



Advanced Multifunctional Coating

presented at

2011 Air Force Corrosion Conference

by

John DeAntoni

Boeing Research & Technology

314-232-2198

john.r.deantoni@boeing.com

17 August 2011

Overview

- **97GY156 Development**
- **97GY160 Development & Test Results**
- **C-17 Field Visits**
- **AMC Field Evaluation**
- **Next Steps**



97GY156 Development

C-17 POLLUTION PREVENTION

Boeing in 2004-2008 participated in the development of an improved self-priming topcoat (SPTC) with Deft Coatings

- Program goals were to improve adhesion, corrosion resistance and UV durability of then current chrome free TT-P-2756 SPTC
- Leverage APC technology into SPTC
 - Coating uses same fluoropolyurethane technology as APC currently used on C-17
- Leverage recent advances in chrome free corrosion inhibitor technology
 - State of the art chrome free corrosion inhibitor eliminates need for a primer



Development of AMC for C-17

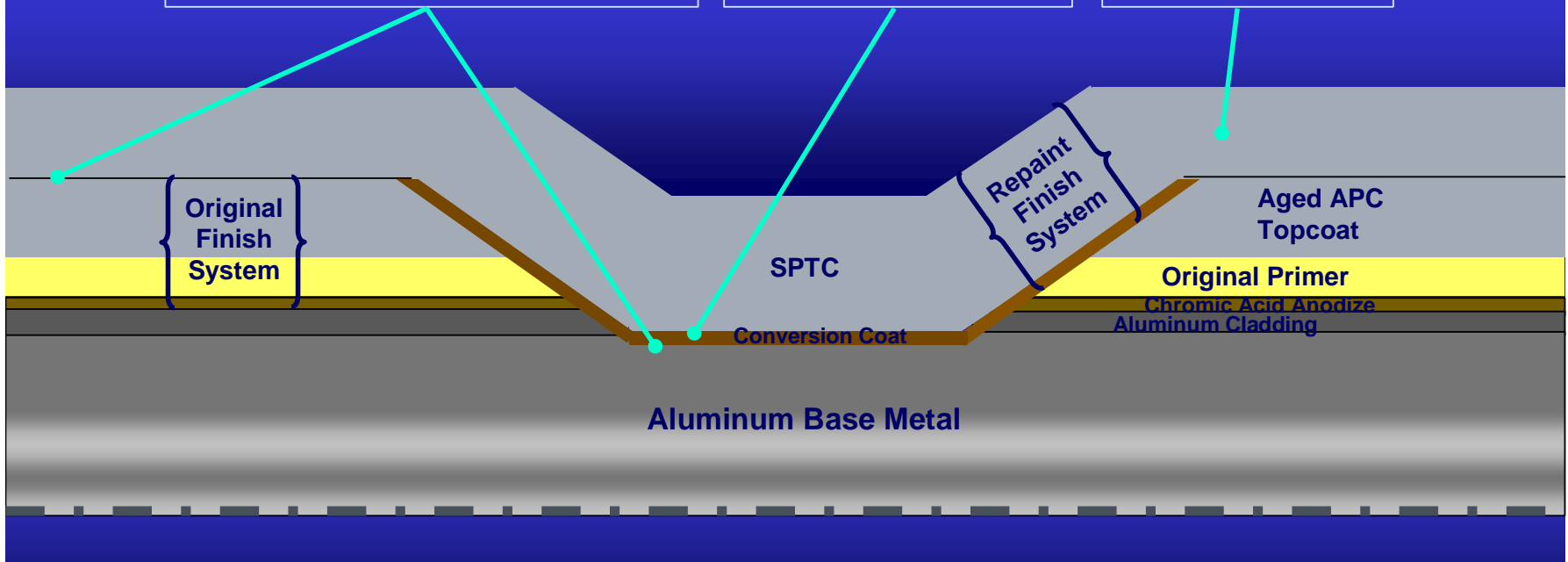
C-17 POLLUTION PREVENTION

- Final product developed was **97GY156**
- Coating good candidate for C-17 touch-up
- Leveraging 97GY156 technology, Deft reformulated to C-17 color standard; named product 97GY160, Advanced Multifunctional Coating (AMC)
- No major changes between the two coatings
 - Changes in color pigments only

Touch-up Process

SPTC Application Using TO Optimal Refinish Process

1. Bring entire aged surface to water-break-free condition with abrasive & clean water
2. Deox & conversion coat exposed metal
3. Apply SPTC topcoat to refinish area





