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Effects of Lubrication of LRU Electrical Connectors – Recent Flight Test Results on F16 Aircraft

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ABSTRACT

Extensive work has been done in recent years to evaluate the effectiveness of specific Corrosion Prevention Compounds (CPCs) applied to LRU(Line Replaceable Units) electrical connectors for the purpose of reducing Cannot Duplicate (CND), Retest OK (RETOK), and eventual removals of LRUs from aircraft. This practice has long been allowed according to T.O. 1-1-689. However, it has seldom been adopted due, in part, to the absence of good supporting technical data describing benefits vs. risks.

This work represented a continuation of earlier studies in which the F16 aircraft (and to a lesser degree the F15) were used as the test bed for this work. This particular OSD effort was in many respects nothing new other than a further demonstration of the effectiveness of on particular lubricant and on as large a sample size as possible. The lubricant was one conforming to MIL-L-87177A and specifically one that had been reformulated to be more environmentally “friendly”.

The results of this work were consistent with those of earlier and similar work. Application of the lubricant at the LRU level typically produced substantial reductions in LRU removal rates on most, but not all, LRUs at all bases.

Key Words: Avionics Corrosion; Lubrication; CPCs

INTRODUCTION

The removal of Line Replaceable Units (LRUs) may lead to a considerable expense in the event that the LRUs cannot be repaired at base level and are returned to depot for repair. One mechanism by which such faults may occur could be termed a subtle form of corrosion on the connector contact surfaces. Thin films may form over time which can be at thicknesses below the limits of visible detection. In theory and in practical experience such films which are inherently insulators may give rise to intermittent contact to produce the classical CNDs and often sudden failure without warning. The fact that such films can often not be observed often presents a problem to many maintenance personnel and the casual observer. One consequence from this fact that is often stated is that connector corrosion "does not occur at our base". As a result it is seldom, if ever, recorded in military databases such as the Air Force Reliability & Maintainability Information System (REMIS).

Studies have been conducted to explore the effectiveness of CPCs/lubricants as an inexpensive means of reducing such failures. Extensive ground and laboratory tests conducted at Battelle and reported elsewhere have been conducted on all of the CPCs on the QPLs for MIL-C-81309E and MIL-L-87177A. (1,2,3) It was concluded that very few of these materials would exhibit performance characteristics judged to be totally free of known risks for use on electronic/electrical connectors. When this work was started in the late 90's, the conclusion was that no more than 3 of these CPCs were suitable for these applications. With this information now available, two CPCs were selected for initial flight tests using the F16 aircraft as the primary test platform. Those CPCs were 1) Zip Chem D5026-NS (MIL-C-81309E) and 2) Lektro Tech 87177A/Super Corr B (MIL-L-87177A). Both of these materials were judged to be technically equivalent in performance with no known engineering risk. Early flight tests proved this to be the case and with very positive results in terms of reduced LRU removals.

Subsequent to this early work one of these materials (Super Corr B) was changed to provide a more environmentally suitable organic carrier/solvent. As a result, a request was made from Hill, AFB for the laboratory evaluations to be repeated using the new version known as Super Corr A. This was followed by work through Hill and supported by OSD funding, to repeat the flight tests on as large a sample size as possible on LRUs in the F16 fleet.

The results from these latter studies are the subject of this paper. This work has involved over 150 aircraft and over 3500 LRUs using only the Super Corr A. All results remained positive for reduced LRU removal rates. No negative effects were ever reported from any base. As in earlier work, it was shown that the effectiveness of these treatments varied greatly among LRUs.

EXPERIMENTAL

Test Procedures

In this work, all of the lubricant was used in aerosol form. The lubricants were obtained as one large lot and supplied to the participating bases from Battelle. It was hoped that in order to get the lubricant applied quickly and on the largest number of aircraft possible, it would be applied on the flightline as in earlier work. Generally this did not occur due to operational reasons. Therefore, the applications were usually done as aircraft rotated into Phase inspections. The only burden placed on the bases was to apply, report what was treated , and then operate as normal. In other words, there was only a single application on any LRU connector.

The original program plan called for applications on a small (but hopefully large total) number of LRUs with the local option of applications onto as many LRUs as possible. The reality of this situation was that "you take what you can get and make the best of it" as an appropriate description of what was eventually reported. Fortunately, there was enough participation and enough aircraft involved that the objectives were met. Specifically, enough LRUs of the same type were treated and flown over a long enough period of time to obtain large sample sizes for analysis.

