USE OF MIL-L-87177A AS A CORROSION PREVENTION COMPOUND AND LUBRICANT ON P-3 COMPONENTS

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ABSTRACT

P3 FST-4 is in the process of expanding a very successful prototype application of MIL-L-87177A Type 1 Grade B corrosion preventive compound (CPC)/ lubricant on P-3 aircraft located at Patrol Squadron VP-30, Naval Air Station (NAS) Jacksonville. The information presented will describe potentially large effects on reduced aircraft degradation due to corrosion, reduced maintenance man-hours, and improved readiness.

P3 FST-4 has performed the prototype CPC/lubricant application on P-3 flap tracks, jackscrews and asymmetry detector chains. The prototype was extremely successful and maintenance procedures are currently being updated. Application of MIL-L-87177A to the flap tracks, jackscrews and asymmetry detector chains of the Navy's entire P3 fleet, may save more than 40,000 maintenance man-hours per year. The cost avoidance by expanding the prototype to other corrosion prone areas may be very significant, but the magnitude is currently unknown.

Preliminary test results on corrosion protection at the Materials Engineering Lab at NAVAIRDEPOT Jacksonville (NADEP Jax) prompted the prototype using MIL-L-87177A. The use of this product was so successful as a corrosion protectant that VP-30 maintenance personnel began documenting other potential application locations.

The US Air Force in conjunction with Battelle Labs has been testing this product for several years, with excellent results, on F-16 avionics and electronics connectors. The USAF has calculated a cost avoidance of approximately $450 million, in three years, on 150 aircraft based at different geographic locations around the US. Initial estimates indicate cost avoidances could reach $500 million annually for the entire F-16 fleet[1]. These and other results have prompted the advancement of the P-3 CPC/lubricant prototype to include approximately 100 corrosion prone areas in avionics and electronics connectors as well as corrosion prone mechanical and structural areas.

Alternatives to the current solvent in the tested MIL-L-87177A, Halon 141b, are currently being tested. Halon 141b, a Class 2 ozone depleting substance (ODS), is being phased out by the Environmental Protection Agency. One solvent alternative, AK-225T, has initially resulted in better corrosion prevention in salt fog testing than the original Halon 141b[2].

KEY WORDS

Corrosion	Lubricant
MIL-L-87177	Grade B
MIL-L-87177A	CPC
VV-L-800	MIL-C-81309
P-3	F-16
ASTM D 2266	Maintenance

INTRODUCTION

The current lubricant / corrosion protectant used on the P-3 flap tracks, jackscrews and asymmetry detector chains is a light oil, VV-L-800 (MIL-PRF-32033). Jackscrews extend and retract P-3 wing flaps. VV-L-800 breaks down almost immediately when exposed to moisture. Since the screwjacks are carbon steel, corrosion develops within hours. See Figure 1. This corrosion results in additional wear and binding of the P-3 flap tracks and screwjacks. Therefore, VV-L-800 is applied during the daily maintenance inspection. VP-30 Maintenance Control contacted P-3 FST-4 in an effort to find a product with better corrosion protection and lubrication qualities over an extended period of time. This query resulted in the testing of MIL-C-81309 and MIL-L-87177A, as potential replacements for VV-L-800.

Figure 1. P-3 Jackscrew soon after water contact.

EXPERIMENTAL PROCEDURE

Initial Testing. Qualitative corrosion resistance testing was performed by Mr. John Benfer at the NADEP Jax Materials Engineering Lab as a screening method for determining the feasibility of replacing VV-L-800 with MIL-C-81309 and/or MIL-L-87177A. This was an initial single study incorporating duplicate samples. Testing was performed on 4x4 inch AISI 1010 carbon steel coupons prepared by abrasive blasting with glass bead media. 168-hour (7 day) accelerated corrosion tests were performed IAW ASTM B 117. Following the 168-hour (7 day) accelerated corrosion testing, the AISI 1010 steel coupons were visually evaluated for percent rusting and photo documented as follows; VV-L-800 had approximately 90 percent rust with 50 percent rust after 47 hours, MIL-C-81309 Type II had approximately 30 percent rust, and Lektro-Tech, MIL-L-87177A, Type 1, Grade B, had less than 5 percent rust after 7 days[3]. See Figures 2,3, and 4 below.

Results indicate that MIL-C-81309, Type II and MIL-L-87177A, materials tested provide improved corrosion performance as compared to VV-L-800. In addition, MIL-L-87177A meets similar ASTM D 2266 lubricity requirements as VV-L-800. P-3 FST-4 Engineering, Code 4.3.3.2, and NADEP Jax Materials Engineering, Code 4.3.4.6, recommended that the MIL-L-87177A be prototyped by VP-30 on P-3 flap tracks, jackscrews, and asymmetry detector chains to determine suitability of use by operational squadrons as a replacement to VV-L-800 for this application.

