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

2011 Air Force CORROSION Conference

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Report Documentation Page

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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)**

System		Conversion Coating		Primer		Topcoat
No.	Description	Product	Type	Product	Type	
1 (control)	**Chromated Control**	Turcoat Liquid Alumigold	C	MIL-PRF-23377H, Ty I, Cl C	C	99GY001, APC
2	**Reduced-Chrome**	Turcoat Liquid Alumigold	C	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
3	**Reduced-Chrome**	Turcoat Liquid Alumigold	C	44GN098 Deft NCP	N	99GY001, APC
4	**Low-Chrome**	LCC1 (250 ppm Cr^{+6})	L	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
5	**Low-Chrome**	LCC1 (250 ppm Cr^{+6})	L	44GN098 Deft NCP	N	99GY001, APC
6	**Low-Chrome**	LCC2 (50 ppm Cr^{+6})	L	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
7	**Low-Chrome**	LCC2 (50 ppm Cr^{+6})	L	44GN098 Deft NCP	N	99GY001, APC
8	**Non-Chrome**	Alodine 5700	N	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
9	**Non-Chrome**	Alodine 5700	N	44GN098 Deft NCP	N	99GY001, APC
10	**Non-Chrome**	PreKote	N	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
11	**Non-Chrome**	PreKote	N	44GN098 Deft NCP	N	99GY001, APC
12	**Non-Chrome**	AC-131	N	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
13	**Non-Chrome**	AC-131	N	44GN098 Deft NCP	N	99GY001, APC
14	**Non-Chrome**	Dorado Kote 7	N	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
15	**Non-Chrome**	Dorado Kote 7	N	44GN098 Deft NCP	N	99GY001, APC
16	**Non-Chrome**	Gardobond X4707	N	10PW22-8 Akzo Nobel NCP	N	99GY001, APC
17	**Non-Chrome**	Gardobond X4707	N	44GN098 Deft NCP	N	99GY001, APC
2A	**Low-Chrome**	Turcoat Liquid Alumigold	C	10PW22-8 Akzo Nobel NCP + 50 ppm Cr^{+6}	L	99GY001, APC
3A	**Low-Chrome**	Turcoat Liquid Alumigold	C	44GN098 Deft NCP + 50 ppm Cr^{+6}	L	99GY001, APC
4A	**Low-Chrome**	LCC2 (50 ppm Cr^{+6})	L	10PW22-8 Akzo Nobel NCP + 50 ppm Cr^{+6}	L	99GY001, APC
5A	**Low-Chrome**	LCC2 (50 ppm Cr^{+6})	L	44GN098 Deft NCP + 50 ppm Cr^{+6}	L	99GY001, APC
6A	**Low-Chrome**	AC-131 (Sol-Gel)	N	10PW22-8 Akzo Nobel NCP + 50 ppm Cr^{+6}	L	99GY001, APC
7A	**Low-Chrome**	AC-131 (Sol-Gel)	N	44GN098 Deft NCP + 50 ppm Cr^{+6}	L	99GY001, APC
8A	**Low-Chrome**	Dorado Kote 7	N	10PW22-8 Akzo Nobel NCP + 50 ppm Cr^{+6}	L	99GY001, APC
9A	**Low-Chrome**	Dorado Kote 7	N	44GN098 Deft NCP + 50 ppm Cr^{+6}	L	99GY001, APC

* 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

Qualification of Non-Chrome Primers for C-130J

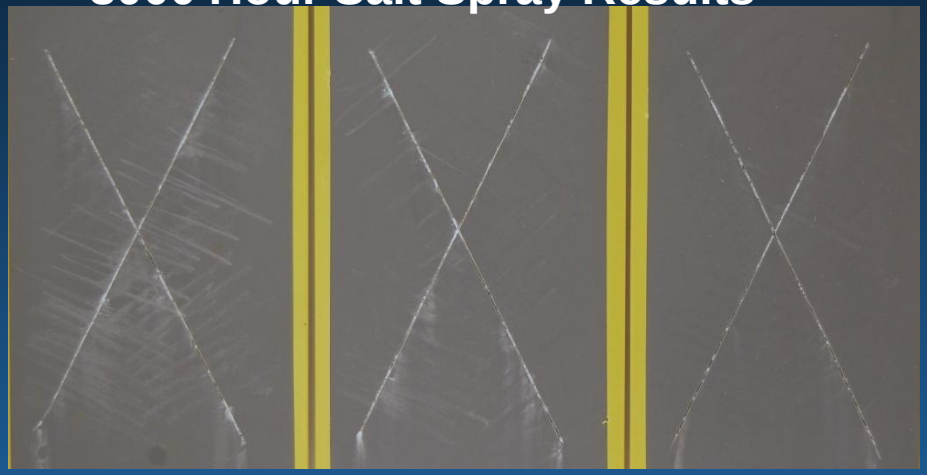
WB NCP for C-130J OML QUALIFICATION TESTING

