EFFECTS OF CORROSION INHIBITIVE LUBRICANTS ON ELECTRONICS RELIABILITY

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Abstract
All electrical connectors corrode – even high quality gold plated connecting surfaces are not immune from the laws of physics. Thin and often invisible insulating films can form on the surfaces of electrical connectors. Such corrosive films are produced by the reactions of natural environments with the elements used in the manufacture of commercial and military electrical connectors. Such films may represent a significant source of faults such as Cannot Duplicate (CND) and Retest OK (RETOK) faults. USAF studies for the last twenty years have shown that application of certain corrosion inhibitive lubricants (CILs) or corrosion preventative compounds (CPCs) can substantially impact CND and RETOK rates thus improving avionics reliability. This paper addresses prior research and current operational and depot level application of CIL/CPCs in the Department of Defense (DoD).

Introduction

Today's avionics systems assume a major responsibility for the performance, safety, and success of commercial and general aviation. These avionics systems control the operation of flight-critical and flight-essential equipment, including navigation, communications, power distribution, flight and engine controls, displays, and wiring. The reliability of these complex and often interrelated systems in any environment is critical for safe operation [1]. The wiring on the aircraft can act as conduits for water condensed by changes in temperature and altitude during flight or on the ground. Once the condensation forms within the wire bundles it starts to travel to the lowest point in the harness -usually the LRU. If the connectors are not properly sealed, water will eventually enter the LRU through the connectors, resulting in premature failure or corrosion problems. The November 2004 DoD Corrosion Prevention and Mitigation Strategic Plan on page 31 table A-11 references one of the USAF sustainment priority projects as follows: "Improved avionics reliability through the use of corrosion-inhibiting lubricants" [13].

Background

Fretting corrosion between contacts may have materially contributed to several F-16 crashes when their main fuel shutoff valves closed uncommanded. The main fuel shutoff valve (MFSOV) is the main fuel line shutoff valve of the single engine. To facilitate strainer cleaning and disconnection from the engine for certain services, this valve can be commanded to close, forming a seal to facilitate maintenance actions. Additionally, there is an actuating switch in the cockpit so that the pilot could close the valve in event of engine fire or emergency. The corrosion products of tin and steel pins provides a potential conductivity path between pins A to B and C to B that may be adequate to drive the MFSOV to close. A corrosion inhibiting lubricant spray, MIL-L-87177A Grade B, has been identified and is used

Figure 1.0 – Corroded F-16 MFSOV Electrical Connector

annually in a preventative maintenance context. Treatment of F-16 electrical connectors with the MIL-L-87177A Grade B was remarkably effective. Conductivity of the tin plated pins was fully restored and the CPC prevented continued corrosion, so much so that in a test at one base - the aircraft so treated demonstrated a 16% improved mission capable (MC) rate. In addition, millions of dollars saved by cost avoidances were documented by treating the aircraft and aircraft ground equipment (AGE) connectors. [6]

"Phase I" - Ground and Lab Studies

The F-16 MFSOV findings were the forerunner to an effort launched in 1994 as a ground based, field and lab study. A study conducted by Battelle Labs reviewed lubricants that had been qualified under MIL-C-81309E (Navy) and MIL-L-87177A (Air Force). Technical performance assessments and risk evaluation on twelve lubricants were accomplished. Battelle concluded a significant difference among lubricants in performance. Futher, the study showed that only a few lubricants will survive comprehensive evaluation. The best two lubricants are Zip Chem D5026NS (MIL-C-81309E) and Lektro-Tech Super Corr B (MIL-L-87177A). These two CPCs are totally suitable for avionics under the Tri-Service technical manual: NAVAIR 16-1-540 (Navy), TO 1-1-689 (AF), and TM-1-1500-343-23 (Army).

