OPERATIONAL TESTING OF NON-CHROME PRIMER FOR EXTERIOR MOLDLINE OF AIR FORCE AIRCRAFT

Final Report
for
Subcontract 030200083

Submitted to:
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1.0 BACKGROUND

In 1996 a JG-PP project was initiated to identify alternatives for chromate paint primer on exterior mold line surfaces of aircraft. The project consisted of a laboratory-testing phase followed by operational testing. The laboratory testing was completed in 1997 without finding a nonchromate primer that was 100% equal to the performance of chromate control primers in all tests. Test results did, however, indicate that some primers were near the performance of chromate control primers. After reviewing the test results the stakeholders decided to proceed with the operational testing phase and selected Akzo Nobel 10PW22-2 for application on two F-15S, four T-45s and one Harpoon missile canister. PRC-DeSoto EWAE118 was selected for application on one AV-8B, and eight F/A-18 aircraft.

Results of operational testing for the original test period of mid 1997 to September 1999 indicated that the test primers were performing comparable to the chromate primers applied elsewhere on the airframe with the exception of isolated adhesion failures on F-15 titanium substrates. However, based on over two years of field testing the stakeholders were not comfortable with declaring success, or failure, and elected to continue the testing for two additional years. In addition to extending the test period, two more F-15s, two C-17s and one C-130 was added to the operational test matrix.

The purpose of this project was to continue evaluation of some of the early test aircraft noted above and initiate additional testing. During this project the primer evaluation on the first two F-15 test aircraft was completed with the pre and post stripping evaluations performed after six years of operational monitoring. The two additional F-15 aircraft that were painted in 2000 were also inspected during this project. Operational testing of nonchrome primer on KC-135 aircraft was initiated in December 2002 with the fielding of an aircraft with PRC-DeSoto EWAE118 nonchrome primer. This test aircraft paint process is discussed along with inspection results from two inspections during this project period. Inspections were also performed on both C-17 test aircraft. Aircraft 93-0602 and 95-0107 were each inspected during this contract period and inspection results are noted.

In addition to nonchrome primer testing extensive operational testing has also been performed on multiple weapon systems with PreKote,™ a nonchrome surface treatment and other chrome free surface treatments. The KC-135 was recognized as an ideal test platform for nonchrome primer and nonchrome surface treatments due to its age and service environments. A test to evaluate Pantheon Chemical, PreKote™ nonchrome surface treatment on a KC-135 aircraft was initiated with the application of PreKote™ on a test aircraft in October 2003. (Ref. KC-135 Chromate-Free Surface Pretreatment Operation and Evaluation Demonstration Plan, Dated 19 September 2003)

2.0 KC-135 AIRCRAFT 60-0318 WITH NONCHROME SURFACE TREATMENT

BACKGROUND

Extensive operational testing has been performed on multiple weapon systems with PreKote™ and other chrome free surface treatments. The KC-135 is one of the older and more corrosion prone aircraft in the Air Force inventory and nonchrome surface treatments have not been evaluated on this platform. This test is intended to evaluate Pantheon Chemical, PreKote™ nonchrome surface treatment on the right hand side of aircraft 60-0318 for a minimum of 18 months. (Ref. KC-135 Chromate-Free Surface Pretreatment Operation and Evaluation Demonstration Plan, Dated 19 September 2003

2.1 PAINT PROCESS

The aircraft was prepared and painted October 14-17, 2003. Overall the aircraft cleaning for the test and control surfaces were very effective. The use of power scrubbers for detergent cleaning and brightener agitation on the control side provided a clean and chemically active surface for the chromate conversion coating. Conversion coating resulted in a typical amber color change that was not uniform over the surface. Conversion coating color on the control side was also diminished from the repeated rinsing during processing of the test side.