Figure 2. VV-L-800 Treated AISI 1010 Steel Coupon Following ASTM B117 Salt Fog Corrosion Testing (7 day).

Figure 3. MIL-C-81309 Type II Treated AISI 1010 Steel Coupon Following ASTM B 117 Salt Fog Corrosion Testing (7 day).

Figure 4. MIL-L-87177A Treated AISI 1010 Steel Coupon Following ASTM B 117 Salt Fog Corrosion Testing (7 day).

Process. A 6-month engineering prototype was performed by VP-30 on an in-service P-3 aircraft, Bureau Number (BUNO) 159513, between February and August 2002. Application locations included flap tracks, flap screwjack actuators, and asymmetry detector chains. The application method, which is the same as the application of VV-L-800, was aerosol spray. The solvent in the Lektro-Tech MIL-L-87177A, Halon 141b, rapidly evaporates leaving a coating of lubricant/corrosion protectant that does not run or drip. The surface is then lightly wiped to remove and distribute any excess film. Initial applications of MIL-L-87177A were on a daily basis and then quickly extended to the 28-day washdown interval. The 28-day washdown involves a pressure spray similar to that of a fire hose. P-3 FST-4 engineering initially performed inspections every two weeks for two months to determine if any negative results had occurred. No negative results were noted and inspections were extended to coincide with the 28-day washdown. Figure 5 shows a screwjack after application of MIL-L-87177A and two weeks of normal operations. Normal operations include humid atmospheric conditions, flight in rain and over salt water, and drive-through rinses in bird baths.

Figure 5. Two weeks of normal operations after application of MIL-L-87177A.

RESULTS

The 28-day interval showed improved corrosion protection and lubrication over the daily application of VV-L-800. Jackscrews spun freely with no resistance and no corrosion was found on components treated with MIL-L-87177A. One specific instance where two jackscrews were not re-lubricated after the 28-day wash resulted in no corrosion or binding after 3 days. The jackscrews appeared dry, but a light film of protectant was present to the touch. Had the aircraft been using VV-L-800, these jackscrews would have shown excessive corrosion and potentially created a flap asymmetry problem. The application time per aircraft is the same as application time for VV-L-800, which is estimated to be ½ hour on average per aircraft. The amount of MIL-L-87177A used for this application is also approximately the same as VV-L-800, which is 1/4 can per aircraft. The annual comparison of daily versus every 28 days is 182.5 man-hours to 6.5 man-hours per aircraft, or 46,640 man-hours for a fleet of 265 aircraft. Assuming only 80% of the fleet is flying at a given time, the man-hour savings is still greater than 37,000. The annual quantity of product would be reduced from 91.25 cans of VV-L-800 to 3.25 cans of MIL-L-87177A per aircraft, or 23,320 cans for a fleet of 265 aircraft. This is a significant reduction in man-hours and product quantity required to lubricate and protect P-3 flap components.

Success of the prototype application has resulted in an update of the P-3 technical manuals to incorporate the lubrication change on the flap tracks, jackscrews, and asymmetry detector chains as discussed above. Further prototype testing to include approximately 100 other P-3 mechanical and structural components, avionics connectors, and electrical connectors is to begin early October 2003. The locations associated with these components vary greatly in temperature. High temperature locations include engine and auxiliary power unit mechanical components and electrical connectors. Other locations experience the extreme temperature and moisture cycles associated with aircraft flight. Some of these are cannon plugs and barrel connectors located in the flap wells that become so corroded they are damaged upon removal at scheduled inspection intervals. Unpressurized external electrical connectors and components tend to corrode because air is evacuated at altitude. As the aircraft descends, moist sea level air is forced into the components. This moisture initiates corrosion that can cause open circuits, shorts, and system failures. MIL-L-87177A protects connector pins and sockets by coating them with a thin film that blocks moisture to metal contact.

Transition. Success of the initial testing and prototype of MIL-L-87177A has prompted the transition to other aircraft platforms through the Materials Engineering Competency at NADEP Jax. The EA-6B slat gearbox limit switch located in a “sealed” area of the empennage has had a very high failure rate due to corrosion. Accelerated salt fog corrosion testing, ASTM B 117, has shown that an application of MIL-L-87177A increased electrical operation to 1400 hours versus 100 hours for the control. Technical manuals have been updated to require the application at this location. See figures 6a and 6b.