- *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)*

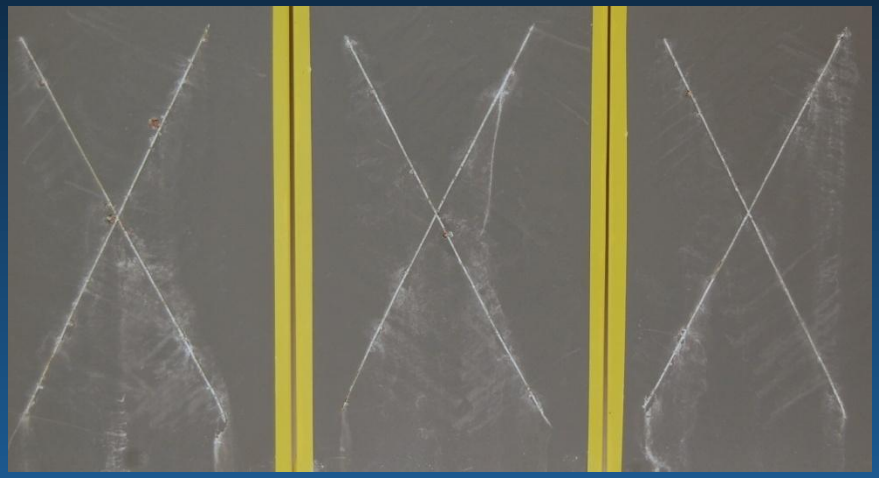
Qualification of Non-Chrome Primers for C-130J

WB NCP for C-130J OML

- 3000 Hour Salt Spray Results

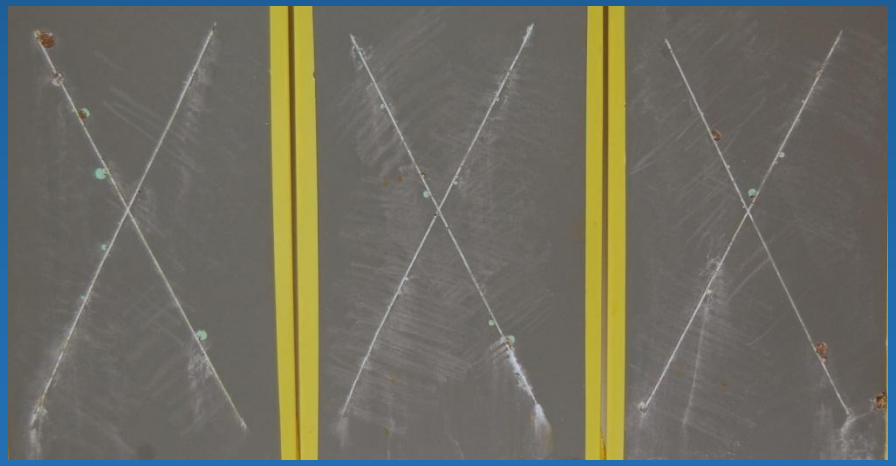


System 1: Alumigold-23377-APC (chromated control)



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 Cr^{+6} 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)**

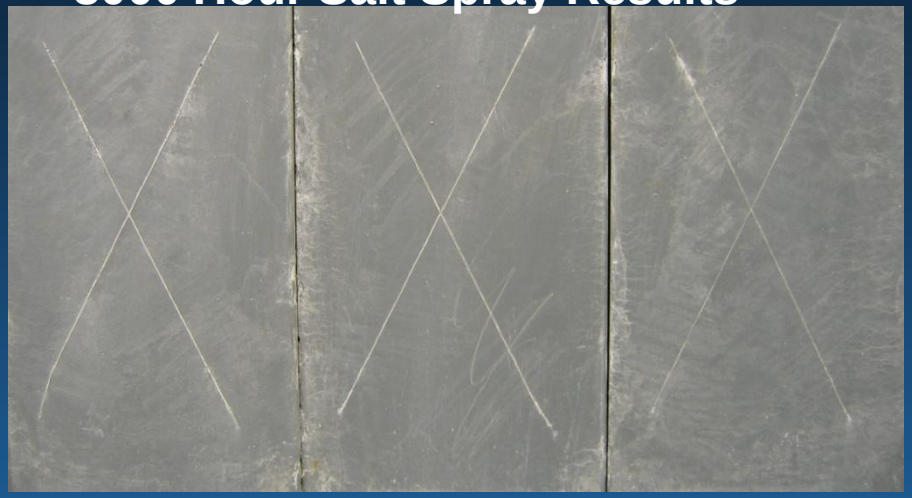
System		Conversion Coating		Primer		Topcoat
No.	Description	Product	Type	Product	Type	
S1 (control)	Chromated Control	Turcoat Liquid Alumigold	C	Akzo Nobel 10-P20-13	C	99GY001, APC
S2	Reduced-Chrome	Turcoat Liquid Alumigold	C	Akzo Nobel Aerodur 2100 MgRP	N	99GY001, APC
S3	Reduced-Chrome	Turcoat Liquid Alumigold	C	Axon Products EP-19-G4	N	99GY001, APC
S4	Reduced-Chrome	Turcoat Liquid Alumigold	C	Deft 02GN084	N	99GY001, APC
S5	Reduced-Chrome	Turcoat Liquid Alumigold	C	Hentzen 16708TEP	N	99GY001, APC
S6	Reduced-Chrome	Turcoat Liquid Alumigold	C	PRC-Desoto RW-3899-64	N	99GY001, APC
S7	Reduced-Chrome	Turcoat Liquid Alumigold	C	PRC-Desoto RW-4057-64	N	99GY001, APC
S8	Reduced-Chrome	Turcoat Liquid Alumigold	C	Sherwin Williams CM04813787	N	99GY001, APC
S9	Reduced-Chrome	Turcoat Liquid Alumigold	C	Sicopoxy 577-630	N	99GY001, APC
S10	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	Akzo Nobel Aerodur 2100 MgRP	N	99GY001, APC
S11	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	Axon Products EP-19-G4	N	99GY001, APC
S12	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	Deft 02GN084	N	99GY001, APC
S13	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	Hentzen 16708TEP	N	99GY001, APC
S14	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	PRC-Desoto RW-3899-64	N	99GY001, APC
S15	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	PRC-Desoto RW-4057-64	N	99GY001, APC
S16	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	Sherwin Williams CM04813787	N	99GY001, APC
S17	Low-Chrome	Alodine 5700 with 50ppm Cr^{+6}	L	Sicopoxy 577-630	N	99GY001, APC
S18	Non-Chrome	Alodine 5700	N	Akzo Nobel Aerodur 2100 MgRP	N	99GY001, APC
S19	Non-Chrome	Alodine 5700	N	Axon Products EP-19-G4	N	99GY001, APC
S20	Non-Chrome	Alodine 5700	N	Deft 02GN084	N	99GY001, APC
S21	Non-Chrome	Alodine 5700	N	Hentzen 16708TEP	N	99GY001, APC
S22	Non-Chrome	Alodine 5700	N	PRC-Desoto RW-3899-64	N	99GY001, APC
S23	Non-Chrome	Alodine 5700	N	PRC-Desoto RW-4057-64	N	99GY001, APC
S24	Non-Chrome	Alodine 5700	N	Sherwin Williams CM04813787	N	99GY001, APC
S25	Non-Chrome	Alodine 5700	N	Sicopoxy 577-630	N	99GY001, APC
S26	Non-Chrome	AC-131	N	Akzo Nobel Aerodur 2100 MgRP	N	99GY001, APC
S27	Non-Chrome	AC-131	N	Axon Products EP-19-G4	N	99GY001, APC
S28	Non-Chrome	AC-131	N	Deft 02GN084	N	99GY001, APC
S29	Non-Chrome	AC-131	N	Hentzen 16708TEP	N	99GY001, APC
S30	Non-Chrome	AC-131	N	PRC-Desoto RW-3899-64	N	99GY001, APC
S31	Non-Chrome	AC-131	N	PRC-Desoto RW-4057-64	N	99GY001, APC
S32	Non-Chrome	AC-131	N	Sherwin Williams CM04813787	N	99GY001, APC
S33	Non-Chrome	AC-131	N	Sicopoxy 577-630	N	99GY001, APC
S34	Non-Chrome	None	N	Akzo Nobel Aerodur 2100 MgRP	N	99GY001, APC

