Electrical Connector Corrosion Prevention Improves Reliability, Reduces Maintenance Man-Hours, Increases Mission Capable Rate, and Reduces Costs

Revision 4

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ABSTRACT

The F-16 Fighter is a proven spectacular combat aircraft, but like most aircraft corrosion plagues its maintainability, reliability, safety, and maintenance cost. An AF Engineer trained in corrosion control discovered dissimilar metals in electrical connector contacts that causes fretting and galvanic corrosion. It appears to have been implicated in six aircraft crashes. Extensive AF corrosion testing of avionics connectors revealed that even MIL-Spec hard gold plated contact connector sets corrode in perceived benign environments to cause intermittents within only six months. The Sandia National Labs reported that the application of MIL-L-87177, Corrosion Preventive Compound (CPC) onto electrical connector contacts "…bulletproofs connectors against chemical and fretting corrosion." A test application on more than 100-aircraft avionics gold-to-gold line replaceable unit (LRU) electrical connectors increased the Mission Capable (MC) Rate an average of 15% and saved millions of dollars just during the test. The Office of the Secretary of Defense (OSD) mandated the CPC application to F-16 connectors as a demonstration for all AF aircraft platforms. The Navy has started using the CPC, also.
KEY WORDS: Corrosion control, galvanic, fretting, dissimilar metals, electrolysis, connectors, tin, gold, intermittents, resistance, graphite, inhibitors, MIL-L-87177, lubricant, humidity, atmospheric, grounding, intergranular, salt, chloride, sea, water, shorts, aerospace, aircraft, missiles, nickel, CPC, intrusion, backplanes, iodine, safety, cables, corrosion protection, MIL-G-45204, MIL-C-39029.

INTRODUCTION

Not all that glitters is a good electrical conductor. Corrosion you can't see may cause your transient or open. NASA's many spectacular achievements have been accompanied by some disasters, one of which was a manned control-module fire on the ground before rocket ignition caused by an electrical connector short circuit and fatal to all. Dissimilar metal corrosion was known to the ancients, but recent studies revealed even MIL-G-45204 hard gold contacts corrode. As material sciences expanded to provide for electricity, the complication of metals and environments demanded more knowledge to prevent electrical circuit corrosion. Electrical connector corrosion is observed in all terrestrial environments even with very low humidity. Figure 1 is an example. A one year evaluation of one F-16 system with gold-to-gold connector contacts revealed Millions in overhaul costs for No-Fault-Found parts believed to have failed just from connector corrosion. DOD has funded implementation of a corrosion preventive compound-lubricant (CPC/Lube) treatment of F-16 electrical connectors to mitigate corrosion which a 3-year study demonstrated significantly improved aircraft mission capability and saved many millions of dollars.

