chrome Primers for C-130J

C-130 NCP Flight Test Summary

- Planned 36-Month Duration (1/2 PDM Cycle). Inspections performed every 6 months beginning at 3 months after their return to home station following Depot. Expected completion January, 2013.

- Candidate NCP Finish Systems
  - Alumigold + Deft 44GN098 (WB NCP) + APC (reduced-chrome System 3)
  - Alumigold + Akzo Nobel Aerodur 2100 MgRP (SB NCP) + APC (reduced-chrome System S2)
  - Alodine 5700 + Deft 02GN084 (SB NCP)+ APC (non-chrome System S20)
  - Alodine 5700 + Hentzen 16708TEP (SB NCP) + APC (non-chrome System S21)

- C-130 Aircraft
  - 82-0055 Kulis ANG
  - 93-1456 Charlotte ANG

- Areas Treated with NCP Finish Systems
  - Right Outer Wing Flap, upper and lower surfaces
  - Left Outer Wing Flap, upper and lower surfaces
  - Right Horizontal Stabilizer, upper surface
  - Left Horizontal Stabilizer, upper surface
Aircraft 1:
82-0055 Kulis ANG

O.W. Flap (upper and lower surface)
System 1
Alumigold + 44GN098 + Deft APC

Horizontal Stabilizer (upper panel surface)
System 3
Alodine 5700 + 02GN084 + Deft APC

System Identification

System 1
Alumigold + Deft 44GN098 + Deft APC

System 2
Alumigold + Aerodur 2100 MgRP + Deft APC

System 3
Alodine 5700 + Deft 02GN084 + Deft APC

System 4
Alodine 5700 + Hentzen 16708TEP + Deft APC
Aircraft 2: 93-1456 Charlotte ANG

**System Identification**

- **System 1**
  - Alumigold + Deft 44GN098 + Deft APC
- **System 2**
  - Alumigold + Aerodur 2100 MgRP + Deft APC
- **System 3**
  - Alodine 5700 + Deft 02GN084 + Deft APC
- **System 4**
  - Alodine 5700 + Hentzen 16708TEP + Deft APC

- **O.W. Flap (upper and lower surface)**
  - System 3
  - Alodine 5700 + 02GN084 + Deft APC

- **Horizontal Stabilizer (upper panel surface)**
  - System 1
  - Alumigold + 44GN098 + Deft APC
  - System 2
  - Alumigold + 2100 MgRP + Deft APC
  - System 4
  - Alodine 5700 + 16708TEP + Deft APC
NCP Flight Test

NCP Application
Candidate NCP finish systems applied by WR-ALC personnel
NCP Flight Test

- **Status to date**
  - *Performed the 15-month inspection of 82-0055 in Nov, 2010 and the 15-month inspection of 93-1456 in March, 2011. Planning to perform 21-month inspection of 93-1456 in September, 2011 and a 26-month inspection of 82-0055 in October, 2011 (delayed due to deployment).*

  - *The candidate finishes are performing as well as the baseline finish on both airplanes. No color changes, no chalking, no thickness changes, no adhesion loss, and no corrosion observed in the test areas.*

  - *Within the candidate NCP test areas, a few paint chips (impact damage) were seen that removed finishes down to the bare substrate. No active corrosion was observed.*
Questions?