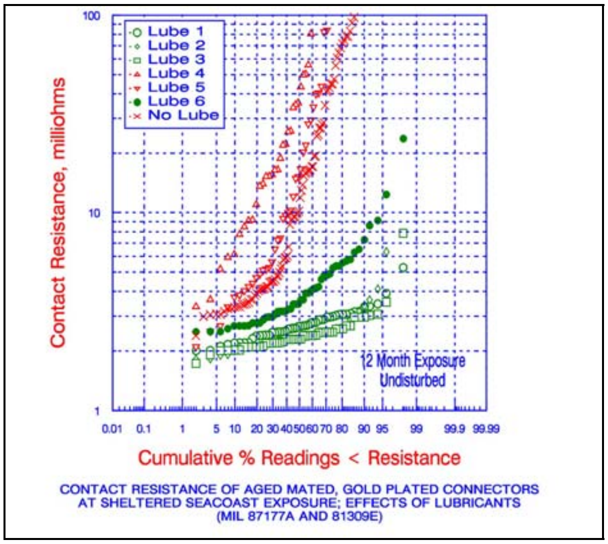
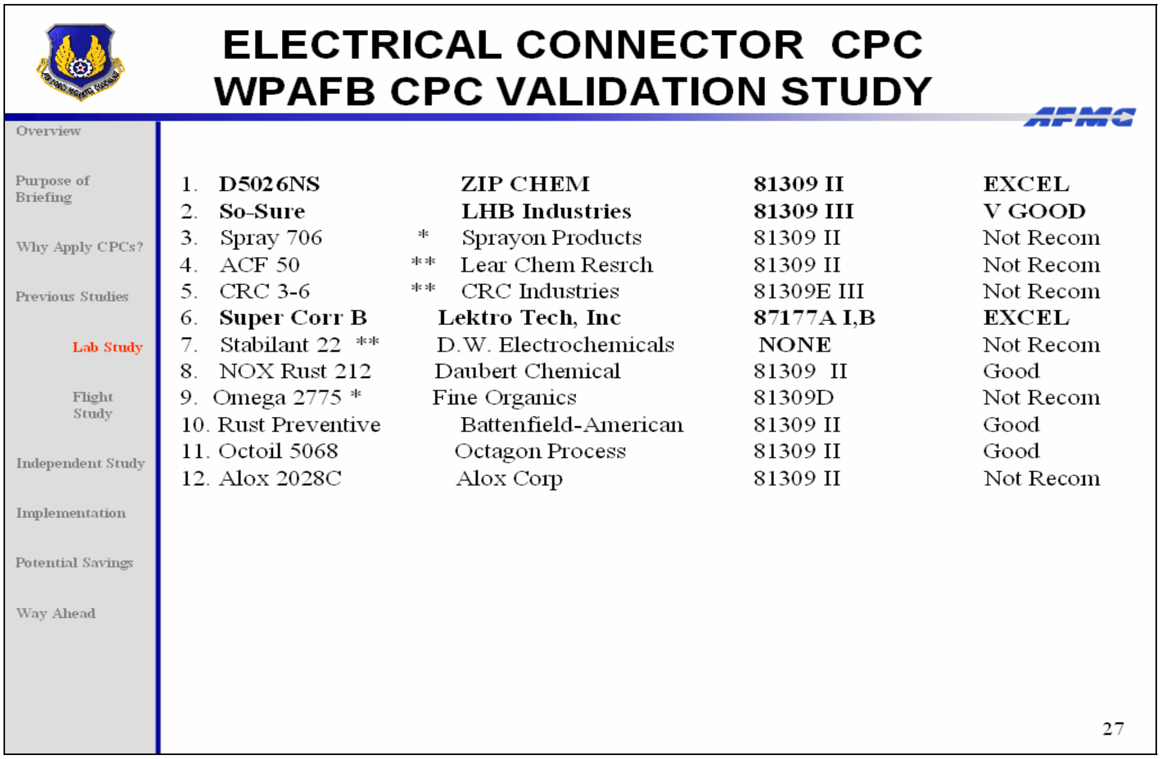


Figure 2.0 – Contact Resistance Change Distributions for Twelve 81309 and 87177A CPCs [5]

The objective in the study was to measure contact resistance change distributions for each CPC. Twelve COTS CPCs were studied – one of several criteria for "best CPC" was smallest change possible (<10 milliohms). It was discovered that with no CPC, failure is rapid. Also concluded was that there were large differences among MIL spec lubes, some may actually promote corrosion, some give marginal benefits, and the best two or three offered excellent corrosion inhibition.



1. D5026NS	**ZIP CHEM**	**81309 II**	**EXCEL**
2. So-Sure	**LHB Industries**	**81309 III**	**V GOOD**
3. Spray 706	* Sprayon Products	81309 II	Not Recom
4. ACF 50	** Lear Chem Resrch	81309 II	Not Recom
5. CRC 3-6	** CRC Industries	81309E III	Not Recom
6. Super Corr B	**Lektro Tech, Inc**	**87177A I,B**	**EXCEL**
7. Stabilant 22 **	D.W. Electrochemicals	NONE	Not Recom
8. NOX Rust 212	Daubert Chemical	81309 II	Good
9. Omega 2775 *	Fine Organics	81309D	Not Recom
10. Rust Preventive	Battenfield-American	81309 II	Good
11. Octoil 5068	Octagon Process	81309 II	Good
12. Alox 2028C	Alox Corp	81309 II	Not Recom

Figure 3.0 – Results of the WPAFB Electrical Connector CPC Validation Study [4]