97GY160 Test Results

C-17 POLLUTION PREVENTION

Three laboratory batches of 97GY160 tested

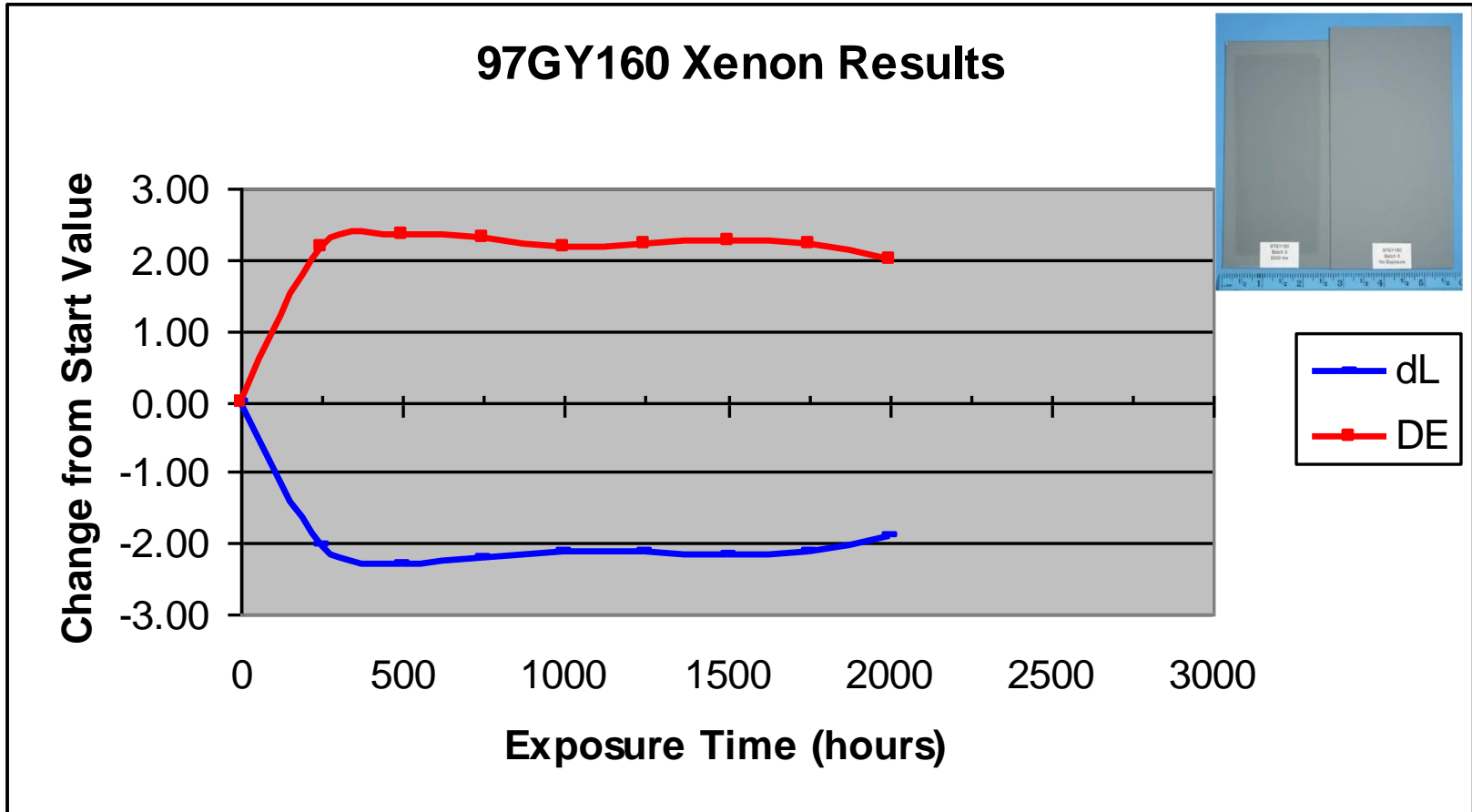
- Batch 1 – DoM* Jan 2007
 - Corrosion screening tests only
- Batch 2 – DoM* Feb 2008
 - Key qualification tests
- Batch 3 – DoM* Mar 2009
 - Selected tests. This batch, color matched to current APC topcoat, was evaluated to gain more data on rain erosion performance, color change on weathering, & viscosity.
- Matched or exceeded current system/requirements on all tests except color change in accelerated weathering

* DoM signifies date of manufacture

97GY160 Test Results

Weather-O-meter® Exposure of 97GY160 Lab Batch #3

Graph shows curves for both delta E (total color change) & delta L (change in lightness / darkness). (Negative delta L = darker.)