* 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)

Qualification of Non-Chrome Primers for C-130J

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)**

ID	TYPE	PRODUCT NAME	MANUFACTURER	TYPE	COLOR	CANDIDATE OR CONTROL
C1	Primer	10-PW20-4	Akzo Nobel	Water-borne	Green	Control
C2	Primer	10-P20-13	Akzo Nobel	Solvent-borne	Yellow	Control
P1	Primer	44GN098	Deft Coatings	Water-borne	Green	Candidate
P2	Primer	02GN084	Deft Coatings	Solvent-borne	Green	Candidate
P3	Primer	16708TEP	Hentzen	Solvent-borne	Tan	Candidate
P4	Primer	RW-3899-64	PRC-Desoto	Solvent-borne	Grey	Candidate
P5	Primer	RW-3946-64	PRC-Desoto	Water-borne	Light Grey	Candidate
P6	Primer	Aerodur 2100 MgRP	Akzo Nobel	Solvent-borne	Grey - Silver	Candidate
T1	Topcoat	9002W109G	Akzo Nobel	Water-dispersed poly	36118	-
T2	Topcoat	03W127A	Deft Coatings	MIL-PRF-85285	17925	-
T3	Topcoat	12-11520	Sterling Lacquer	Vinyl lacquer	34424	-

Note: Color number per Fed-Std-595

Qualification of Non-Chrome Primers for C-130J

NCP for C-130J Inner Mold Line Qualification Testing

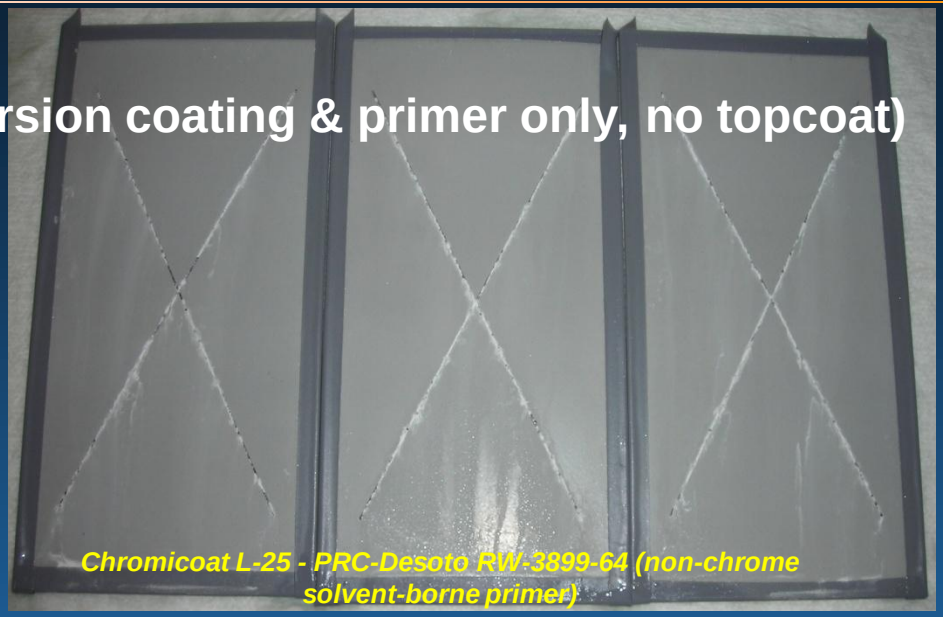
- *Viscosity*
- *Solvent Content*
- *Condition in Container*
- *Surface Appearance*
- *Drying Time*
- *Lifting*
- *Adhesion, Cross Hatch*
- *Solvent Resistance*
- *Salt Spray (2000 hours)*
- *Pot Life*
- *Impact Flexibility*
- *Water Resistance*
- *Humidity Resistance (30 days)*
- *Filiform*
- *Fluid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