"Phase II" - Flight Testing on F-16 Aircraft

Following the ground study flight testing was conducted to determine the effectiveness of MIL-L-87177A on selected gold/gold connectors to line replaceable units, LRUs, such as avionics boxes, computers, enclosed switching equipment, card edge connectors, etc. Systems involved in the testing included avionics, weapons, flight controls, and landing gear. This test, completed in 1999, included 150 USAF F-16 at ten geographically diverse USAF bases and 2 Air National Guard (ANG) reserve units. LRUs with connectors treated with MIL-L-87177A demonstrated as much as a 15 times increase in mean time between failure (MTBF). Treatment of electrical connectors with MIL-L-87177A Grade B was so effective in maintaining the conductivity of connectors and preventing corrosion that in testing at the ANG base in Homestead, Florida, treated aircraft demonstrated a 16% improved mission capable rate, and maintenance costs averaged $600K per year less than those not treated. These values correspond to approximate 50% less maintenance man-hours on those aircraft treated. Referring to Figure 4.0 below, one estimate computed by the 482nd Fighter Wing when 10 out of 18 A/C had been through the lubricant process was $3.1M in cost avoidance by eliminating exchange cost and reducing maintenance man-hours. Battelle independently computed $2.2M savings based on average $25K depot level repair exchange cost. Homestead ANG continues to treat electrical connectors - though the test program ended in 1999. MIL-L-87177A, Grade B is now required for application in the F-16 main fuel shutoff valve connector every 100 flight hours. No substitute for MIL-L-87177A is authorized for this application. The F-16 Management Directorate, the Wright Patterson AFB "Fasteners, Actuators, Connectors, Tools, and Subsystems (FACTS) Office," had estimated the savings of $450 million over three years on the tested 150 F-16 aircraft. Estimates have been made of the potential savings resulting from reduced LRU removals and exchange cost avoidance if similar treatments were applied to just the same LRU population across the entire F-16 fleet. Estimates have projected annual savings of $200-500 million. Estimates are expected to be higher in coastal areas[2]. The below figure represents cumulative removals per flight hour for all work unit codes (WUCs) on treated F-16 aircraft at Homestead AFB.

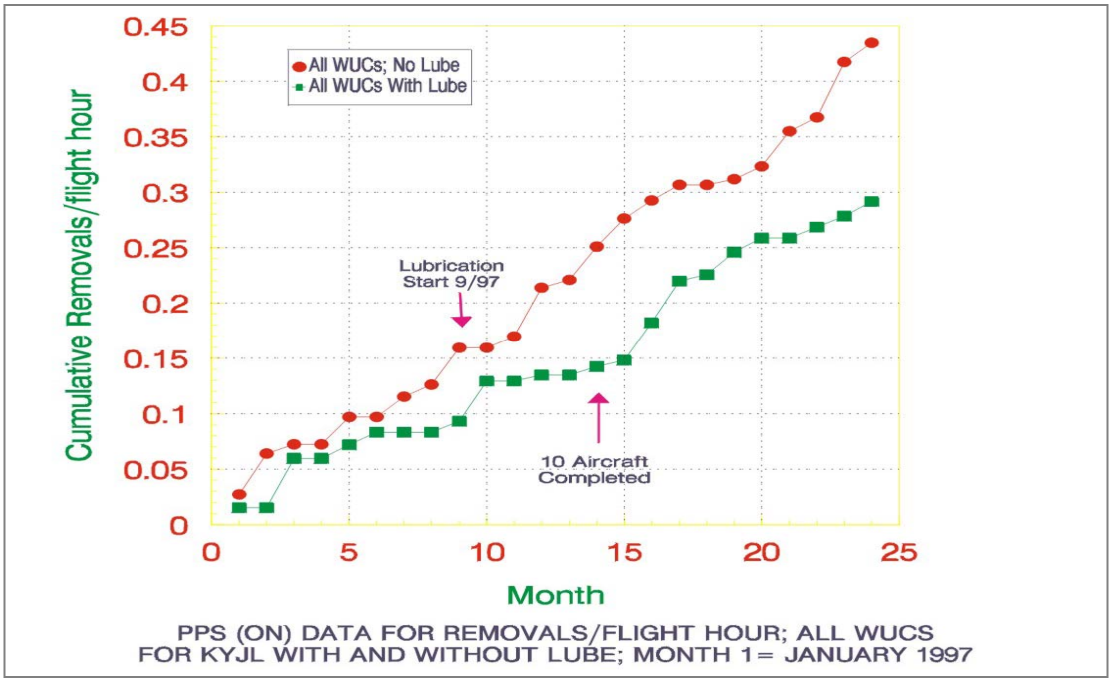


Figure 4.0 – Cumulative Removals/Flight Hour for All WUCs on F-16s at Homestead [8]

MIL-L-87177A – Bullet Proof

In May 2002 Sandia Labs released a paper titled "MIL-L-87177 Lubricant Bulletproofs Connectors Against Chemical and Fretting Corrosion.[3]" At the time of this report it was known that MIL-L-87177A compliant CIL/CPCs protect electrical components, mechanical components and surfaces by coating them with a thin stable film that has a very low vapor pressure (PSI), a very low surface tension, a high dielectric constant, and is stable from –70 to +550 degrees Fahrenheit and is non-flammable. The result is an absolutely superior CIL/CPC offering a thin film which does not "gum up", evaporates relatively slowly, and is immiscible with water. In 2000 a NACE paper was presented which addressed a commercial CIL/CPC's performance against MIL-L-177A performance. An excerpt follows: "The Commercial Lubricant delayed onset of first failure to beyond 55 million cycles in one test where a failure was actually observed and to beyond 20 million cycles in another test terminated without failure. The Commercial Lubricant recovered an unlubricated connector driven deeply into failure, with six failed pins recovering immediately and four more recovering during an additional 420 thousand fretting cycles. MIL-L-87177 was not able to recover a connector under similar conditions."[7]. Additional studies have shown that suitable levels of corrosion protection are attainable with a diluted 20% solution of an 87177A based material in HCFC 141b. It is important to note that the results of Dr. Abbot's work in his final report [5] are that at least one CIL/CPC qualifying under MIL-L-81309 seems to perform equally well to inhibit connector corrosion in terms of vapor barrier and evaporation rate, this is the DN5026NS compound by Zip-Chem.