97GY160 Test Results

C-17 POLLUTION PREVENTION

**2000-Hour Salt Spray – 2024 T-3 Bare, Alodine 1200
97GY160 Lab Batch # 2 vs. Current Coating System**

Chromate Primer + APC Topcoat



97GY160 AMC





97GY160 Test Results

C-17 POLLUTION PREVENTION

**2000-Hour Filiform – 2024 T-3 Clad, Alodine 1200
97GY160 Lab Batch # 2 vs. Current Coating System**

Chromate Primer + APC Topcoat



97GY160 AMC





97GY160 Test Results

C-17 POLLUTION PREVENTION

**2000-Hour Filiform – 7075 T-6 Clad, Alodine 1200
97GY160 Lab Batch # 2 vs. Current Coating System**

Chromate Primer + APC Topcoat



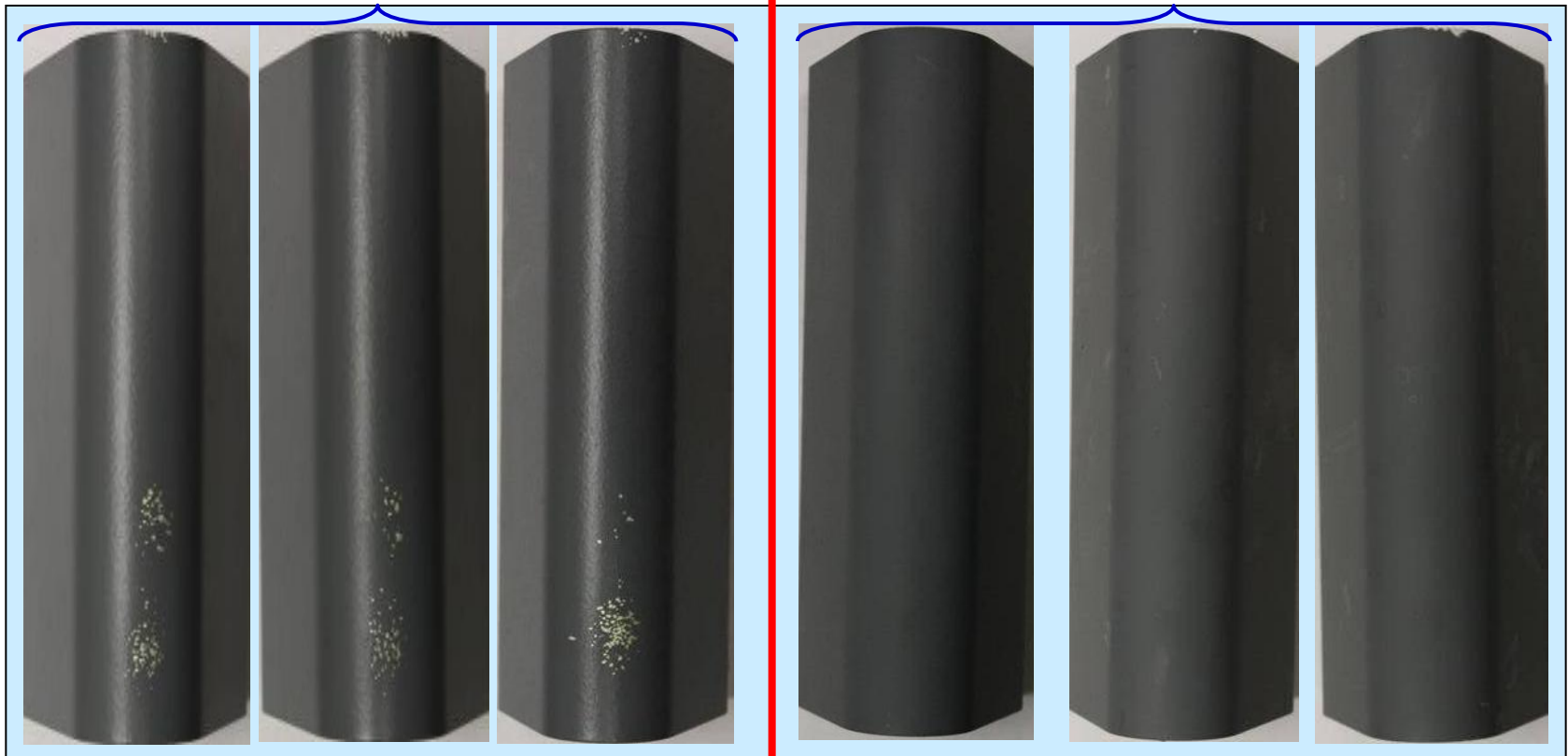
97GY160 AMC



Rain Erosion Testing

Spray OEM system - after 45 minutes

Spray AMC – after 120 minutes



3.1 mil average total DFT* for 3 foils

3.8 mil average DFT for 3 foils

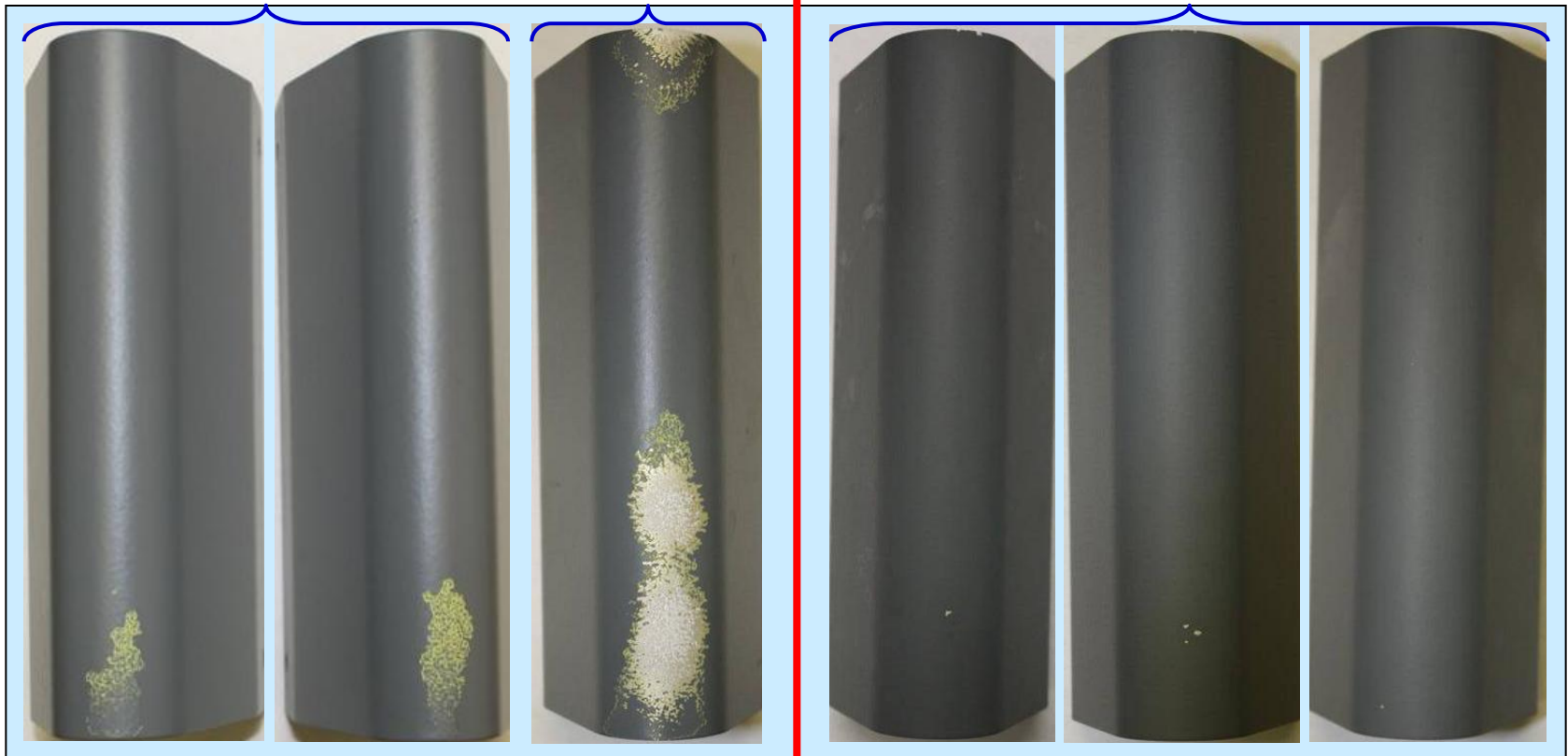
**DFT signifies dry film thickness*

Rain erosion evaluated due to issues associated with OEM system

Rain Erosion Testing

Repaint OEM syst. over aged OEM syst.
after 30 min after 120 min

Repaint AMC over aged OEM syst. after
120 min

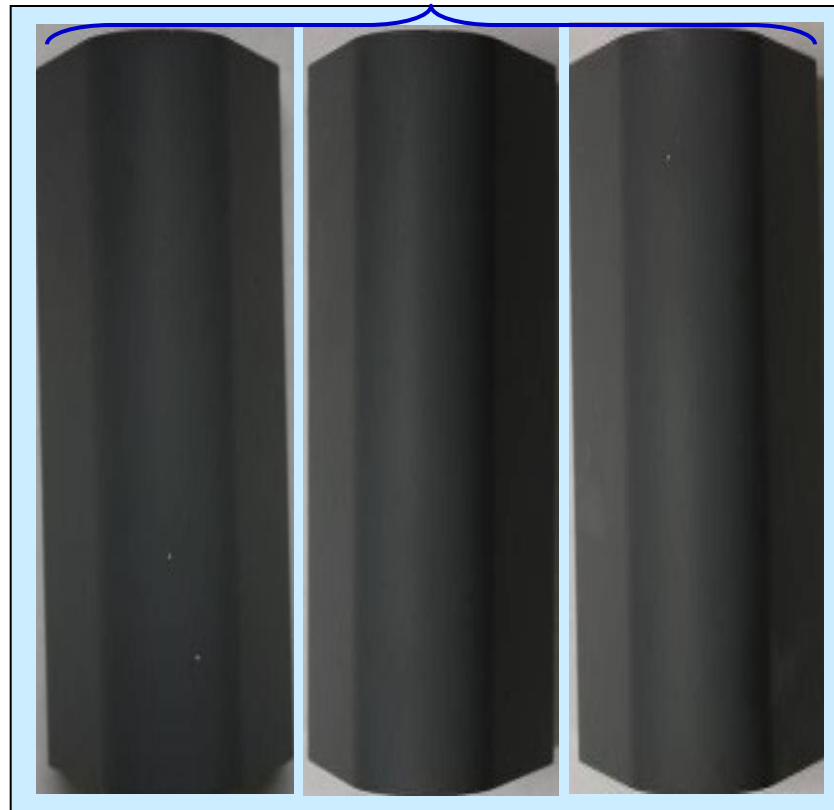


6.7 mil total average DFT for 3 foils

4.7 mil average DFT for 3 foils

Rain Erosion Testing

Repaint ~ 2 mil AMC over ~ 2 mil aged AMC after 120 min





AMC Potential Benefits

C-17 POLLUTION PREVENTION

- **Environmental & Safety**
 - Reduced worker exposure to chrome, (97GY160 is chrome-free)
 - Reduced hazardous waste
 - No need for primer; therefore VOCs of primer are eliminated
 - Lower VOCs than C-17 advanced performance coating (APC)
- **Appearance & Durability**