Qualification of Non-Chrome Primers for C-130J

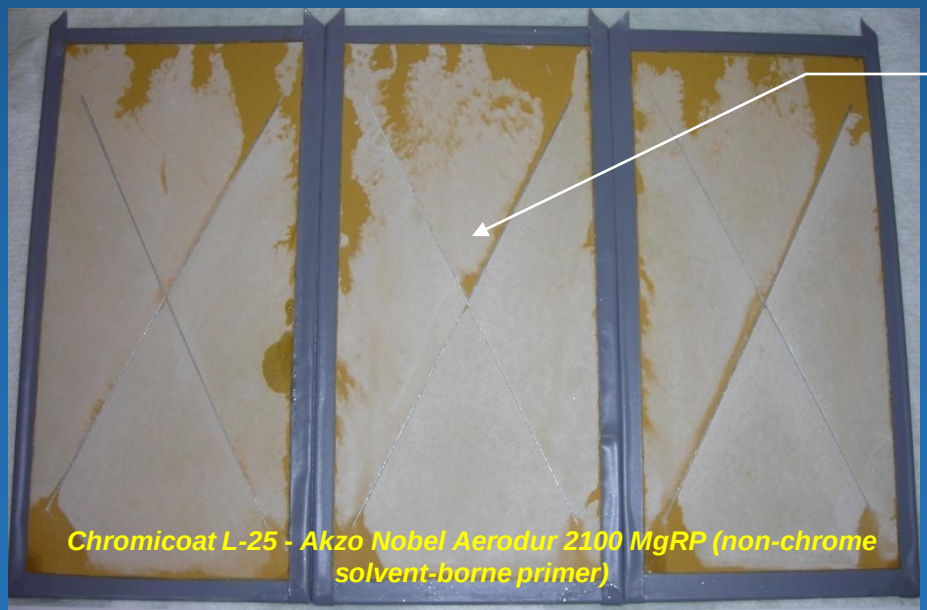
NCP for C-130J Inner Mold Line

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

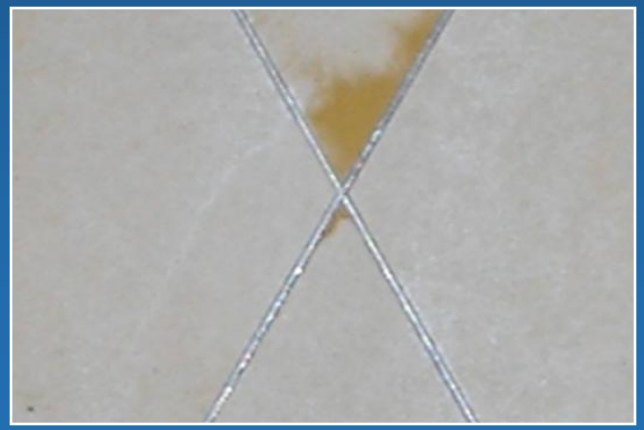
Chromicoat L-25 - Hentzen 16708TEP (non-chrome solvent-borne primer)



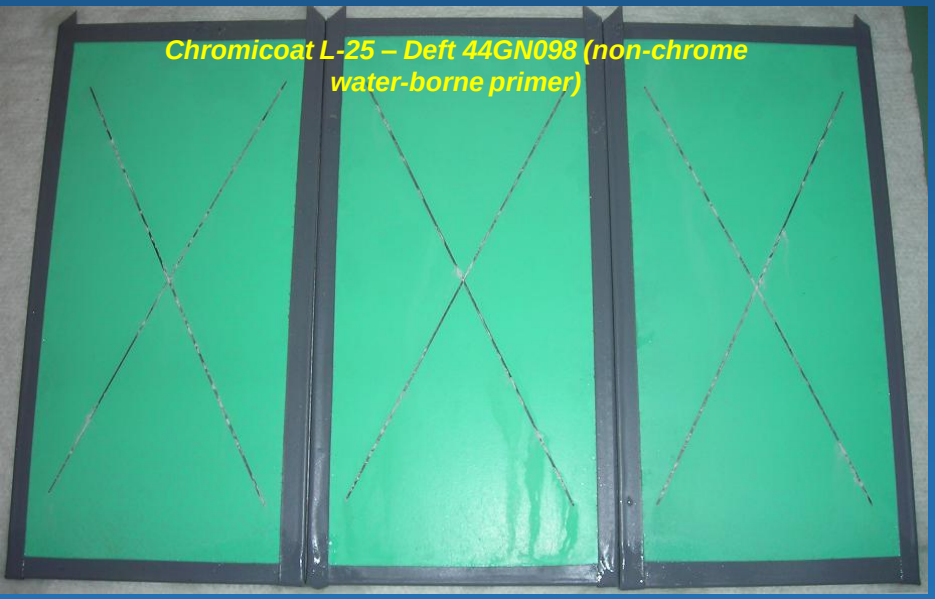
Chromicoat L-25 - PRC-Desoto RW-3899-64 (non-chrome solvent-borne primer)