"Phase III" - Flight Testing on Additional Fixed and Rotary Wing Aircraft

The next study consisted of three major components. First, continued tracking and updates of Phase II test Line Replaceable Units (LRUs) on F-16 aircraft from 1997 – 1999 carried on up to 2001. The goal in additional data collection for those assets was to assess longevity of CPC effectivity. Second, further flight-testing using the Zip Chem and Super Corr B lubricants was conducted on other platforms fixed and rotary wing platforms. The following platforms participated in Phase III: F-15 (Kadena, Jacksonville), HH60 helicopters (Patrick, US Coast Guard), HH65 helicopters (US Coast Guard), and C-141 (Wright Patterson, Andrews). As many as forty-five different LRUs were being incorporated into the study. The figure below represents cumulative removals as far out as 30 months after application of the CPCs to the F-16 aircraft at Nellis. This data would seem to vindicate the thermal aging and evaporation rate predictions and actuals obtained in the initial “Phase I” ground and lab studies conducted in the mid 90s. It was hoped that the “best of breed” CIL/CPCs would offer good longevity in effectivity. The last component of the “Phase III” effort was to assess the potential for application in an indoor depot level environment.

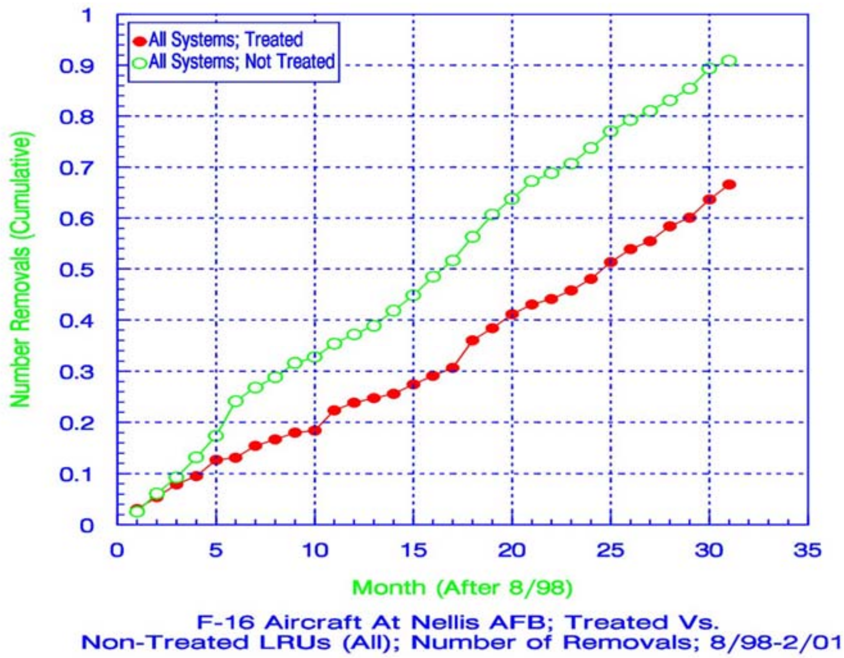


Figure 5.0 – Cumulative Removals on All Systems - Two Years After Initial Lubrication [9]

A second component of the above effort to validate longevity of effect was to expand the test sample to other aircraft, fixed and rotary wing, and other services in geo-dispersed and corrosion prone locations. The F-15 locations were Jacksonville and Kadena. In May 2001 Kadena reported that work was being done on the ground terminals in Bay 5 of the F-15s, and that much of the work was corrosion related. This is significant in that although in the earlier F-16 work it was frequently reported that corroded ground terminals were found to be culprits in many CNDs, Kadena was the first base to apply CPCs to ground terminals! Much of the Kadena data reported by Dr. Abbot in his 2003 final report looks quite positive relative to other data samples from other locations and platforms – much of the benefit may have been derived from treatment of ground connections. See figure X below for a summary of Kadena F-15 results for all WUCs. [9].