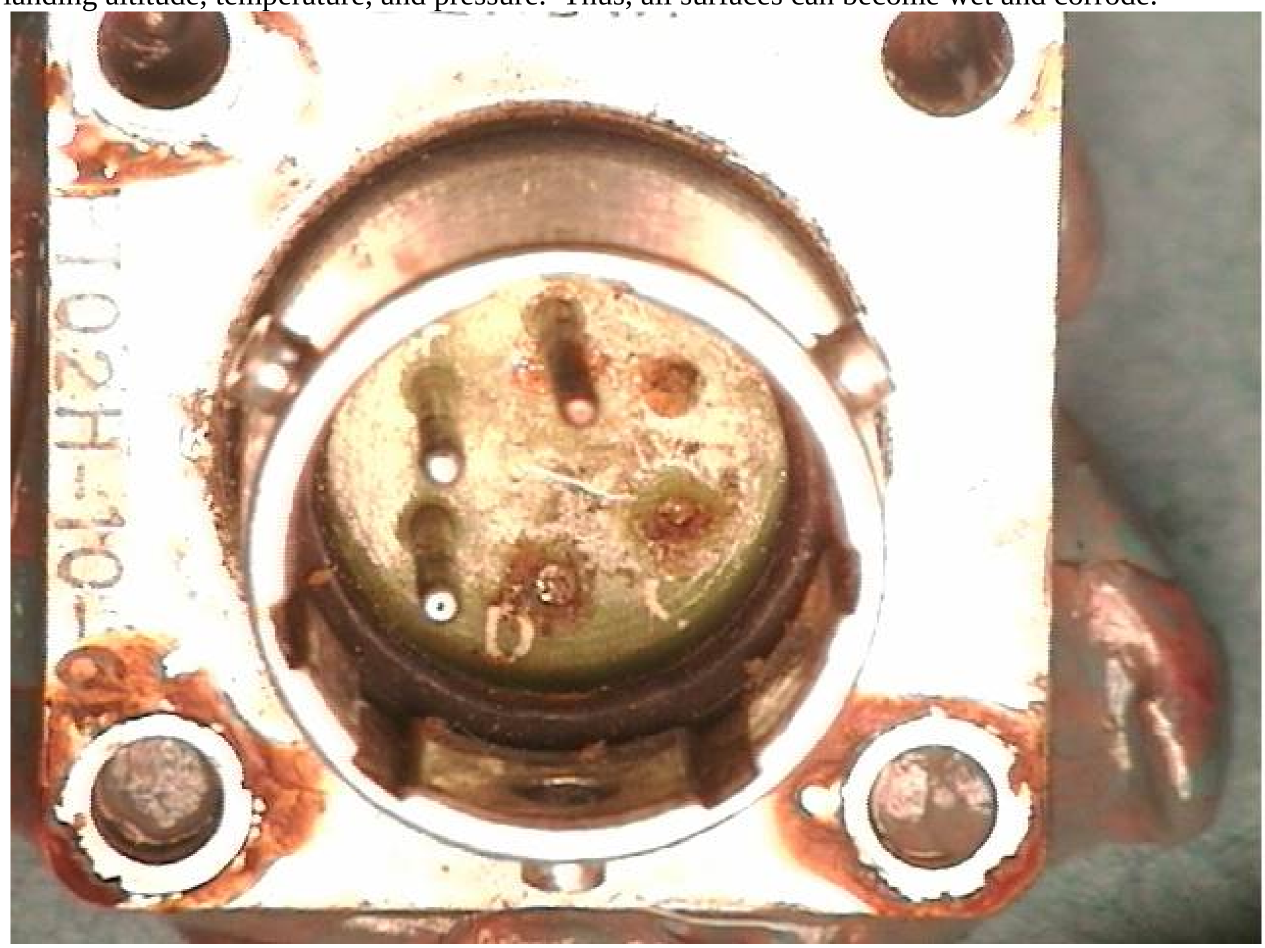
"The significant technical challenges and the high cost directly related to corrosion provide strong incentives for engineers and other technical personnel to develop a firm grasp on the fundamental bases of corrosion."[1] Corrosion suggests an unwanted degradation of a valuable metal that has been won from nature by some chemical or metallurgical reduction process elevating the metal "energy level." Corrosion is a chemical-metallurgical reaction that reduces the energy level of a discrete system composed of a metal, an oxidizer, moisture or some other chemical, and corrosion products, and electricity often is a by-product of the reaction. The oxide or salt corrosion products become like the ore from which the metal was made. Batteries to produce electricity and film exposure are beneficial corrosion reactions. Corrosion products have greater volume than the base metal, (expended batteries may burst) so on electrical connector contacts the corrosion products push the contacts apart reducing the number of current contact "asperities" (the mountains or "protuberances" on the surface of the metal contacts). At the microscopic level you know the contacts are not smooth with full area contact, and current flows mostly between the asperities. During electroplating, metal ions may be attracted to the asperities first elevating their height thus separating the contacts more. Reducing the number of current paths will increase resistance to current flow, and continued forcing the contacts apart may cause intermittent opens or hard opens. Vibration can break loose corrosion products holding the contacts apart resulting in just intermittent opens. Moisture in the corrosion products may allow some current flow among contacts. Corrosion of aircraft Line Replaceable Units (LRUs) costs the military many millions of dollars per year. So, how do we prevent that corrosion?