The first application of the PreKote™ was applied with power scrubbers similar to the Alkaline cleaner process on the control side. Time required for the two processes were similar and cleaning effectiveness is likely similar but not quantifiably measured. Power scrubbers are very effective in removing contaminates when aided by cleaners. The process plan required the second application, to be agitated with pole scrubbers and allowed to dry in place. This step proved to be the most difficult to accomplish, as envisioned, due in part to having only two spray applicators and lack of experience with applying solutions intended to dry in place. Sections of the aircraft were completed out of sequence resulting in unintended rinsing of sections that should not have been rinsed.

Primer and topcoat thickness was greater than required on the fuselage and wings surfaces. Primer thickness ranged 0.90-1.91 mils and averaged 1.46 mils. Topcoat ranged 1.73-4.99 mils and averaged 2.72 mils. Base line color and gloss readings were also recorded at the same locations where film thickness was measured.

Additional details are contained in the report titled “Application Process Documentation for KC-135 Aircraft 60-0318” submitted November 2003.

2.2 FEBRUARY 2004 INSPECTION RESULTS

The aircraft had logged only 24.1 hours since painted at the Depot four months earlier and this inspection revealed only minor paint defects. Chipped paint, red rust on some fastener heads and mechanical damage was similar on the test and control sides with no indication of performance differences.

3.0 KC-135 - AIRCRAFT 59-1472 WITH NONCHROME PRIMER

BACKGROUND

Operational testing of nonchrome primer has been performed on multiple weapon systems for several years with positive results. The KC-135 was considered to be a more significant performance challenge for nonchrome primer due to its age and operating environment than some of the other test vehicles. The purpose of this test is to evaluate PRC DeSoto, EWAE118 nonchrome primer on the right hand side of aircraft 59-1472 for a minimum of 24 months. (Ref. KC-135 Non-Chromate Primer Operational Test and Evaluation Test Plan Dated 24 April 2002). Due to the end of this contract the final inspection was performed 14 months into the evaluation period.

3.1 PAINT PROCESS

For additional details of the paint process Ref: **"**Paint Process Documentation For KC-135 Aircraft 59-1472 December 3-7, 2002"
Aircraft preparation for paint was very effective. The use of power scrubbers for detergent cleaning and brightener agitation provided a clean and chemically active surface for the conversion coating. Conversion coating provided an amber color but not a dark golden color as expected.

The painters applying the primer were not familiar with spraying waterborne coatings and they had some difficulty applying the primer at the desired thickness without runs and sags. The Type II primer is also dark green by design and requires additional experience with the product to obtain consistently uniform film thickness in the absence of excellent lighting.

An area for concern was the propensity for the primer to run which resulted in dry film thickness less than desired on vertical surfaces. This was also an issue with this primer when sprayed on a C-17 aircraft in 2001 with the same type of spray equipment. Previous applications of EWAE118 primer with High Volume Low Pressure spray equipment have not exhibited this problem.

Topcoat thickness on the right hand wing was also an area for concern. Topcoat thickness measured on the right hand upper wing was as low as 1.30 mils with an average of 1.55 mils. Testing has shown that the Advanced Performance Topcoat UV degradation performance is reduced when the thickness is less than 1.7 mils.

3.2 JULY 2003 INSPECTION RESULTS

With few exceptions the exterior surfaces were as expected after six months exposure and 138 flight hours. Except for minor corrosion initiating around a drain hole and around isolated fasteners on the inboard lower wings the defects were typical for six months. Most defects were chipped paint around fasteners and small areas of chipped paint, likely resulting from debris in the paint that has been removed by foot traffic on the upper wings.

Color and gloss readings were taken at the same locations where readings were recorded prior to leaving the Depot. Gloss readings ranged from 1.6 to 3.2 with slightly higher gloss on the fuselage than the wing. There were negligible differences between the gloss on the test versus the control sides. Color readings ranged from a Delta E of 0.91 to 1.08, which are higher than anticipated for 6 months of service. The higher readings may be due to the use of different color equipment used for the initial readings and the test readings. Analysis of the data factoring in the potential differences due to equipment, results in a Delta E range of 0.32 to 0.48. Color readings at the next inspection will be recorded with both colorimeters to better understand the impact of using different equipment.