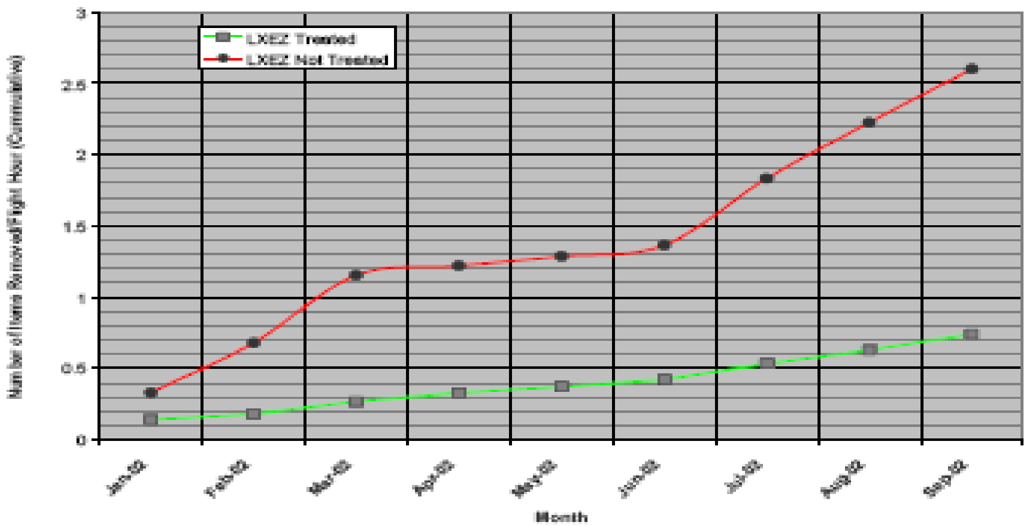


Figure 6.0 – Cumulative Removals on All Systems F-15 Aircraft, Kadena

Indoor Depot Lubrication Component

The scope of this component of the effort involved testing in the WR-ALC organic depot with a minimum of 30 different LRUs and over 100 shop replaceable units (SRUs) being treated with the corrosion preventive compounds (CPCs). The study sought to investigate any indoor implementation issues, human factors problems, and performance of CPCs. Data was tracked by LRU serial number. In the final analysis, the indoor depot implementation component at WR-ALC was determined to be inconclusive for a number of reasons - including human factors considerations. The author observes from Dr. Abbot's work in the depot lubrication study that application at the SRU level is likely to be beneficial. For WUC 76LEO, used mainly on the F-16, there appears to be a considerable decrease in removals per flight hour around 9 -12 months after depot lubrication start-up for this LRU - the removal rate reduction was around 40% [9]. Dr. Abbot's final comments in this section of the 2003 final report addresses the human factors concern regarding the odor created by the CPCs.

LRU Calculations

Action	*Time/min*	*$*
Treat 10 SRUs from LRU each	141.0	$235.10
Prep LRU Connectors	2	3.34
Treat LRU Connectors	0.1	0.17
Dry LRU Connectors	5	8.33
Input Serial # Data to Track	1	1.67
Total Additional Time & $s	148.20 m	$248.61

Assumptions: Avg Shop RCC Rate of $100 /per hour
Avg 10 SRU's per LRU

SRU Calculations

Action	***Time/min***	***$***
Remove SRU from LRU	3	5.00
Prep SRU for Treatment	2	3.34
Treat SRU with Compound	0.1	0.17
Dry SRU	5	8.33
Replace SRU in LRU	3	5.00
Input Serial # Data to Track	1	1.67
Total Additional Time & $s	**14.10 m**	**$23.51**

Assumptions: Avg Shop RCC Rate of $100 /per hour

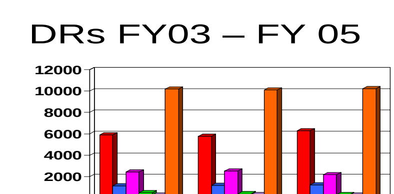
Table 1.0 – Depot Implementation Costs for Treating All ESG and EW Systems

After the depot study, the above depot implementation costs were obtained through market research and discussion with maintenance personnel. The cumulative product line repair flow for common avionics and EW systems through WR-ALC has been estimated to be on the order of 40,000 SRUs and 20,000 LRUs annually. From the above tables the annual recurring costs to implement 100% depot CIL/CPC treatment at both LRU and SRU levels for these avionics systems may be on the order of six million dollars per year. The primary human factor to be addressed is fume control. The most cost efficient method is to purchase portable, flexible vapor filtration units to be used at Avionics repair benches. Portable units are cheaper, moveable with LEAN initiatives, don't require permanent installation, and are rapidly procureable and usable.

Figure 7.0 –COTS Portable Filtration System

False Alarms, CNDs, RTOK

It is prudent to offer the following definitions from AFI 10-602: **False Alarm (FA) -** a system-indicated malfunction that can't be validated because no request for corrective maintenance follows. **Cannot Duplicate (CND) -** a situation that results in an operationally observed or recorded malfunction for a system or subsystem that on-equipment maintenance personnel can't duplicate or confirm. **Retest OK (RTOK) -** a maintenance event involving a part or subsystem malfunction at the on-equipment maintenance level that personnel can't duplicate at the off-equipment maintenance level. As a result of this event, personnel may return the item to service without taking corrective action. A CND differs from a false alarm in that it signifies a malfunction that can't be confirmed. Several issues can arise from corrosion in electrical connectors: increased electrical resistance, shorts, signals misinterpreted by computers, uncommanded activation or deactivation of systems, reduced safety and readiness, and increased maintenance and life cycle costs. From FY03 to FY05 WR-ALC saw almost six thousand PQDRs (out of box failures) per year. After discussions with support point activities in the organic depot, it was determined that over 700 of these out of box failures over a three year period were dispositioned as "no defect found" (NDA) – translated RTOK.