 - Deft 97GY160 has demonstrated better rain erosion resistance vs. current primer / topcoat in whirling arm testing
- **Experience with Similar Coating**
 - Fluoropolyurethane resin base same as in current APC used on C-17 exterior; same supplier
- **Labor & Flow Time Reduction**
 - No primer application & equipment cleaning, no primer dry time
 - Reduced masking
- **Weight Saving**
 - Aircraft accrues less weight due to elimination of primer
- **Multiple benefits even if rain erosion is not improved**



Field Visits

C-17 POLLUTION PREVENTION

- Purpose of field visits was to gather data on C-17 leading edge paint failures and flight hours
- Inspected P-180 through P-189
 - Correlate flight hours to amount of leading edge damage
 - Investigate failure mechanism
 - Eventually predict how AMC would improve rain erosion resistance of C-17 leading edges based on inspections and whirling arm test results



Field Visits

C-17 POLLUTION PREVENTION

Aircraft	Paint Job	Flight hours since last paint	Leading edge condition
P-190	OEM	130	No rain erosion or rivet rash
P-41	strip & repaint	217	No rain erosion, early isolated rivet rash and adhesion loss around access panels
P-45	strip & repaint	291	Moderate rain erosion left and right slat 4 and rivet rash all slats
P-188	OEM	320	Rivet rash all slats
P-190	OEM	730	Isolated slight rain erosion, start of rivet rash
P-187	OEM	603	Rivet rash all slats
P-184	OEM	880	Isolated slight rain erosion, start of rivet rash
P-189	OEM	897	Rivet rash all slats
P-185	OEM	991	Rivet rash all slats