Overall there were no significant differences between the type and quantity of defects between the test and control sides of the aircraft. Most of the defects were on the wings and were not unexpected due to foot traffic and erosion generated chipping of paint adjacent to fasteners.

3.3 FEBRUARY 2004 INSPECTION RESULTS

The aircraft had logged 357.1 flight hours since it was painted in December 2002. Defects noted during the inspection were minor but there had been multiple repairs made to the coating. The aircraft was located in the fuel hanger during the inspection and base personnel had recently inspected and performed multiple coating repairs. Minor coating defects that had not been repaired were typical for a one year inspection. Most defects were chipped paint on fastener heads and around fasteners.

Color and gloss readings were taken at the same locations where readings were recorded prior to leaving the Depot. Gloss readings ranged from 1.2 to 2.7 which was a slight reduction from the 1.2 to 3.2 range measured at the previous inspection. There were negligible differences between the gloss on the test versus the control side. Color readings ranged from a Delta E of 0.65 to 0.87, which were lower than at the six-month inspection. The difference in readings is likely due the use of different color equipment used for the initial readings and the readings at the last inspection. The fuselage had higher Delta E measurements than the wing which was not expected since the wing is exposed to more direct sun exposure. The average Delta E reading for all locations on the test side was 0.78 which was the same as for the control side.

There was significantly more touch-up paint on the test side compared to the control side of the aircraft. Based on discussion with maintenance personnel the touch-up was applied after repairing corrosion but the severity of corrosion was not well defined. Visual inspection of touch-up areas did not reveal significant corrosion repair, (evidence of sanding to feather the coating) and the team agreed that the next inspection should be performed prior to maintenance to better assess corrosion damage severity.

4.0 F-15 AIRCRAFT 81-024

BACKGROUND

Operational testing of nonchrome primer began on F-15, 81-024 when it was painted in June 1997. The aircraft had been previously stripped to bare metal with Type V plastic media followed by hand sanding as needed. The test areas consisted of the upper and lower surfaces of the right hand wing with a chromate control primer on the left hand wing. Test surfaces were primed with Akzo Nobel 10PW22-2/ECW-119 nonchrome primer and the remainder of the aircraft was primed with MIL-PRF-23377 chromate primer.

In March of 1999 aircraft 81-024 was completely over-coated including the fuselage. The original test primer was used on the on the right hand wing test surfaces. Later in 1999 the left hand wing was replaced eliminating a direct comparison surface. The entire aircraft was repainted again in October 2000 using a nonchrome tie-coat but the repaint was not due to adhesion failures of the test coating.

During the previous six years this aircraft has been assigned to AETC at Tyndall Air Force Base in Panama City, FL.

4.1 JUNE 2003 INSPECTION DETAILS

The pre-strip inspection was performed on 19 June by:
Steve Finley, HQ AFMC/LGP-EV and
Larry Triplett, Boeing, Integrated Defense System
The post strip inspection was performed on 23 June by:
Larry Triplett, Boeing, Integrated Defense System and
John Stephens, F-15 Engineering, Warner Robins AFB

The aircraft had a total of 3,815.2 flight hours when painted and 4,917.0 flight hours at this inspection. Flight time during the six-year test period was 1,101.8 hours.

4.2 PRE-STRIP INSPECTION RESULTS

The left-hand wing, painted with chromate primer in 1997, was replaced in 1999. Inspections of the replacement wing were not performed and only results for the right-hand test wing are reported.

The purpose of the pre-strip inspection was to assess corrosion and adhesion performance that was visually evident through the coating. There were small areas where the substrate was exposed on the upper and lower surfaces but no significant adhesion failures. Two suspect corrosion areas were noted on the upper aft box at mechanical damage locations. White residue at the two sites may be residue from the corrosion inhibitors in the primer and discoloration will be evaluated after de-paint.

The aircraft was over coated two times after the original test primer application in 1997. Each of the overcoats utilized nonchrome tie coat and paint chips viewed with 10X magnification confirmed the repaints.