	FY 03	FY04	FY05
PQDR	5878	5781	6270
MDR	1107	1151	1224
WDR	2445	2505	2150
SWDR	476	367	308
OTHER	263	294	259
TOTAL	10170	10098	10217

Figure 8.0 – WR-ALC DRs from FY03 – FY05

Mr. Jim Phillips, a Reduction in Total Ownership Cost (RTOC) cost analyst with Battelle, obtained some recent data on the number of LRUs that were received at the overhaul shop to be repaired but the overhaul shop could not find any fault on the specific LRU. A data run done on only four of the work unit code series on the F-16 (WUC 74, 75, 13, & 46) revealed that there were more than 80,000 units that were NFF= no fault found during FY 05. After analyzing only the WUC 74 system data, there were 2464 LRUs that were NFF from 1 Oct 04 until 17 Aug 05 when the run was made, and to that time the cost to the AF to "buy back" the NFF units was over $33,000,000.00 [11]

Component	**Failure mode.**
Antenna Systems	Short circuits or changes in circuit constants and structural deterioration.
Chassis, housings, covers, and mount frames	Contamination, pitting, loss of finish, and structural deterioration.
Shock mounts and supports	Deterioration and loss of shock damping effectiveness.
Control box mechanical and electrical tuning linkage, and motor contacts	Intermittent operation and faulty frequency selection.
Water traps	Structural deterioration.
Relays and switching systems	Mechanical failure, short circuits, intermittent operation, and signal loss.
Plugs, connectors, jacks, and receptacles	Short circuits, increasing resistance, intermittent operation, and reduced system reliability.
Multi-pin cable connectors	Short circuits, increasing resistance, intermittent operation, and water seal deterioration.
Power cables	Disintegration of insulation and wire/connector deterioration.
Display lamps and wing lights	Intermittent operation, mechanical and electrical failures.
Wave guides	Loss of integrity against moisture, pitting, reduction of efficiency and structural deterioration.
Fluid cooling system lines	Failure of gaskets, pitting, and power loss.
Printed circuits and microminiature circuits	Short circuits, increased resistance, and component and system failures.
Batteries	High resistance at terminals, failure of electrical contact points, and structural deterioration of mounting. Erroneous cockpit signals.
Busbars	Structural and electrical failures.
Coaxial lines	Impedance fluctuations, loss of signal, and structural deterioration of connectors.

TABLE 2.0 EFFECTS OF CORROSION ON AVIONICS EQUIPMENT [1]

Recent and Current Efforts

WR-ALC EAB Briefing – 9/30/05

It is unknown how many of these PQDRs are the result of electronics connector corrosion. On September 30th, 2005 the author presented a briefing to the WR-ALC Engineering Advisory Board (EAB) recommending the use of CIL/CPCs across the center during PDM flow when Group A (aircraft wiring) connectors were exposed. Upon receiving the briefing the Director of Engineering (DOE) asked for an assessment from the EN technical staff. The results of the technical assessment are that as of this writing the chief engineers for C-130, C-5, C-17, and other platforms such as Special Operations Forces (SOF) fixed and rotary wing engineers are read in and briefed on the benefits of CIL/CPCs in the context of reducing FA, CND, and RTOK rates by application to electrical connectors during accessibility opportunities such as PDM flow.

C-130 Avionics Modernization Program (AMP)

The author recently left the C-130 Avionics Modernization Program after two years experience in dual roles at times of both Integrated Logistics Support and Production Operations IPT lead. The author has maintained contact with WR-ALC AMP SPO engineers and AFSOC users regarding the benefits of CIL/CPCs, with emphasis on 87177A as a way to provide a low-cost "bulletproofing" against FA, CND and RTOKs in the multi-year test program after trial installations. The AMP program replaces practically all aging avionics forward of bulkhead 245 on C-130s – the author views this unprecedented accessibility to aircraft side electrical connectors and new LRUs as incredibly opportune. It is the recommendation of the author that the AMP SPO add the application of MIL-L-87177 compliant CIL/CPCs in an O&A CLIN on the EMD contract for application at Boeing San Antonio trial install, and that the during the production phase of the effort that the time compliance technical order (TCTO) and model based instructions (MBIs) supplement existing technical orders (T.Os) to substitute any legacy 81309 CIL/CPCs and include provision for both 87177A and ZIP Chem D-5026NS. For every year that the Air Force does not require the use of these lubricants, the service loses the opportunity to avoid annual expenses that total hundreds of millions of dollars. [10]

Figure 9.0 – C-130H in Trial Installation – Boeing San Antio, TX

Current Depot Lubrication Efforts

The author has proposed an indoor depot implementation spiral approach in which selected LRU external connectors are treated, such as cannon plugs, BNC connectors, RF connectors, etc. This approach results in a much more conservative approach fiscally. With the SRU cost component removed, and the focus for treatment is solely on the external accessible connectors, the following table shows a more cost effective and potentially high ROI approach.