Data Analysis

There were no data analysis requirements placed on the bases. The only request was for each base to report informally the Tail Number, date of treatment, and LRU by 5 character Work Unit Code (WUC). This requirement was generally met.

All data analyses were done by Battelle. The data source was what was reported to the official Air Force database of REMIS. Various types of data were pulled using custom programs developed in Remistalk but the emphasis in the analyses was on Numbers of Removals, and Maintenance Man-Hours. These data were separated by Tail Number and WUC and analyzed accordingly. It could be argued that this procedure could be questionable due to the fact that when an LRU is removed it could be replaced by a new (and otherwise untreated) LRU. One answer to this comes from experimental and earlier analyses to suggest that on the initial treated installation, the lubricant may be applied to either or both the LRU connectors and associated harness connectors. In any event, the lubricant will be transferred or remain "forever" on at least the wiring harness connector to perform the same function even when mated to a fresh surface. The experimental evidence has been that even a small amount of lubricant at the interface will serve a useful purpose.

TEST RESULTS

Some specific examples will be shown to illustrate the type of data obtained and the apparent effects of lubrication. The metric being used here is number of LRU removals per flight hour. Data are shown for only one base for several reasons. First, this base appeared to be one of the most diligent in support of this project and data reporting Second, this base had a large number of aircraft. The fact that not all aircraft got treated proved to be an advantage, since there was an opportunity to directly compare the treated and untreated populations. This also proved fortunate, since as a standard analysis practice, data were obtained across all commands as well as just the owning command (ACC in this case). These data are shown in Figure 1.

The results of Figure 1 show a significant reduction in rate of removals for this base as time progressed. This is somewhat typical. It also appears that in spite of this favorable, local trend, their data did not reach the level attained across all commands. These latter results are simply reported as a matter of record, but it is the first results that are of most importance to this work.

The data in Figure 1 represent a grand summary across all LRUs treated at this base. Figures 3 and 4 illustrate other examples which are believed to represent a fair appraisal of effects observed throughout this work at all bases. With this said, it must be noted that simply treating LRU connectors would not be expected to effect improvements for all LRUs. This is illustrated in Figures 5 and 6. There is no implication in these data, that lubrication did or should adversely affect performance. It is recognized that for some LRUs there must be other hardware and/or software effects that would far overshadow any beneficial effects of connector lubrication.