4.3 POST-STRIP INSPECTION RESULTS

Upper Wing

An inspection was performed after stripping to determine if corrosion was present that was not visible through the coating. Suspect locations at mechanical damage areas, on the upper aft wing box noted in the pre-strip inspection results contained no corrosion products or metal discoloration after stripping. Multiple areas of mechanical damage were inspected with 10X magnification but no corrosion was found. The only evidence of corrosion noted on the upper wing surface was metal discoloration on the outboard wing tip just inboard of the navigation light. Examination of the area with 10X magnification revealed no measurable pits.

Lower Wing

As with the upper surface no corrosion pits were found on the lower wing surfaces. Substrate discoloration was noted on the outboard wing tip and inboard of the wing tip. Total surface area of the discolored substrate was approximately four square inches. There were no pits or corrosion residue present at the sites.

4.4 AIRCRAFT 81-024 SUMMARY

There were only minor adhesion defects noted prior to stripping and defects found on the test wing were not unexpected or uncommon. Similar defects were readily noticeable on other areas of the aircraft. The largest location was less than three square inches and most sites initiated either adjacent to fasteners or at the edge of a skin or panel.

Corrosion was not found during any of the previous inspections during the past six years on this aircraft and no paint adhesion failures have been noted due to corrosion. The two small areas of substrate discoloration noted above represents the initial stages of corrosion but no pitting was present. It is possible that the

discoloration was present prior to the initial painting but not likely since it was not noted in the pre-paint inspection in 1997. An examination of the lower wing tip on the left-hand wing revealed similar discoloration.

After six years the nonchromate primer has performed well on this F-15 and equal to the chromate primer on this aircraft.

5.0 F-15 AIRCRAFT 79-011

BACKGROUND

Operational testing of nonchrome primer began on F-15, 79-011 when it was painted in August 1997. The aircraft had been previously stripped to bare metal with Type V plastic media followed by light hand sanding where needed to remove paint residue. The primer test areas were the upper and lower surfaces of the right hand wing and a chromate control primer was applied on the left hand wing. Test surfaces were primed with Akzo Nobel 10PW22-2/ECW-119 nonchrome primer and the remainder of the aircraft was primed with MIL-PRF-23377 chromate primer.

Within eighteen months after painting at the depot, aircraft 79-011 developed significant adhesion failures on the lower surface of the right hand wing coated with the test primer. Most of the adhesion failures were over titanium substrates. The peeling paint was repaired in April 1999, by removing all poorly adhering paint and primer from the lower wing surface with plastic scrapers. Most of the coating was removed from the titanium skins and some surfaces of the aluminum skins. After coating removal the edges were feathered by sanding and surface preparation of the titanium was performed as specified in T.O. 1-1-8. The entire lower surface and leading edge of the wing were re-primed with the original Akzo Nobel test primer. In July 2001 the entire aircraft was scuff sanded and over coated using a nonchrome tie-coat primer specified in T.O. 1-1-8. The tie-coat primer was not the Akzo Nobel test primer but the test surface remained nonchrome preserving the test. At the last inspection prior to stripping, approximately 4.5 years after the initial coating repair, there were no adhesion failures on the repaired surfaces.

During the previous six years this aircraft was assigned to AETC at Tyndall Air Force Base in Panama City, FL.

5.1 AUGUST 2003 INSPECTION DETAILS

The purpose of the pre-strip inspection was to assess corrosion and adhesion performance that was visually evident through the coating. The following text documents the pre-strip and post-strip field evaluation inspection results. The pre-strip inspection was performed on 15 August at the strip facility by:
Steve Finley, HQ AFMC/LGP-EV and
Larry Triplett, Boeing, Integrated Defense System

The post strip inspection was performed in the wing shop on 22 August after the wings were removed from the aircraft by:
Larry Triplett, Boeing, Integrated Defense System

The aircraft had a total of 4,649.3 flight hours when painted and 6,257.5 hours when it returned to the depot. Flight time during the six-year operational test period was 1,608.2 hours.

The aircraft was over coated two times after the original application in 1997 with portions of the lower outboard right hand wing receiving three over coats as noted in higher film thickness. As previously noted each of the overcoats utilized nonchrome tie coat and paint chips removed from the aircraft and viewed with 10X magnification confirms the repaints were nonchrome primer.