P-98	scuff & overcoat	1057	Moderate rain erosion and isolated rivet rash. Leading edge failure to bare metal
P-188	OEM	1083	Rivet rash all slats. Some continuous vertical erosion along fastener rows/start of erosion
P-183	OEM	1250	Isolated moderate rain erosion, rivet rash all slats
P-182	OEM	1324	Isolated moderate rain erosion, rivet rash all slats
P-180	OEM	1521	Isolated moderate rain erosion, rivet rash all slats
P-181	OEM	1634	Isolated moderate rain erosion, rivet rash all slats
P-38	strip & repaint	1827	Moderate rain erosion and isolated rivet rash all slats
P-36	strip & repaint	2252	Severe rain erosion left hand slats 3 & 4

Leading edge erosion progression





Field Visit Summary

C-17 POLLUTION PREVENTION

- Earliest leading edge failure around rivets after 217 flight hours (strip & repaint)
- Earliest failure across leading edge after 291 flight hours (strip & repaint)
- Based on this data it appears that leading edge erosion is slightly worse with strip and repaint than OEM paint with comparable flight hours
- Initial failure is not typical rivet rash
 - Failure moves out from around fastener
 - Fasteners still have paint on them
 - Non-continuous or thin paint around fastener/hole and seams fails from rain/sand erosion



AMC Field Evaluation

C-17 POLLUTION PREVENTION

- C-17 Division approved AMC field evaluation for McChord, Elmendorf and Hickam AFB's
 - Two aircraft – one wing leading edge slats
 - Six aircraft – all areas requiring repaint
 - 4 mils target thickness for AMC leading edges
 - 2 mils target thickness for AMC all other areas
 - One additional aircraft targeted for Elmendorf AFB