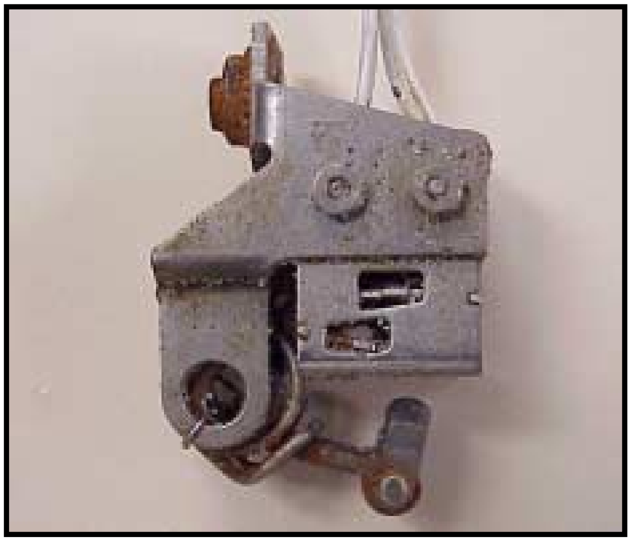

Figure 6a. MIL-L-87177A - Electrical failure at 1400 hours.

Figure 6b. Control - Electrical failure at 100 hours

F-14 and F-18 ejection seat components are currently being treated with MIL-L-87177A. One such location is the ejection pawl and clevis pin. This area is affected by crevice/galvanic corrosion as shown in figures 7a-7c. Until they can be redesigned, these components are treated when disassembled. Once redesigned, disassembled components may continue to be treated. Another location currently being tested with MIL-L-87177A is the electrical connectors of the ejection seat electronic sequencer. These connectors are spring loaded and susceptible to stress corrosion cracking. A failure here would result in connector separation and not allow the seat to eject in an emergency.

Figure 7a. Cadmium plated steel pin.

Figure 7b. Plunger in end of pawl.

Figure 7c. CRES pawl showing pin hole.

Figure 7d. Cadmium plated bronze plunger.

Material Characteristics. The MIL-L-87177A, Type 1, Grade B, manufactured by Lektro Tech Inc., has a number of characteristics that are desirable in aircraft maintenance:

- The solvent evaporates in 5 to 10 seconds – laboratory and demonstration observation.
- Coverage is a non-tacky thin film with a very low vapor pressure, which does not readily pick up debris or evaporate – Battelle Labs test results and demonstration observation.
- The film has a very low surface tension, which results in good coverage, is immiscible with water and will not be displaced by water - laboratory and demonstration observation.
- The product tested is non-flammable even when sprayed in aerosol form – MSDS and Tech Data sheets.
- Lubrication properties are similar to VV-L-800 – MIL-L-87177A specification.
- Large dielectric constant. Eliminates electromigration when tested on fine-line solder coated copper patterns[4] – Battelle Labs test results.
- Non-hazardous to user – MSDS sheet.

Risks. The MIL-L-87177A used in testing uses Halon 141B, a Class 2 ODS. Due to environmental regulations involving Halon 141B, the manufacturer is in the process of reformulating the product. The Environmental Protection Agency is working with the Department of Defense to ensure continued Halon 141b availability until a final alternative is selected. This risk is determined negligible.

The most critical risks are the inadequacies of, and requirements to call out, Military Specifications when defining maintenance instructions for military applications. Some products may barely pass testing for MIL specifications on their best day, while other products may excel in all testing on their worst day. Use of inferior lubricants/CPCs may actually promote corrosion in severe environments[3].

CONCLUSIONS

The most important conclusion from the historical data and prototype testing is the availability of an excellent corrosion preventive compound that has lubrication properties. The application of a high quality CPC/lubricant on aircraft components can reduce maintenance man-hours, reduce part replacement costs, increase life of aircraft, increase safety, and increase readiness. If the cost avoidance estimates for the US Air Force F-16 fleet can reach $500 million per year, the transition to platforms in all military branches could reach billions of dollars per year.

The application locations tested by the Air Force are not normally treated by CPC/lubricants. These are electrical connectors that are susceptible to subtle and not so subtle forms of corrosion that interfere with the electrical operation of the F-16. Testing by the Navy at NADEP Jacksonville incorporates not only electrical connectors, but mechanical and structural components as well. Future testing will also include ground support equipment. The material properties of the tested product are such that it can be used on a wide variety of locations.

Properties of the tested product far exceed the requirements defined by the MIL-L-87177A specification. Many beneficial properties exhibited by the product tested are not required in the MIL specification. A revision to the MIL-L-87177A specification should be incorporated to maintain the standards available and minimize the chances of using inferior products.

ACKNOWLEDGMENTS

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