5.2 PRE-STRIP INSPECTION RESULTS

There were numerous small areas where the substrate was exposed on the upper and lower surfaces but there were no systemic adhesion failures of the test or control primers. Some of the areas where the substrate was exposed were initiated by mechanical damage, identified by damage to the substrate.

Two suspect corrosion areas were noted on the upper surface of the test wing, one on the aileron actuator cover and one adjacent to the formation light on the wing tip. White residue was noted at the two sites that may be residue from the corrosion inhibitors in the primer and/or from the substrate. The sites were evaluated after stripping for discoloration of the substrate and pitting.

5.3 POST-STRIP INSPECTION RESULTS

Upper Wing
An inspection was performed after stripping to determine if corrosion was present that was not visible through the coating. The wings were located in tooling fixtures and only portions of the lower wing were accessible for a full visual inspection. All of the upper surfaces were accessible and the wing tips had been removed. Two suspect corrosion areas, one on the wing tip and one on the aileron actuator cover of the right hand wing were visually inspected with 10X magnification. Discoloration of the metal was still evident after stripping but no pitting was present. Part of the wing tip defect area was masked during stripping preventing a complete removal of the coating but no pitting was evident.

Lower Wing
There was no substrate discoloration or evidence of corrosion found on the lower surfaces of either wing. As was noted earlier much of the center section of wing

was not accessible due to the wing tooling but most of the center section is titanium, which eliminates the concern for corrosion.

5.4 AIRCRAFT 79-011 SUMMARY

There were only minor adhesion defects noted prior to stripping. There were more on the upper surface of the left wing than on the right-hand test wing but all of the adhesion defects were neither unexpected nor uncommon. The largest location was less than three square inches and most sites initiated either adjacent to fasteners or at the edge of a skin or panel. There have been no systemic adhesion failures on the titanium or aluminum skins on the lower right-hand test wing after the repair in early 1999.

Two corrosion sites were noted on this aircraft on the upper surface of the test wing, one on the aileron actuator cover and one on the outboard wing tip. A corrosion site was noted on the aileron actuator panel at a previous inspection in June 2000. The site noted in 2000 was at a different location than the location noted at this inspection and that site could not be identified after stripping. It should be noted that the actuator cover was bright aluminum color after stripping with no indication of chromate conversion coating as was observed on adjacent panels. After stripping the two corrosion sites exhibited substrate discoloration but no pitting.

After six years the nonchromate primer has performed well on this aircraft. The presence of two sites of substrate discoloration of less than 0.5 square inches each does not indicate that the nonchromate primer is inferior to the chromate primer.

6.0 F-15 Aircraft 83-031 and 82-032

BACKGROUND

In September 1999 the F-15 program chose to field two additional aircraft and expanded the test surface area on each aircraft beyond the one wing on the previous test vehicles. Both of the test aircraft were painted in February 2000 at Warner Robins Air Logistics Center. Akzo Nobel, 10PW22-2-nonchrome primer was applied to the right-hand half of aircraft 83-031 and PRC-DeSoto, EWAE118 test primer was applied to the right-hand half of 82-032. Both 83-031 and 82-032 were primed with the test primer from the aircraft centerline outboard. The remainder of each aircraft was primed with chromate MIL-PRF-23377 primer and top-coated with MIL-PRF-85285 topcoat. Pre treatment of aluminum surfaces prior to priming was chromate conversion coating, Mil-C-81760.

6.1 AIRCRAFT 83-031 – February 2004 Inspection Results

This aircraft was painted at the depot in February 2000. The forward fuselage and vertical stabilizers was scuff sanded and repainted in January 2001 with nonchrome tie coat primer. 959.3 flight hours have been logged since it was painted at the depot and 322.4 hours since the last inspection January 2003.