THE CORROSION TRIANGLE APPLIED TO ELECTRICAL CONNECTORS

Like heat for the initiating energy in the "Fire Triangle," water, sometimes as humidity condensate, frequently is an agent in a corrosion triangle; (1). A metal that can oxidize, (2). An oxidizer like O_2 in the air, and (3). Moisture or some other chemicals. That combination initiates and promotes corrosion in many metals. The initial corrosion may proceed slowly but moisture retained in deep cracks and holes in the metal continuously promotes corrosion even if the metal surface is plated or painted, provided an oxidizer is present or oxygen can pass through holidays in the coating.

MIL-C-39029 hard gold electroplated connector contacts may be the best manufactured contacts, but Battelle while performing an USAF study on corrosion of gold contacts, proved that even these best gold contacts can corrode. Fifty-microinches of hard gold are plated over nickel that is plated over copper. The gold is more noble, cathodic, to both nickel and copper, but were there no gold porosity the surface gold could not react with the nickel. Moisture forms a conductive circuit in pores through which electrons may pass from the nickel surface to the gold causing corrosion. Often more noble metals are plated over more active metals. “Such coatings on steel are therefore expected to act strictly as barriers to prevent corrosion of the steel substrate. For this to be successful, the coatings must be pore free and flaw free….Generally, electroplated or hot dipped coatings that are completely free of pores and other discontinuities are not commercially feasible. Pits eventually form at coating flaws, and the coating is penetrated. The substrate exposed at the bottom of the resulting pit corrodes rapidly. A crater forms in the substrate, and because of the large area ration between the more noble coating and the anodic crater, the crater becomes anodic at high current density.”[2]

Corrosion in early aircraft electrical connectors appears to have been declared prevented by the invention of hermetically sealed connector sets, but military aircraft zoom into the sky for scores of thousands of feet from Standard conditions, 14.7-psi at sea level to less than 5-psi at altitude. Some hermetic seals may prevent pressure differential breeches of a few psi, but a ten-psi differential appears to allow the air in F-16 connectors to vent while ascending to 30,000-ft, 50,000-ft or 75,000-feet and to provide an entry force while descending. Descending aircraft fly through humidified air that will precipitate some of the moisture in the connectors while descending or when the pilot reaches his landing altitude, temperature, and pressure. Thus, all surfaces can become wet and corrode.



Tin plated pin contacts that mated with the harness connector’s gold plated sockets. The connector pins’ configuration in the aircraft as shown above are upward vertical such that moisture and SnO corrosion products could accumulate at the base of the pins. Water was found in these connectors that were called hermetically sealed. Note that pins B, C and D are gone, probably corroded off the fastest at the base where water could puddle, and pin A is very thin at the base. Pins A, B, C, and D were ones that could have had a plus DC voltage. Like this overhaul removal, when the actuator on which this connector is built is overhauled, these connectors are so corroded that they are replaced.

Figure 1.

"Gold is often used decoratively and for electrical contact applications. Gold that is plated directly over copper will increase the corrosion rate of the copper through the unavoidable porosity of the gold deposit. Gold will also rapidly diffuse into copper. Therefore, electroplated nickel or cobalt barrier coatings are normally plated underneath the gold coating. For wear applications, alloys with nickel or cobalt are preferred; however, pure gold has a lower contact resistance. Pulse plating will reduce porosity and increase the hardness of electrodeposited gold." [3]

When "plating holidays" exist, the underlying metal is "visible" to the plate. A moisture bridge between layers is a dissimilar metal couple, and in many metal combinations the corrosion products are salt ions that promote or become high pH corrosive chemicals. Uhlig wrote, "Thin electroplates of gold like those of other metals tend to be pourous."[4] A really heavy electro-plate may cover the holes and cracks, but the aqueous plating solution may be trapped. One option for the problem is to remove the moisture with a water displacing and immiscible thin film compound which neither allows oxygen to pass through nor polymerizes with atmospheric oxygen to form gums as do many popular aerosol lubricants. To eliminate corrosion the corrosion triangle must be prevented.