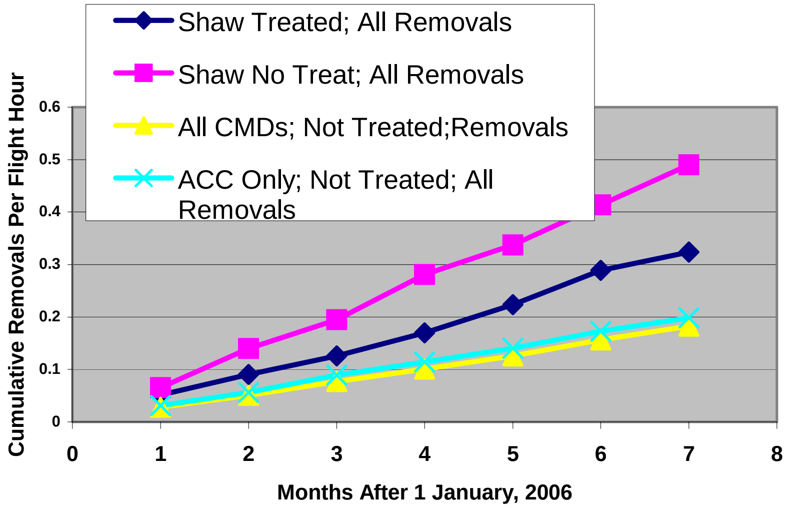

FIGURE 1 – Effects of LRU Lubrication On F16 Aircraft At Shaw, AFB

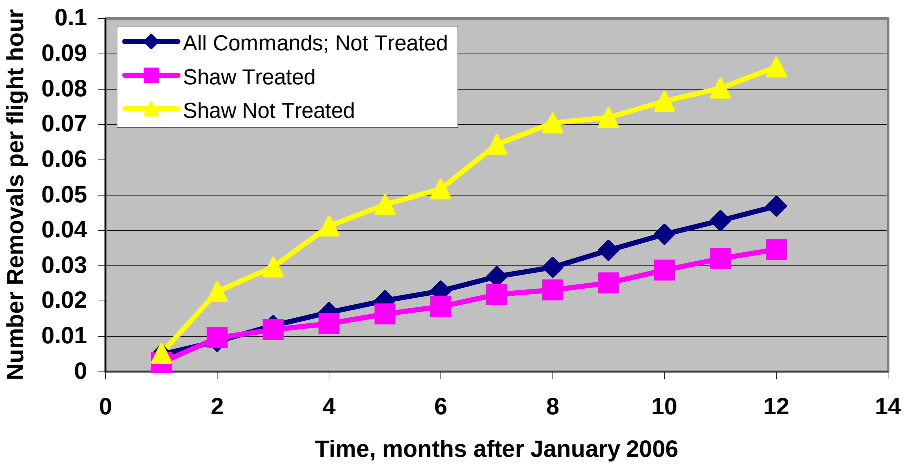

FIGURE 2 – Effects of LRU Lubrication On F16 Aircraft At Shaw; LRU #1

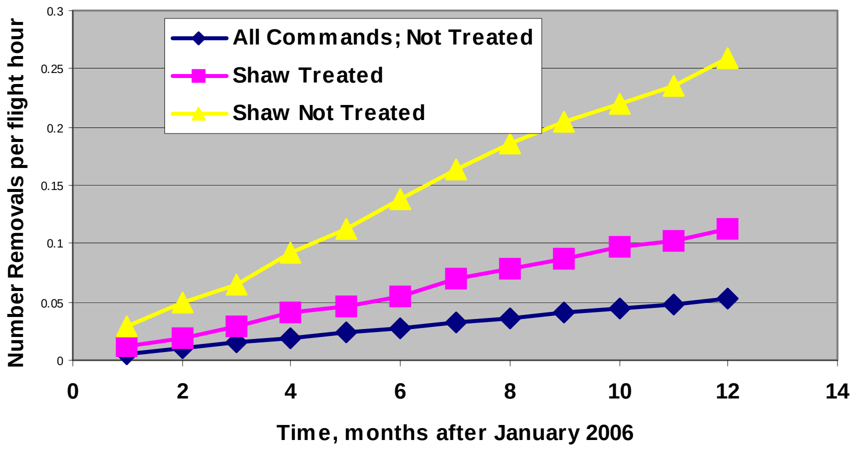

FIGURE 3 – Effects of LRU Lubrication On F16 Aircraft At Shaw; LRU #2

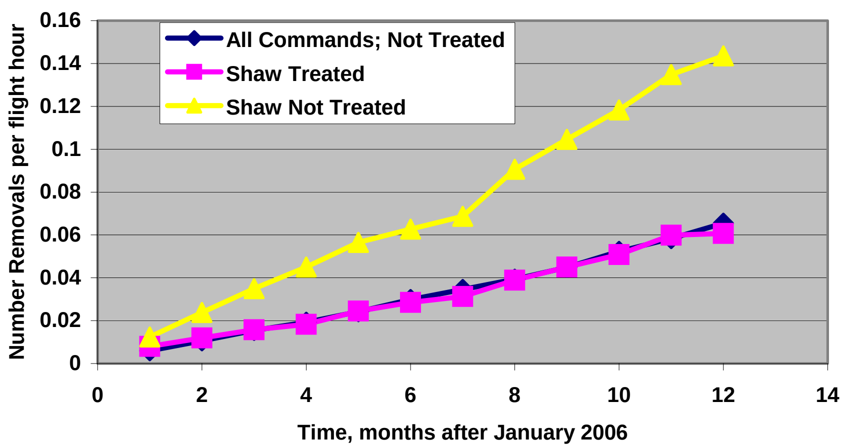

FIGURE 4 – Effects of LRU Lubrication On F16 Aircraft At Shaw; LRU #3

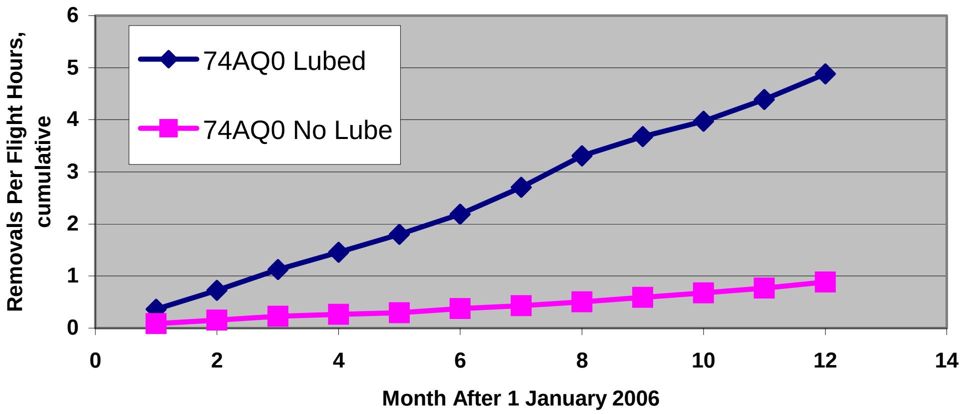

FIGURE 5 – Effects Of LRU Connector Lubrication For LRU #4 Over Multiple Bases (CRWU,FFAN,FMKM,FTFA, HAYW,KBJA,NUEX, and LUXC); Adverse Effects on Statistics of Low Flight Hours At A few Bases

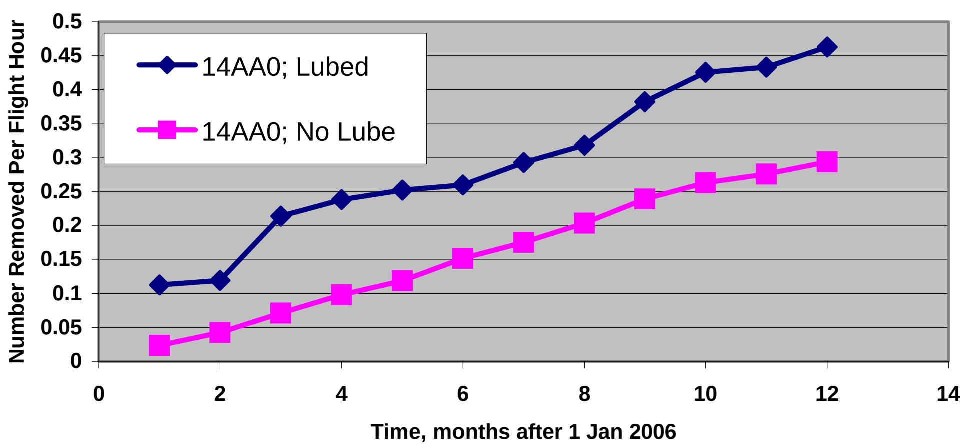

FIGURE 6 – Effects Of LRU Connector Lubrication For LRU #5 Over Multiple Bases; AJXH;CRWU;HAYW;NUEX;LUXC;DCFT; and WAAR

CONCLUSIONS

The presents work has continued to demonstrate the potential for the use of a simple and low cost technology that may lead to large cost avoidance by reducing Cannot Duplicates (CNDs) and Retest OK (RETOK) which in turn may lead to reduced LRU exchange costs. This appears to be the most visible benefit, since the available data have not been able to demonstrate any change in Mission Capable (MC) rates from such treatments.

The basis for this OSD funded work was cost reduction/cost avoidance. One of the objectives in such work is to project a Return on Investment (ROI) in the event of full implementation of this or any technology. In this case, the ROI should be very high due to the high