There were paint adhesion related defects but no corrosion was found during the inspection. There were considerably more areas of peeling paint and larger surfaces of aluminum substrate exposed on the upper surface of the left hand wing (control area) than on the right-hand wing (test area). Except for the adhesion failures on the upper wing, all defects were minor with numerous bare fasteners relatively equal in quantity and severity on both sides of the aircraft. The majority of the bare fasteners were due to fastener removal but several showed no signs of removal initiating the adhesion failures. Most adhesion failures on the test surfaces were small with the majority less than one square inch.

6.2 AIRCRAFT 82-032 – February 2004 Inspection Results

This aircraft was painted in February 2000 at the depot and was scuff sanded and over coated with nonchrome tie coat primer in December 2001. It has logged 1073.5 flight hours since painted and 587.0 hours since the last inspection.

Paint defects were minor consisting of small areas of peeling paint, bare fastener heads and erosion on leading edge surfaces. There was no corrosion noted at this inspection or previous inspections.

6.3 F-15 Summary

There were no indications that the nonchrome test primers are performing noticeably different than the chromate control primer on either aircraft. There was more adhesion failures on the chromate control, upper L/H wing, on aircraft 83-031 but gross adhesion failures were confined to the upper wing and can be attributed to pre-paint preparation.

No corrosion was found any inspections and adhesion defects, except for the upper wing previously mentioned, were minor and relatively equal on the test and control sides of the aircraft.

7.0 C-17 AIRCRAFT 93-0602 BACKGROUND

BACKGROUND

Aircraft #93-0602 was painted at the Boeing Aerospace Support Center (BASC), San Antonio, TX in July 2000 with PRC-DeSoto nonchromate primer. The nonchromate primer test area consists of the upper surface of the right-hand wing, the engine nacelles on the right-hand wing and the emergency crew door on the forward fuselage. The

remainder of the aircraft was primed with the original production chromated primer, Akzo Nobel 10P20-12, and opposite hand surfaces on the left side serve as the control.

Two fuel cell covers on the upper surface of each wing and the emergency crew door were stripped to the substrate to evaluate the primer on bare metal surfaces. All of the painted exterior surfaces of the aircraft were scuff sanded to remove loose and oxidized topcoat prior to moving the aircraft to the paint hangar. Paint around locations where the substrate was exposed, primarily fasteners, was sanded to remove any loose paint and feathered at the edges. After sanding, the aircraft was detergent washed and rinsed with tap water. All of the bare metal surfaces, including the fuel cell test covers and emergency door, were chromate conversion coated with Alodine 1200S and rinsed with tap water.

7.1 JANUARY 2003 INSPECTION DETAILS

The following documents the field evaluation inspection results for the most recent inspection performed on January 22, 2003 at Altus AFB, OK.
The aircraft has a total of 7,486.7 flight hours and it has accumulated 2,154.5 since it was painted in July 2000.

Individuals performing this inspection were:
Steve Finley, HQ AFMC/LGP-EV
Larry Triplett, Boeing Integrated Defense Systems

7.2 INSPECTION RESULTS

Left-Hand Wing Chromate Control
Most defects documented at this inspection were not related to the coating applied for this test. Since this aircraft was over coated with a coat of primer and topcoat specimens of paint chips could easily be inspected to determine the location of failure. In most cases the failure mode was original factory applied primer to substrate or original topcoat to primer.

There were numerous locations of cracked and/or peeling paint that were approximately 0.3 to 0.5” diameter. Many of the sites were noted at the last inspection but additional locations were found at this inspection. Most of the sites initiated as cracked paint that begins to lift after prolonged exposure to moisture. Failure areas were either original factory applied chromate primer to substrate or topcoat to original primer. In all cases the failure was the initial coat of primer for this type of defect. The chromate control primer was identified in multiple paint chips between the two layers of topcoat indicating the adhesion failures to be at the original primer surface.

Other defects included peeling paint along the trailing edges of the wing to flap seals. Some of the failures were at the original factory applied primer and some were at the test primer to substrate.

An adhesion failure noted on the top of inboard flap at the last inspection has been repaired. The size of the defect at the last inspection was approximately three square feet and after the repair peeling has continued exposing the composite substrate. The composite substrate exposed on the top of the #2 engine pylon has not been touched up and has not changed significantly in size since the last inspection.