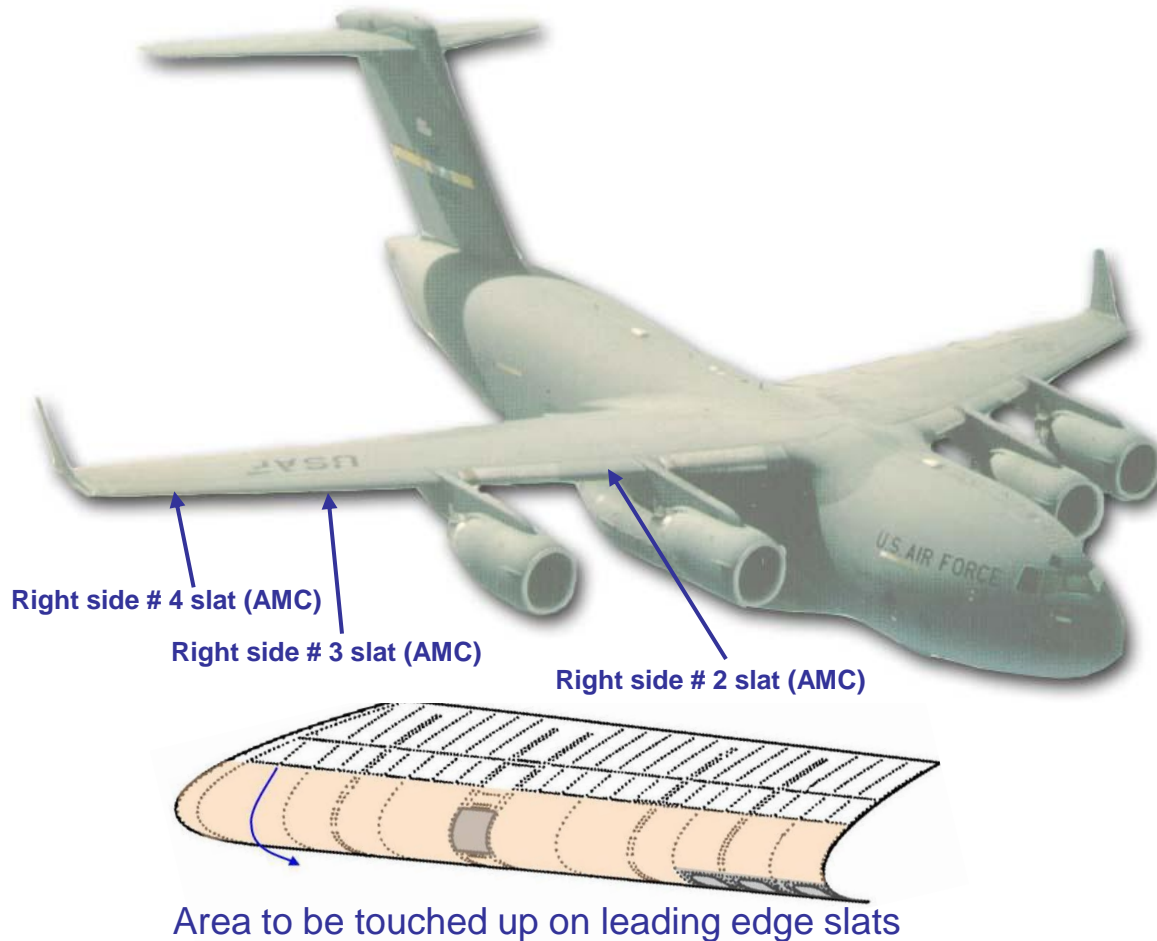
AMC Production Batch Manufacture

C-17 POLLUTION PREVENTION

- Two production batches of AMC manufactured
 - 50 gallon production batch manufactured on 3/23/2010
 - 20 gallon production batch on 3/15/2011
 - Test results similar to three lab batches

AMC Field Touch-Up Evaluation

C-17 Wing Leading Edge Slats, Right side with AMC



First AMC Aircraft

- P-87 (tail no. 10187) right wing leading edge slats painted with AMC on April 28, 2010 at McChord AFB
 - Ranie Feiock, Corrosion Control Program Manager and TSgt Anthony Nowak, Assistant Corrosion Control Program Manager were main POC's
 - P-87 aircraft was identified as CAT III ranking, indicating a paint condition that may include sectionalized painting of wing leading edges, nacelles and flaps
 - P-87 had a scuff and overcoat on November 2007

P-87 After Sanding



Test wing right side slats 2, 3 and 4 after sanding with 120 and 220 grit sand paper

P-87 Alodine Process

- Process per Henkel Surface Technologies Process Bulletin No. 234113
 - Deoxidine 605 scrub for 1-3 minutes
 - Water rinse
 - Alodine 1201 for 1-5 minutes
 - Water rinse
 - Dry



Alodine kit



Deoxidine scrub

P-87 Alodine Process



Test slats after alodine process

P-87 Paint Process



Test slat after masking



TSgt Nowak applying AMC



Good color match of AMC with wing



AMC next to soot covered wing



Note: Front main landing gear door to be protected from liquid oxygen system via Charleston AFB suggestion



P-87 Inspections

C-17 POLLUTION PREVENTION

- **AFTO-95 document (aircraft historical record) updated to include that the leading edges are inspected at approximately every 500 flight hours**
- **500 hour inspection was also entered into the aircraft plans & scheduling system**