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)**

Qualification of Non-Chrome Primers for C-130J

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***

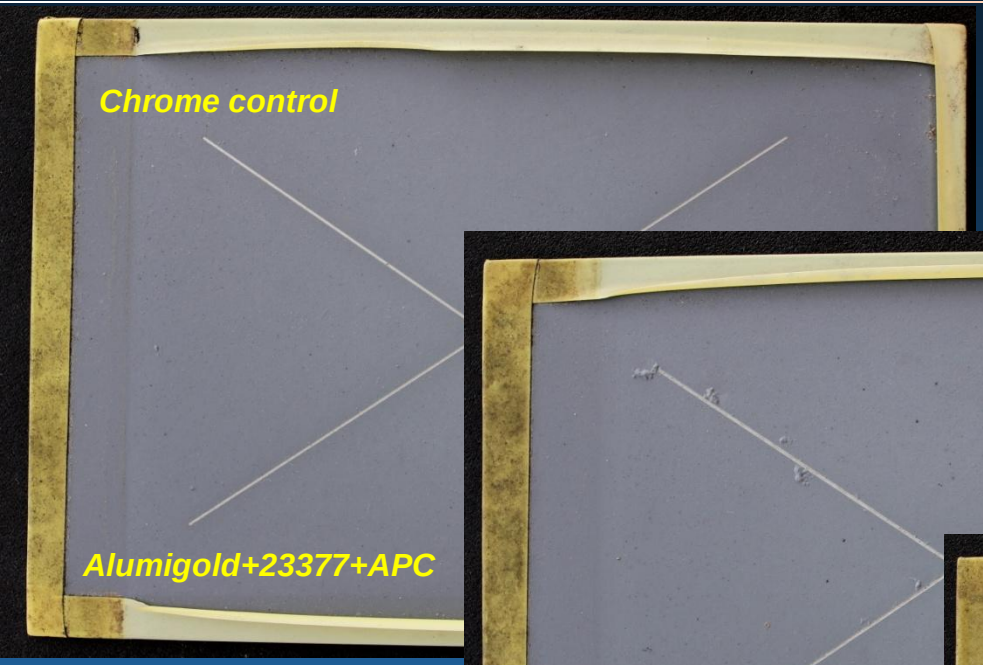
- ***Briefed AFCPO and C130 SPO Engineering in 2008 on results of all lab testing performed (WB NCP, SB NCP, and IML NCP).***

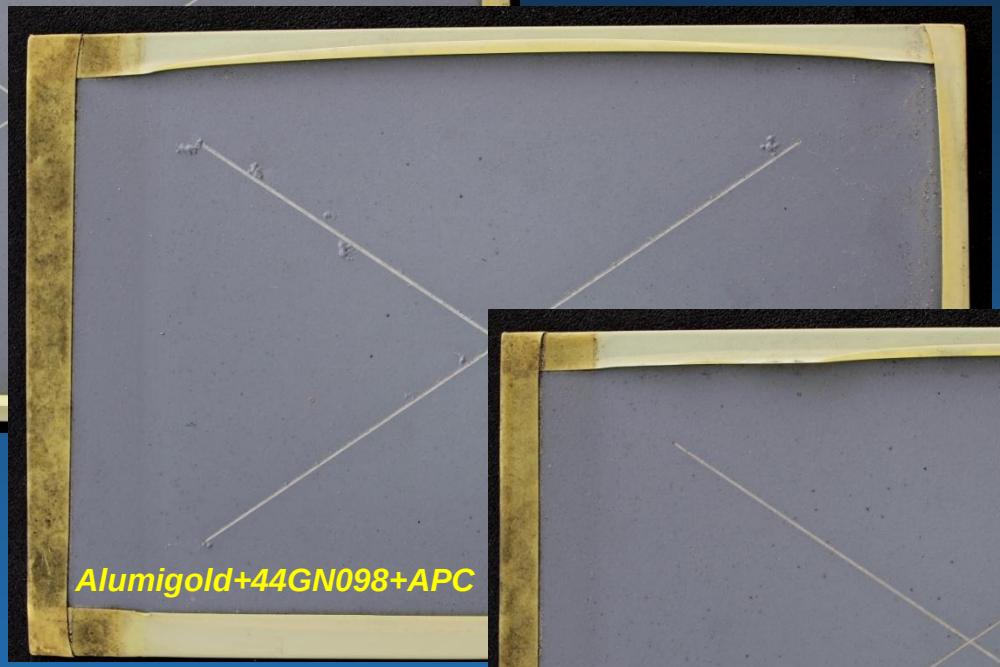
  Recommendations/Outcome:

  » *24-month beach exposure (completed)*

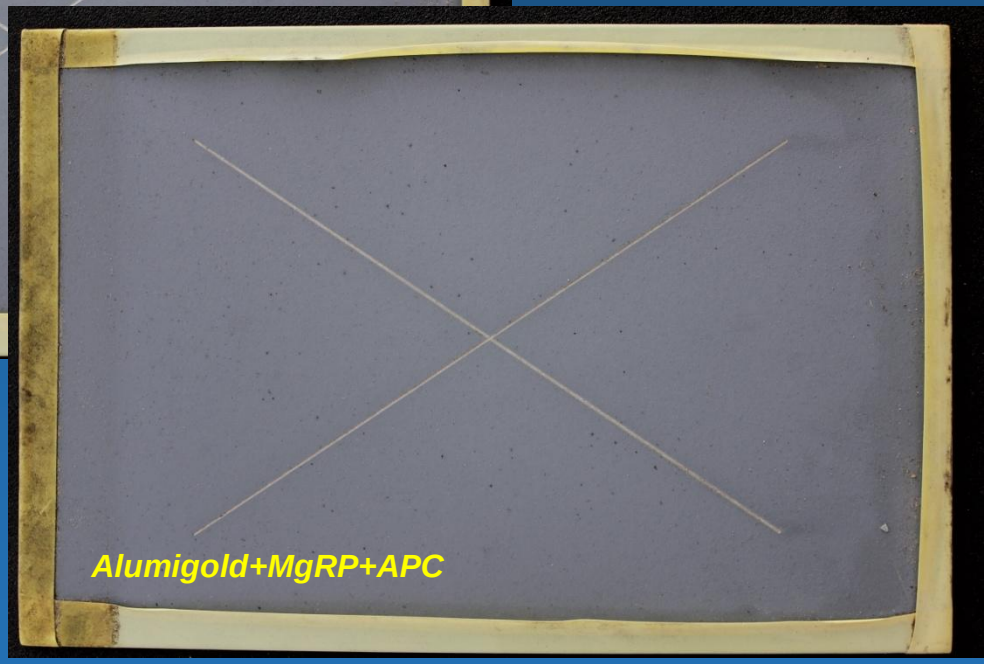
  » *3-year flight testing (on-going)*

NCP Beach Exposure





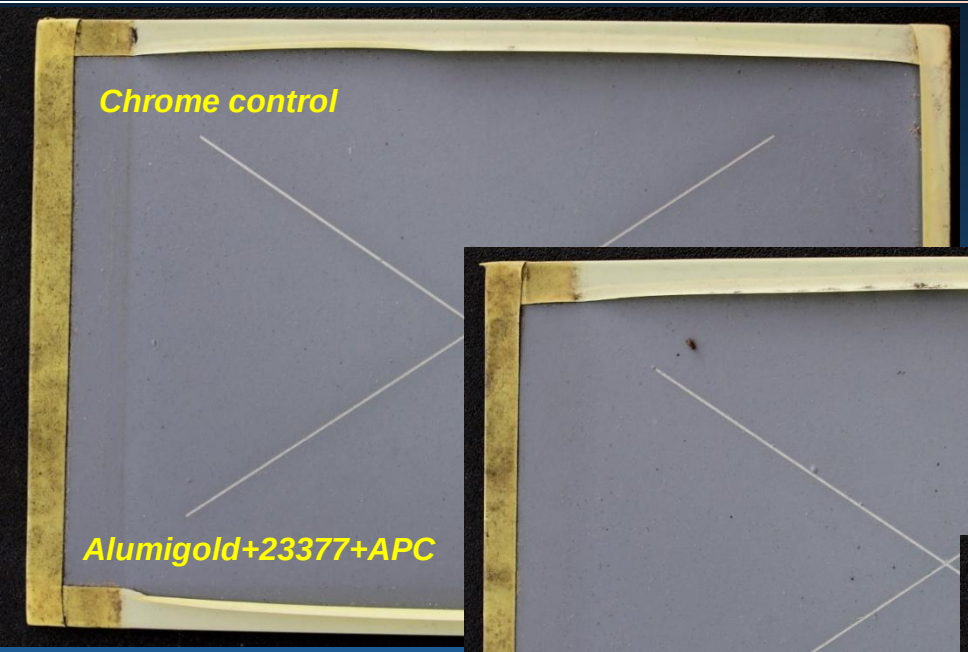
Reduced Chrome Systems

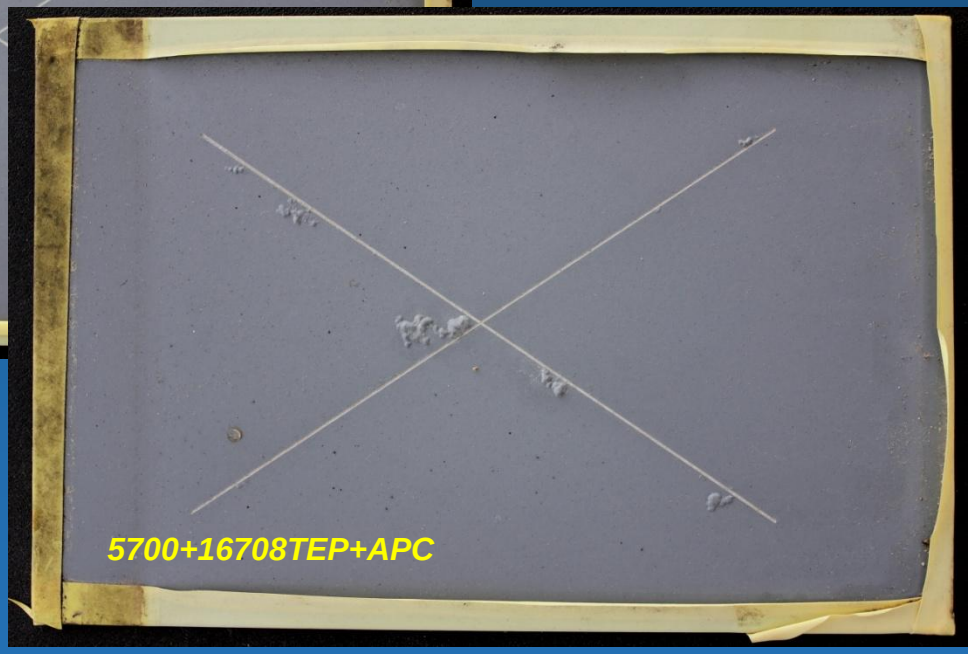


24 Month Inspection

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

NCP Beach Exposure





No Chrome Systems

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**

	SCRIBE		