Peeling paint on the titanium engine supports have increased slightly but the failure mode continues to be the factory-applied primer peeling from the substrate.

Right-Hand Wing With Nonchrome Primer
Defects seen on the upper surface of the right-hand wing were multiple locations of minor chipped and peeling paint.

As seen on the left wing multiple locations of cracked and/or peeling paint, approximately 0.3 to 0.5" diameter, were noted in the same area on the right-hand wing. Many of the sites were noted at the last inspection but additional locations were found at this inspection. Failure mechanisms were the same as on the chromate control wing, either factory applied chromate primer to substrate or topcoat to primer. Again in all cases the failure was at the initial coat of primer. The nonchrome primer applied for the test was identified in multiple paint chips between two layers of topcoat indicating the failure to be at the original primer surface.

Primer to titanium substrate failure up to approximately 2 x 3" was noted on the #4 engine to wing support. The failure mode of the peeling paint areas was the original factory applied primer to substrate. Based on the color, the primer on the engine support was identified as DMS 2144 primer.

There were multiple areas of peeling paint to the substrate along the aft edges of the flap seals as noted at the last inspection. The largest location was approximately 0.8 x 14 inches long. Some of the peeling paint was test primer to substrate and some is original factory applied primer to substrate.

7.3 C-17 Aircraft 93-0602 SUMMARY

Most of the new defects noted at this inspection were additional sites of chipped or peeling paint near the inboard center of each wing. Most of the defect sites were small approximately 0.3 to 0.5" diameter and were associated with the original factory applied primer. Similar defects were observed on the right-hand test side and left-hand control side of the aircraft. All of the paint chips examined from the small defect areas indicated that the failure was not at the interface of the test or control primer applied in July 2000.

Color and gloss readings were not recorded at this inspection due to equipment problems but the visual evaluation of the color did not indicate that there were differences between the test and control sides.

There have been no systemic failures of the coating system during the thirty months since application in July 2000. Some of the peeling on the trailing edge seals was found to be test primer to substrate but the defects are approximately equal on the test and control side. The largest defect area was peeling paint on the composite inboard flap on the left-hand, chromate control side, which grew to approximately four square feet in area when inspected Jan. 2002. Between the 2002 inspection and this inspection the composite flap has been touched up but additional areas continue to peel exposing small areas of composite substrate.

No corrosion has been found on either the chromate control or test side during any of the inspections.

Leading edge surfaces of the wings continue to be in excellent condition for the number of flight hours with only minor erosion and no discernable differences between the control and test sides.

It was previously stated that the cracking and peeling of the coating on the center wing planks of upper wing surfaces may become more problematic as the coating system ages. As expected additional locations have appeared since the last inspection but they are not related to the test coatings.

8.0 C-17 AIRCRAFT 95-0107

BACKGROUND

The right-hand side of the first C-17 test aircraft; 93-0602 (noted above) was painted in July 2000 with EWAE118 nonchrome primer and top-coated with Advanced Performance Coating (APC). Application difficulties with the test primer experienced on that aircraft prompted the program to request that another aircraft be painted to validate the scuff sand and overcoat process with another nonchrome primer.

Aircraft 95-0107 was selected for the second aircraft and was primed with PRC-DeSoto EWDY048 nonchrome primer. EWDY048 is a MIL-PRF-85582 Type I primer that utilizes the same resin system and corrosion inhibitors as EWAE118 Type II primer applied on 93-0602. The primary reason for selecting the Type I primer for the second test was to minimize the poor visibility concerns of the painters when applying the dark color, Type II primer over gray topcoat. Aircraft number 95-0107, was painted at the Boeing Aerospace Support Center (BASC), Kelly USA, TX October 2001

In addition to the nonchrome primer evaluation on the right-hand side of the aircraft, the titanium leading edge slats were also prepared and painted on this aircraft. The nonchrome

EWDY048 primer was applied to the right-hand slats and Mil-PRF-23377 chromate primer was applied to the left-hand slats. Pretreatments were identical on the left and right sides but differed on the inboard and outboard slats. Left and right inboard titanium slats were sanded to remove soil and oxides and checked for a water break surface prior to primer application. Outboard slats were conversion coated after sanding with thixotropic Alodine 1200. A dwell time of approximately 45 minutes was used to provide a golden color on the titanium prior to priming.