OMNIPRESENT HUMIDITY

Humidity in the air, a root cause of corrosion, can coat all materials with a very thin layer of water which acts as the electrolyte to form a corrosion cell between metal atoms or crystals. An extensive study of U.S. military Base environments around the world revealed distinctly greater corrosion potential in locations near an ocean or salty waters especially if iodine is in the air, but even dry, desert locations had sufficient humidity to cause corrosion at low or moderate rates. Tin to MIL-C-39029 hard gold dissimilar metal contact corrosion in electrical connectors resulted in significantly elevated resistances and opens within three months in some perceived "benign" environments. Vibrations randomly break the tin corrosion products off the surface of the corroded metal and which allows the contacts to regain continuity, but the increased resistance and intermittent opens continue even after the tin is gone. Then the underlying steel pin is the next metal layer to corrode until the pin either is too small to make contact with the socket, breaks off, or is gone.

NASA CREW MODULE FIRE CAUSED BY ELECTRICAL CONNECTOR CORROSION

Corrosion of the copper of a gold plated pin caused a short circuit that overheated the connector and initiated a fire on the ground in the command module of a NASA Satellite preparing for launch. The failure report stated, "The J-3 connector exhibited a burned off pin ("N") with shorting of adjacent pins. Failure was initiated by an electrolytic corrosion of pin "N" due to presence of moisture and chlorides with a 24-VDC impressed on pin "N" with ground on adjacent pin ". The porosity of the gold plating on the pin was high enough to permit passage of copper ions at several locations." The moisture was introduced primarily from the pressurized suit circuit exhaust while the astronaut's face plate was open and possibly to some degree from spilled drinking water which he wiped up with his handkerchief. Failure report MIR-030

THE SANDIA NATIONAL LABORATORIES' INVESTIGATION

The Department of Energy tasked the Sandia National Laboratories to investigate the causes of corrosion in their best-design-and-manufacture connectors used for electrical circuits in nuclear weapon control equipment on missiles and aircraft. The Abstract of the Sandia report stated,

"Electrical connectors corrode. Even our best SA and MC connectors finished with 50 to 100 microinches of gold over 50 to 100 microinches of nickel corrode. This work started because some, but not all, lots of connectors held in KC stores for a decade had been destroyed by pore corrosion (chemical corrosion). We have identified a MIL-L-87177 lubricant that absolutely stops chemical corrosion on SA connectors, even in the most severe environments. For commercial connectors which typically have thinner plating thicknesses, not only does the lubricant significantly retard effects of chemical corrosion, but also it greatly prolongs the fretting life."

Sandia's Conclusions stated, "Having demonstrated that this material does no harm to connectors and has no migration or material compatibility issues and also that it prevents chemical and fretting corrosion, we have decided to apply MIL-L-87177 Connector Lubricant to all new connectors that go into KC stores. We recommend that it be applied to connectors on newly built cables and equipment as well as material that recycle through manufacturing locations from the field." The main title of Sandia's report was, "MIL-L-87177 Lubricant Bulletproofs Connectors Against Chemical and Fretting Corrosion." See http://infoserve.sandia.gov/sand_doc/2002/021454.pdf.

BACKGROUND ON THE MIL-L-87177 CORROSION PREVENTIVE COMPOUND

In 1983 the AF Materials Lab, now called the Air Force Research Lab (AFRL) wrote MIL-L-87177 to describe a corrosion preventive compound/lubricant that the Bell Laboratories invented to prevent corrosion on their switching equipment and connectors in their metropolitan facilities and at microwave relay stations, many of which were in remote locations and expensive to service. The first characteristics for which the Bell Labs' inventor, Dr. George Kitchen, searched was for water displacing compounds that had a wide liquid temperature range. Not until connector corrosion problems were recognized in the F-16 did the AF begin CPC use. The AFRL is writing MIL-L-87177A amendments to require more parameter characteristics that have been found in extensive testing to be necessary for a true corrosion preventive compound/lubricant for aircraft use.