Other Test Aircraft

- P-86 (tail no. 10186) painted with AMC on May 25, 2010 at McChord AFB
 - Identical process as that used on P-87
- P-17, (tail no. 930601) painted on July 25, 2010 & P-10, (tail no. 00535) painted September 27, 2010 had all areas painted with AMC at McChord AFB
- P-68, (tail no. 990168) painted November 15, 2010 & P-67, (tail no. 990167) painted March 3, 2011 had all areas painted with AMC at Elmendorf AFB
- P-151, (tail no. 55151) had all areas painted with AMC at Hickam AFB on March 24, 2011 and P-152 (tail no. 55152) had nose painted with AMC on July 15, 2011





P-87 after 1064 Flight Hours

No discrepancies either wing

C-17 POLLUTION PREVENTION

Left Primer/APC wing



Right AMC wing



Left Primer/APC wing



Right AMC wing



P-86 after 1306 Flight Hours

No discrepancies either wing

Left Primer/APC wing



Right AMC wing



Left Primer/APC wing



Right AMC wing



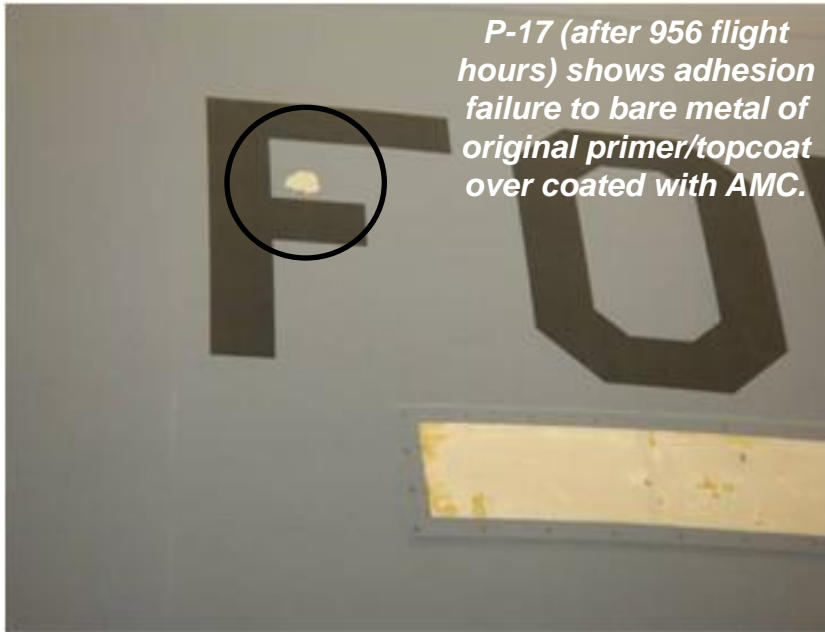


Field Inspection Summary

C-17 POLLUTION PREVENTION

- Eight fielded AMC aircraft
 - Over 5000 flight hours on fielded aircraft
 - Ten inspections
 - AMC performing very well !
 - One minor discrepancy identified
 - » P-17 after 956 flight hours

Discrepancy on P-17 after 956 Flight Hours

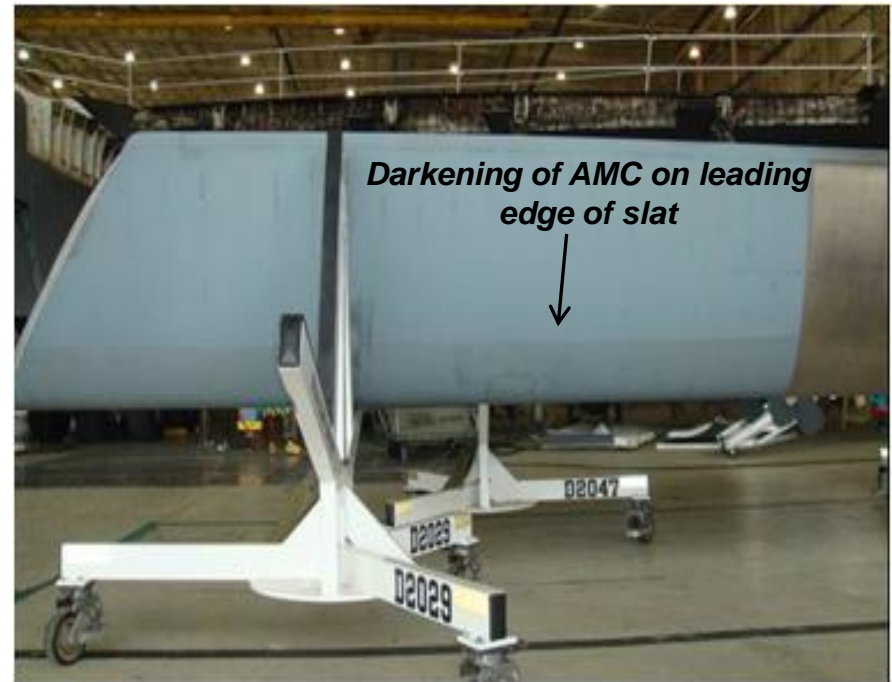


Discrepancy found during inspection at Warner Robins

Color match issues



P113 recently touched-up with APC.