The purpose of the test on the titanium slats was to determine if surface preparation differences and the different primers affected adhesion. In addition to adhesion the test was also to evaluate the topcoat/primer system subjected to high temperature exhaust gas during engine thrust reverser operation.

8.1 OCTOBER 2003 INSPECTION DETAILS

The field evaluation inspection results are for the inspection performed on October 02, 2003 at Warner Robins AFB, GA.
The aircraft has a total of 8,357.4 flight hours and it has accumulated 2,803.0 since it was painted in October 2001.

Individuals performing this inspection were:
Steve Finley, HQ AFMC/LGP-EV
Larry Triplett, Boeing Integrated Defense Systems

8.2 INSPECTION RESULTS

Most of the defects noted at this inspection were minor except for erosion on the aluminum slats and heat damage to the coating on the titanium slats noted at the last inspection one year ago. There were minimal differences between the test and control sides with regard to heat damage on the titanium slats.

A large adhesion failure, approximately 84 square inches, occurred on the upper right hand fuselage since the last inspection. The failure occurred on an anodized aluminum skin that had been stripped to the substrate prior to painting at the Depot. Coating adjacent to the bare substrate was also not adhering well and will require removal prior to repair. In addition to this skin that was stripped prior to painting a lower fuselage skin was also stripped at the Depot but to date no adhesion failures have been noted on that skin.

Small areas of chipped or peeling paint, up to five square inches, were noted at multiple locations on the test and control side. There were more numerous defects on the control side than on the test side. (Ref. sketches 7-10 for locations).

Significant erosion was present on the aluminum (outboard) leading edges with most of the leading edge surface exposed down to bare metal. At the last inspection erosion was slightly greater on the control (left-hand) versus the test side but

differences were minimal at this inspection. Paint loss on the inboard slats occurred primarily at the edges of skins or access covers and at fasteners.

8.3 C-17 95-0107 SUMMARY

On the inboard slats most of the erosion initiated at fasteners or access covers and adjacent to skin splices. Severe erosion was present on the aluminum leading edge slats with much of the leading edges bare on the number 4 slats. Erosion was approximately equal on the left-hand (control) and right-hand (test) primed surfaces at this inspection and erosion increased significantly since the last inspection on both sides. Erosion on the titanium slats was much less than on the aluminum except for the heat affected areas.

Most of the upper wing fuel access covers had been removed for maintenance on both wings at the time of the inspection. The large area on the left-hand upper wing that had been repainted at the last inspection was in good condition.

Except for the adhesion failure to the skin on the upper forward fuselage this inspection revealed that the nonchrome primer is performing equal to the chromate primer. No corrosion was found on the test or control sides.

9.0 OVERALL SUMMARY

The F-15 and C-17 aircraft that were evaluated during this project continue to demonstrate that nonchromate primer with a chromate conversion coating surface treatment is effective for corrosion protection and paint adhesion.

Two of the F-15 aircraft have completed six years of operational testing and were inspected prior to, and after stripping at the Depot. The F-15 inspections did not reveal discernable differences in performance between the chromate and nonchromate primers.

Operational testing of nonchrome primer on the KC-135 aircraft after only 14 months has revealed significantly more touch-up paint on the test side compared to the control side of the aircraft. Based on discussion with maintenance personnel the touch-up was applied after repairing corrosion but the severity of corrosion was not well defined nor visually discernable during the inspection. Evaluation of the PreKote nonchrome surface treatment with chromate primer was evaluated after only four months and as expected did not reveal any differences between the test and control areas.

Continued evaluation of the KC-135, C-17 and F-15 test aircraft is recommended to validate long term performance on these platforms.