QUANTITATIVE ANALYSIS OF BIG BUCK, HUGE BUCKS SAVINGS

Many LRUs sent to be overhauled are "No-Fault-Found" (NFF) upon arrival at the overhaul facility. The Air Force pays for a serviceable LRU in return for an exchange whatever its receipt condition. Of 207 different Part Number (P/N) LRUs at least one unit during FY-05 was NFF at overhaul incoming. Table II gives the number of different P/Ns that had NFF units and the percentage band of their units that were NFF. For example, 8% of one P/N were NFF, so it counted as one of the 29 P/Ns in the 0 – 9% column. *Each* of the 28 P/Ns counted in the 100% column were NFF. The total cost paid to the overhaul shops for return of serviceable parts that were NFF was over $30 Million.

TABLE II

Number of P/Ns that had NFF Units Presented by the Percentage of each P/N that were NFF

0 -9%	10-19%	20-29%	30-39%	40-49%	50-59%	60-69%	70-79%	80-89%	90-99%	100%
29	49	42	22	8	16	7	4	1	1	28

FAILURE REPORTS, NO FAULTS FOUND, COSTS, AND CORROSION SCIENCE

The investigation that led the Air Force and now the Navy to treat problem electrical system parts with the MIL-L-87177A CPC/Lubricant was a F-16 an in-flight emergency and very near mishap believed to be caused by a corroded actuator connector like the one in Figure 1. However, the connector on that specific aircraft part when initially examined did not appear to be damaged. Only when the connector pins were examined under a stereo microscope at 20X were the pins seen to have a shoulder near the bottom of the pin. A measurement verified that the shoulder was at the length that the tin plated pins seated in the gold plated sockets on the mating connector, demonstrating that the tin pin diameters had been corroded thinner. Then a second electrical connector problem emerged; pin retention force was realized to be a synergistic failure factor with corrosion.

Tin, in the same way as aluminum, reacts chemically with oxygen in the atmosphere to form a covalent oxide, Al_20_3 for aluminum and for tin SnO, a white powder. Both aluminum oxide and tin oxide can be wiped off by the chafing action of vibration, but the aluminum oxide forms a tight compressive layer over the base metal and is more adherent to the base metal than is tin oxide. This corrosion and chaffing combination is called "fretting." In a vertically positioned connector as shown in Figure 1 chaffing allows the tin oxide, sg. 6.45, to fall to the bottom of the connector where it may form a thin layer with humidity condensate of a somewhat conductive medium to produce shorts among pins. Uhlig wrote, "Fretting corrosion is greatly retarded when the contacting surfaces are well lubricated so as to exclude direct contact with air."[5]

As a result of these findings the F-16 Management Directorate issued a three-year task to Battelle to study the circuitry that was identified as the cause of the near mishap. Battelle evaluated not only the circuitry for potential breaches but also studied the materials used in the wiring and connectors to determine if material degradations could have been implicated in the failure modes. New, dummy, electrical connector sets duplicating those in the failed circuitry were prepared on test plates and numbered; each test plate had a standardized environmental test coupon. Their resistances across the untreated contacts were measured, and MIL-L-87177 CPC/Lube was applied to some connector sets. Both unlubricated and lubricated dummy connector sets were exposed to normal laboratory corrosion test procedures or mounted in aircraft based at Ellington and Great Falls ANG Bases were mounted in the same aircraft bay as the suspect connectors were to determine if the aircraft environments may be a failure mode factor. The dummy test connector contact resistances were measured at intervals, and calibrated sensors were evaluated for resistances and environmental corrosivity, respectively.