value and known Exchange Costs of the LRUs. However, it cannot accurately be projected due to one unknown associated with reporting problems in the AF database. If, for example, it were to be assumed that all LRU removals resulted in exchanges and the incremental reductions implied by the data all resulted in cost avoidance, the dollar value for just the LRUs studied in this work would exceed perhaps $ 500 million per year. Such a number cannot be supported by depot experience. The reality is that not all removals will result in returns for depot level repair. However, to the present it has not been possible to determine the probable fraction of removals that fall in this category. Such numbers continue to be pursued.

In conclusion, the F16 aircraft has been used as the major test bed in support of this work. However, it should be noted that these results and the application of this technology are not specific to this or any other aircraft. Instead, they should apply across a wide array of flight and ground based applications.

REFERENCES

1) Abbott, W.H.; Evaluation of Lubricant Effectiveness for Corrosion Protection and Improved Reliability of Electrical and Electronic Connectors; Contract # F04606-89-D-0034-RZ05; August 1996

2) Abbott, W.H. ; Lubricant Effectiveness Study For Corrosion Protection and Improved Reliability of Avionics; Contract # F09603-90-D-2217; QP02, March 30, 1999

3) Abbott,W.H. ; Effects of Corrosion Inhibiting Lubricants on Improved Reliability of Avionics; Contract # F42620-00-D-0030-RJ06; June 30, 2003