PRIMER	**PITS**	**OXIDATION**	**BLISTERS**
Control			
44GN098			
MgRP	s		
02GN084			
16708TEP			

s - superficial

none

few

several

Qualification of Non-Chrome Primers for C-130J

C-130 NCP Flight Test Summary

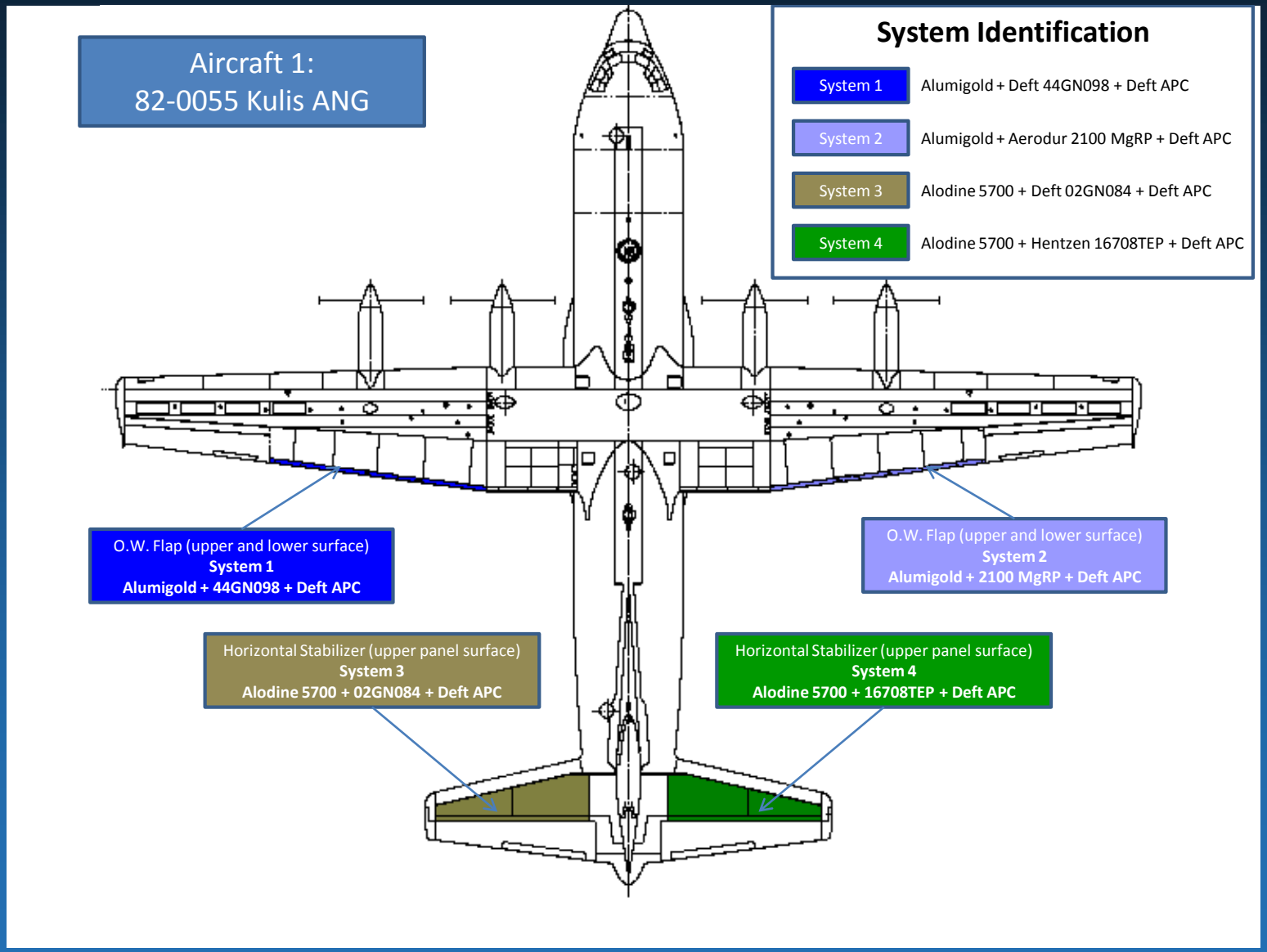
- **Planned 36-Month Duration (1/2 PDM Cycle). Inspections performed every 6 months beginning at 3 months after their return to home station following Depot. Expected completion January, 2013.**