The Battelle report evaluated corrosion between the tin-to-gold plated main fuel shutoff valve actuator connector set contacts and reported to Hill AFB in 1992;

"Results were analyzed for the 3-month flight test hardware from both Ellington and Great Falls. The environmental sensors have indicated that for these two locations and for the flight environments experienced by the F-16 during this period, the effective environments in proximity to the MFSOV were noncorrosive. This is a significant result in relation to the results obtained on connector hardware.'

"The dummy, gold-to-tin, connector hardware showed significant electrical degradation during this period. These results have provided some basis for concluding that rapid electrical degradation can occur at the gold-to-tin interface, and that this degradation can occur in the absence of a corrosive environment. The most probable "driving force" was vibration which produced fretting corrosion.' "The most significant electrical degradation on the dummy connectors occurred on unlubricated samples. The lubricated samples showed far lower rates of degradation. These early results may confirm that the use of a lubricant will greatly reduce the probability for the occurrence of an open condition at the gold-to-tin interface."[6]

The F-16 Structures and Systems Engineering Office has instituted a change in the drawings to require for new actuator procurement or overhaul connectors with gold plated pin contacts to replace the tin plated pin connectors in that circuit. Existing connector sets with tin-to-gold contacts are treated with MIL-L-87177A Grade A or B at least every 100-flight hours.

IDENTIFYING PARAMETERS FOR EFFECTIVE CORROSION PREVENTIVE COMPOUNDS

The AF Material Command office responsible to improve fasteners, actuators, connectors, tools, and subsystems (FACTS Office) heard of Battelle's F-16 investigations and the use of MIL-L-87177 to mitigate corrosion. The FACTS Office tasked Battelle to perform tests to identify the requirements to provide excellent electrical connector reliability and to identify materials that would provide the excellent reliability required for AF aircraft.

The testing revealed surprising results. The amazing and disasterous corrosion results demonstrated with connector sets with tin-to-gold contacts and the only moderate improvement by the use of a lubricant on those dissimilar metal contacts already was established by the previous tests. The subsequent tests were performed exclusively with dummy connector sets with MIL-Spec 50-microinches of hard gold over nickel connectors. The parameters Dr. Kitchen and Battelle identified plus some additional recognized since that testing needed to maintain high reliability connectors are:

1. A thin film, water displacing material that coats the metal in the connectors completely but spreads at asperities to allow conductivity with low or no increased electrical resistance;
2. Sufficient lubricity to prevent fretting and for close tolerance moving part application;
3. Immiscible with water to prevent water to penetrate CPC/Lube to reach the covered metal;
4. Not more than ten-milliohms contact resistance increase across MIL-C-39029 gold-to-gold contacts for at least a two year period in a known severely corrosive environment;
5. A self-healing quality that maintains the low contact resistance, less than 10-milliohms greater than new even after dismated and remated once after being placed in service for one year;
6. Occupational safety and health benign materials in the CPC/Lube formulation;
7. Not flammable;
8. Adherent to the metal so that moving water and wind does not remove it from the metal surface;
9. Wide temperature liquid range to allow maintaining contact coverage,
10. Not polymerize with O_2 in the air or other prominent chemical like fuel vapor and form gums;
11. Very low CPC/Lube base material vapor pressure to prevent evaporation even at high altitudes;
12. Prevent corrosion on 1010 steel test plate for two-years in Myrtle Beach test center;
13. Material compatibility with connector packing, metals, and seals;
14. Material compatibility with aircraft and AGE wiring insulation, transparencies, and plastics;
15. No corrosion on copper for two-years in Myrtle Beach test center;
16. High voltage breakdown resistance and Battelle electro migration test;
17. Non-Flammable as per USA Flame Projection Test;
18. Decomposition temperature 550-deg F (min) for use on jet engines and missile connectors;
19. Freezing point: minus, -70-degrees F (max)
20. Lubricant vaporization: <50% weight loss after 1000-hours at 80-deg C per IBM Test Method;
21 Initial Contact Resistance on Card Edge connectors per Battelle procedure;
22. Low Temperature Performance per Battelle procedure;
23. Thermal Ageing per Battelle procedure;
24. Durability Cycling per Battelle procedure;
25. Vibration Tolerance and Recovery per Battelle Procedure;
26. Temperature-Humidity Corrosion test per Battelle procedure;
27. Corrosive Gas Saturation per Battelle procedure;
28. Not affected by high frequency current and voltages or cause impedance to HF, VHF, etc;
29. Moderate storage temperature capability to prevent bursting the can in trucks in hot places;
30. Not harbor or capture dust, sand, or such foreign matter;
31. Non magnetic and specific gravity less than 1.0 to mitigate attracting dust more than water;
32. No solidifying to buildup of the CPC/Lube on connector parts with repeated applications;
33. Not have an obnoxious smell that could nauseate an applier or pilot;
34. Any aroma dissipates within a short time, within 24-hrs at Standard Conditions, STP.
35. Sufficiently low VOC to comply with all US and foreign user standards where needed.