LRU Calculations

Action	*Time/min*	*$*
Prep LRU Connectors	2	3.34
Treat LRU Connectors	0.1	0.17
Dry LRU Connectors	5	8.33
Input Serial # Data to Track	1	1.67
Total Additional Time & $s	8.1 m	$13.5

Assumptions: Avg Shop RCC Rate of $100 /per hour

Table 3.0 – Direct Cost Estimate for Treating LRU External Connectors

For an annual repair flow of 40,000 LRUs the depot labor cost would be on the order of $540,000 per year. If annual savings of as much as hundreds of millions of dollars per year are realized operationally in reduction of maintenance man-hours and exchange costs, then such a conservative approach to indoor depot lubrication has possible ROI of several orders of magnitude. The author's goal is to implement the spiral approach indoors to complement the PDM flow opportunities in our maintenance shops on the flight line. If aircraft side and LRU side connectors are treated then it may be possible to have a substantial impact on FA, CND, and RTOK rates for operational check flights (OCFs) out of PDM, reducing flow days and subsequently providing war-winning capability in better reliability to the warfighters. The author is submitting an FY07 MSD Engineering project to spiral indoor depot lubrication. The project will seek to implement indoor lubrication using portable filtration on commodities showing the highest CND and RTOK rates.

F-16 Current Efforts

ACC/DRA-16 has approved the use of the corrosion preventive compound Super Corr B for electrical connector contacts on the F-16. The F-16 chief engineer, Mr. Karl Rogers has tasked his group to write a message for all US F-16 users to alert them to the F-16 SPO's "LRU and Electrical Circuits Reliability Improvement Program". The tasker was to request each unit to assign a point of contact (POC) with whom the SPO should interface, and to prepare to participate in the program in with an aircraft treatment plan that will not impact their flying schedule. Each unit was to be requested to contact the 508FSG/GFFBS (YPVS) to "check-in" so that the SPO can begin helping them to get up to speed on the CPC treatment program benefits, requirements, and longevity [14]

In recent discussions with F-16 equipment specialist Rusty Bennett of the 508th FSG/GFFBS, the author has learned that the result of the above tasker is an F-16 Interim Operational Supplement T.O. 1F-16C-2-00GV-00-2S-1 dated 12 Sep 2005 which provides for the revision of the basic manual to delete the legacy part numbers for CPCs in table 14-3 and add part numbers for MIL-L-177 compliant SUPER CORR A and SUPER CORR B. The operating bases are implementing the recommendations of 15 years of research in this area. Additionally, the author has learned that the F-16 MIL-L-87177 Corrosion Prevention Program, is referenced specifically in the Reports To Congress [12] - Status Update, May 2005.

Navy Initiatives
In February of 2005 a white paper [2] was released by Karl M. Martin of the P-3 FST-4 engineering group in Jacksonville, FL. The author suggests Mr. Martin's paper as an excellent reference concerning Navy initiatives and MIL-L-87177 successes. In this work he describes a 224 day engineering prototype effort using MIL-L-87177 in aerosol form approximately 100 components were treated with MIL-L-87177A during an ISIS phase inspection. Electrical connectors were separated, treated internally, reconnected, and treated externally.

Figure 10.0 - P-3 flap well cannon plug shorted due to moisture intrusion and corrosion.

After 224 days, cannon plugs and other electrical connectors were separated and visually inspected. No corrosion was found on or in components treated with MIL-L-87177A. No negative conditions or failures were reported throughout the 224-day time frame on any components treated. P-3 FST-6 is currently writing updates to the Isochronal Scheduled Inspection System (ISIS) manuals, NAVAIR 01-75PAA-6(I)-3 and NAVAIR 01-75PAA-6(I)-4, for internal and external treatment of electrical connectors in P-3 wing flap wells, wheel wells, engine nacelles, and in the hydraulic service center. MIL-L-87177A will be applied any time a connector is separated. [2]

In recent discussions with NAV-AIR engineer John Benfer, the author learned that the Navy is moving much more quickly regarding CIL/CPCs on the structures side than the avionics side. CIL/CPC avionics application is best described as "SPO-centric" or isolated to certain test or prototype efforts. Mr. Benfer's group is currently working to get the requisite test data from a contractor (Raytheon) in order to obtain engineering authority to extrapolate the P3 test successes across multiple Navy fixed and rotary wing assets.

The November 2004 DoD Corrosion Prevention and Mitigation Strategic Plan on page 31 table A-11 references Navy sustainment priority projects as follows: "MIL-L-87177 coating for corrosion protection of electrical connectors" [13].

ARMY Initiatives
At the US Army Corrosion Summit in February 2005, program manager Steven F. Carr briefed the success of the AMCOM-NAVAIR Corrosion Partnership. The FY05 Plan called for the qualification and implementation of new corrosion technology solutions. One area of pursuit is use of MIL-L-87177A which is estimated by the partnership to offer an ROI of 6:1.[summit briefing]. The author recently contacted Mr. Carr and spoke with him on the subject of this paper, and this partnership is the most substantial Army initiative underway in the context of CIL/CPCs as of this writing.