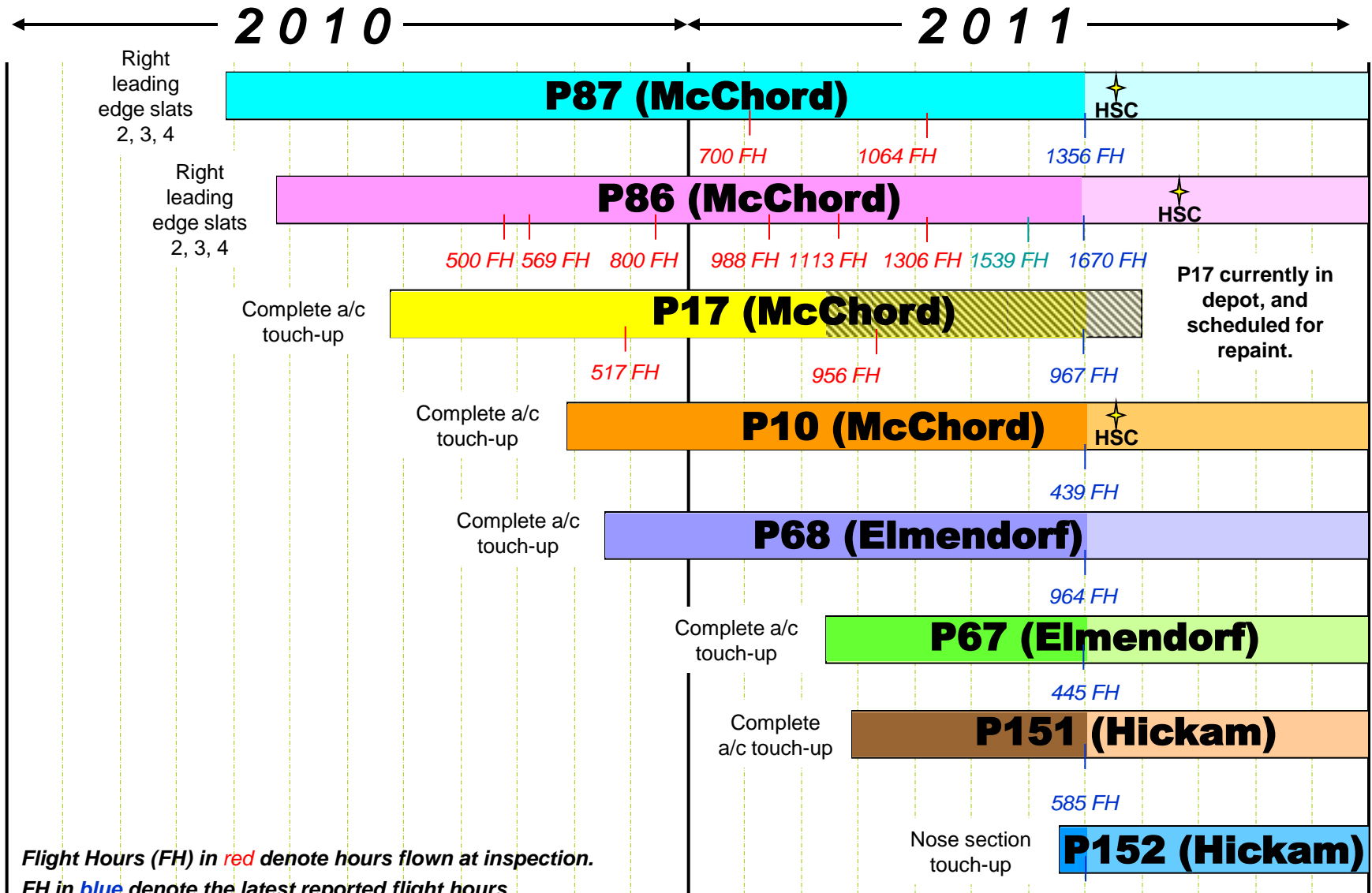


P17 slat after 956 flight hours after leading edge touch-up with AMC.

AMC color match visually no different than routine touch-up areas using APC

C-17's Currently Under Evaluation

C-17 POLLUTION PREVENTION



Flight Hours (FH) in red denote hours flown at inspection.
FH in blue denote the latest reported flight hours.



Future plans

C-17 POLLUTION PREVENTION

- Continue monitoring fielded aircraft
- Touch-up one additional C-17 with AMC
- Coordinate approval process for AMC incorporation into the -23 T.O.
- Evaluate chrome free pretreatments with AMC for a chrome free touch-up system
- Evaluate AMC as a candidate for scuff & overcoats and/or strip & repaints



Acknowledgments

C-17 POLLUTION PREVENTION

Kenneth E. Kessler
C-17 Mission Systems Program Manager,
DAF Mobility Directorate
(937) 656-5340 or DSN 986-5340
Kenneth.Kessler@wpafb.af.mil

Ranie Feiock (McChord AFB)
Steve Johns (Elmendorf AFB)
John Puu (Hickam AFB)



Questions ?