- **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)*

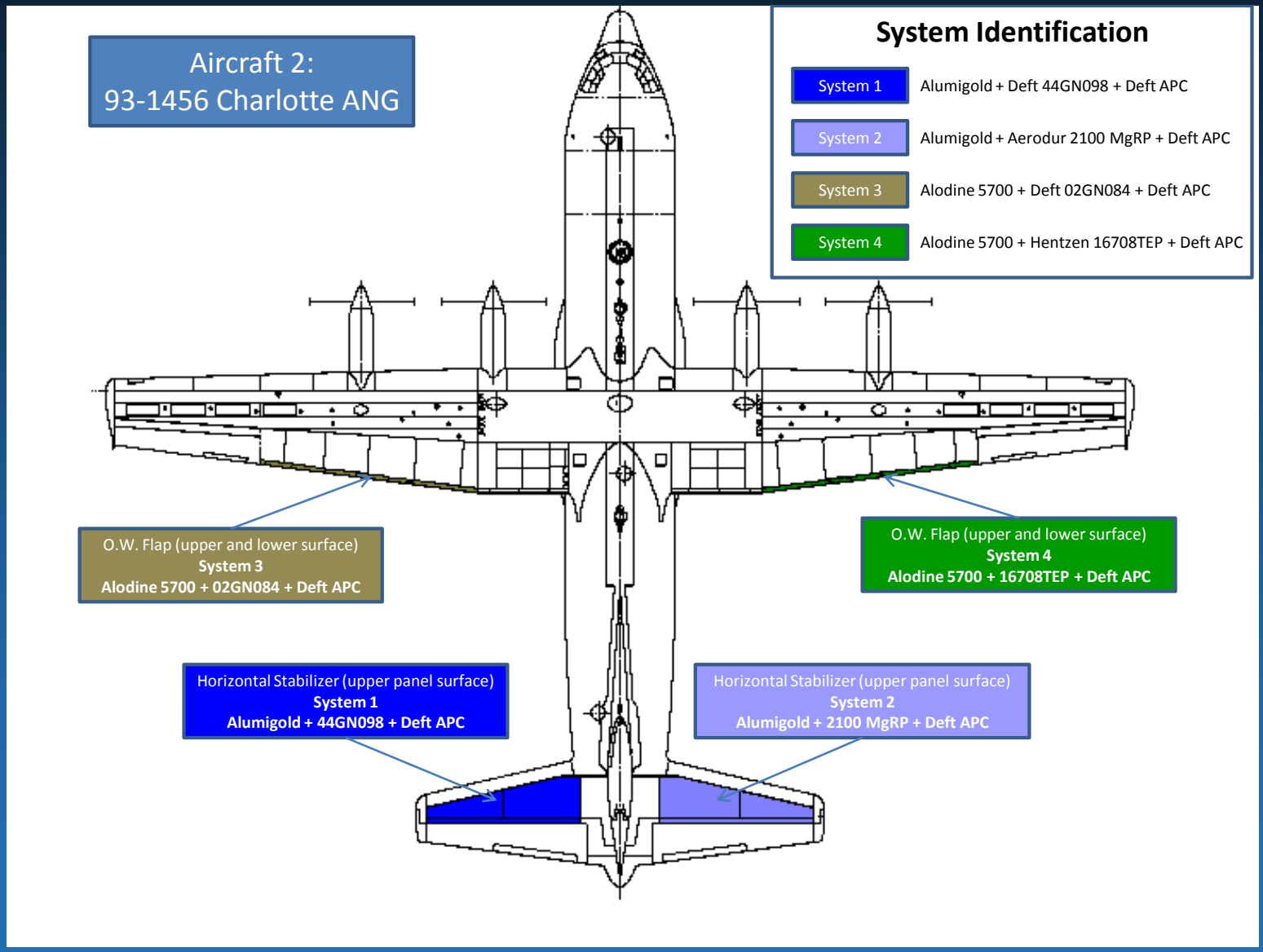
- **C-130 Aircraft**
  - *82-0055 Kulis ANG*
  - *93-1456 Charlotte ANG*

- **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*

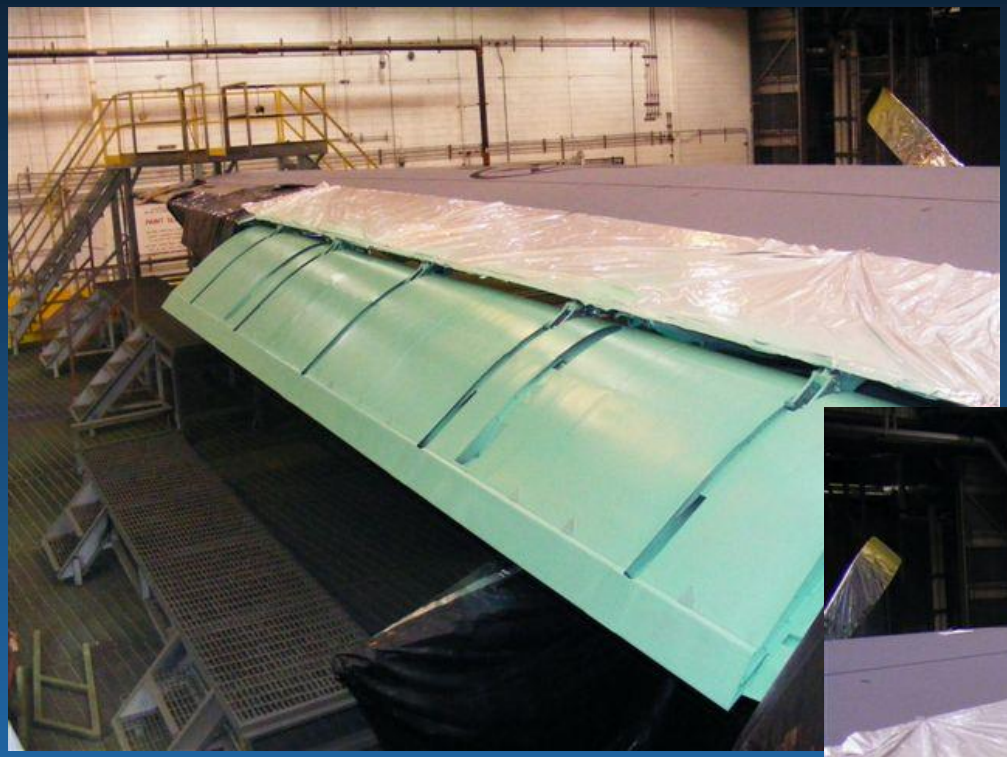
NCP Flight Test



NCP Flight Test



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?