WR-ALC F-15 Flight Line Implementation
Currently, during F-15 programmed depot maintenance (PDM) flow at WR-ALC personnel are not "breaking" group A/B connections between the aircraft and the LRU - unless the LRU is scheduled for removal at PDM anyway. Upon induction into PDM many LRUs are taken off the aircraft (mainly

forward fuselage) and are distributed to various organizations on the center. Personnel are not spraying the external surfaces of connectors or wiring. Thus there is ample access to disconnected connectors aircraft side. Personnel are treating the connector contacts only with MIL-L-87177A compliant Super Corr B . The F-15 SPO did not formally establish an engineering baseline upon decision to begin CPC application to connectors two years ago. There is thus no data such as LRUs by serial number to track any improved performance. The author is working with F-15 engineering to chart tail numbers flowing through PDM since start-up of application to determine any CND/RTOK improvement, but F-15 has other reliability improvement initiatives underway such that any CPC application benefits may be masked by other aspects.

Acquisition

"Two companies manufacture MIL-L-87177A, Lektro Tech Inc. of Tampa, Florida and International Lubricant & Fuel Consultants, ILFC, of Rio Rancho, New Mexico. Lektro Tech P/N SUPER CORR-B, NSN 6850-01-328-3617, uses Halon 141B as the solvent. Halon 141B is non-volatile and Super Corr-B is stable from –70 to +550 degrees Fahrenheit. Due to potential environmental regulations involving Halon 141B (a class II ozone depleting substance), Lektro-Tech has reformulated the product. The reformulation using AK225 as recommended by the Environmental Protection Agency (EPA), has shown in testing to be as effective or better than the original. The EPA authorizes the use of Halon 141B until the substantial stockpiles in the United States are depleted, or upon the submission of product usage waivers/coupons. ILFC P/N 1006-CON-TAC uses Ethyl Acetate, a volatile organic compound, as the solvent. Ethyl Acetate has a flash point of approximately 24 degrees Fahrenheit. Due to mixed composition, the material flash point may be slightly higher. The flash point is defined as the lowest temperature at which a liquid produces enough vapor to ignite in the presence of a source of ignition. This source of ignition need not be a flame. The lower the flash point, the greater the risk of fire. The primary component of MIL-L-87177A is polyalphaolephin, which is not flammable or hazardous. MIL-L-87177A does attack acrylic, lexan, polystyrene, and polycarbonates. Lektro Tech produces MIL-L-87177A in both bulk and aerosol forms. At this time, only bulk material is available from ILFC." [2]. The alternative excellent CIL/CPC referenced in Figure 3.0 is D-5026NS, MIL-C-81309 Type II, medium-soft film /zero ozone depleting product. It is available from ZIP Chem in aerosol, quarts, gallons, five gallons, and drums, with special packaging upon request. The following contact information is offered for this 81309 product: ZIP Chem, 400 Jarvis Drive, Morgan Hill, CA 95037, Phone: 408-782-2335, Fax: 408-782-6304.

Conclusions

Since the conclusion of the Battelle work and the publishing of the Sandia Labs report in May 2002, there seems to be a slow rolling wave of cross service component information and education exchange regarding the subject of this paper. This is reflected in the May 2005 Report to Congress and in the November 2004 DoD Corrosion Prevention and Mitigation Strategic Plan. The concern remains that service components may still be using no value added or potentially detrimental (see Figure 3.0) CIL/CPCs in local electrical harness and connector corrosion control initiatives. In the opinion of the Sandia Labs report is potentially the best single artifact seeking to capture commercial and DoD efforts up to May 2002. Additionally, the author offers this AFKM community of practice URL for subject-related artifacts.

HTTPS://afkm.wpafb.af.mil/ASPs/DocMan/DocMain.asp?Filter=OO-DR-WR-05&FolderID=OO-DR-WR-05-3&Tab=0

The US Air Force has been using and testing MIL-L-87177A Grade B aerosol spray for corrosion control in electrical connectors for more than 10 years. As of March 2002, MIL-L-87177 Grade B has been added to the Air Force Tech Order/Manual 1-1-689, Avionics Cleaning And Corrosion Prevention/Control, as a direct substitute or replacement for MIL-C-81309, Type II and III, in all cases. Again it should be pointed out that the technical research and testing shows that at least one 81309 product may offer some "bulletproof" help, this is the ZIP Chem D-5026NS product.

Finally, the author is working with the WR-ALC engineering directorate and platform chief engineers to recommend interim T.O supplements for center PDMs to reflect MIL-L-177 such as those now published by the F-16 SPO, and has advised the platform chiefs to engage the respective SPOs such as the C-130 AMP SPO to take advantage of any opportunities during maintenance or modifications offering non-impact opportunities to clean and spray electrical connectors with MIL-L-177 compliant or the ZIP Chem D-5026NS CIL/CPCs.

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