These requirements will be prepared for the MIL-L-87177 revision.

OPERATIONAL EVALUATION OF CPC/LUBE EFFECTS ON F-16 AVIONICS CONNECTORS

The FACTS Office also funded a two year operational test, using the two CPCs determined to be the best products in that test, on specific F-16 avionics LRU electrical connectors and the attach harnesses with more than 100 aircraft at six Air National Guard, two Air Force Reserve Bases, and one Air

Combat Command Base. One ANG Base just cleaned their connectors for the first year and then treated them the second. Also, two of the Bases treated about ten, and their LRU reliability data were compared with not only the universe but also their untreated aircraft. The reliabilities of the treated LRUs at each Base were monitored aircraft by aircraft, and the composite data for their treated aircraft at each Base were compared with the composite data from the ANG universe.

The results of the operational study are:

1. Significant reductions in the number of "pulls," the avionics LRUs that the pilots reported failed in flight and were removed from the aircraft;
2. Significant reduction in the number of LRUs that were pulled but the problems "could not duplicated" (CND) in the backshop.
3. Significant reduction in the number of avionics LRUs "exchanges" sent to be overhauled;
4. The average mean time between demands (MTBD) for the treated aircraft LRUs was greater than 2.6 times the universe rate.
5. The maintenance man hours (MMH) required to keep the treated aircraft "mission capable" (MC) was a third less than the universe MMH per aircraft.
6. Although the participating Base personnel were requested to report any difficulties or personal problems associated with the CPCs no negative report was received. Instead one Base continued to CPC/Lube treat all their aircraft connectors with MIL-L-87177A, and the Maintenance Chief Master Sergeant recently reported they not only still are doing it, but also they love it. It improves their MC status, improves their sortie completion rate, reduces their MMH, reduces their LRU exchange rate and reduces their exchange costs. The Master Sergeant who monitored their test reported that each of the aircraft that were treated cost $600K less/year to maintain than their untreated aircraft.

MIL-L-87177A GRADES A AND SUPER CORR B USE AS LUBRICANTS

The Navy uses MIL-L-87177A as a corrosion preventive lubricant on the P-3 Aircraft Jackscrews, on electrical connector contacts, and on bare metal with phenomenal improvements and cost savings. Although the Air Force has concentrated on the MIL-L-87177A as a CPC, the enduring base material is similar to organic compounds produced by some major petroleum manufacturers for their wide liquid temperature range tolerant synthetic lubricants. The grade for this specification has a much lower normal force tolerance than the engine oils, but one of its glories is that the normal force between connector contacts is adequate to spread the oil allowing electrical continuity at asperities where the electrical contact normally occurs anyway. The synthetic engine oils are not recommended for connectors, but this CPC-lubricant which keeps water off the metal may prevent ice forming on stores release mechanisms that in present practice do not release from aircraft reliably.

TESTING TO VERIFY IMPROVEMENTS IN THE CPC/LUBRICANT FORMULA

The most recent Air Force investigation, 2002 to 2005, demonstrated that changes in the formulas of more than one product that were expected to be of negligible effect resulted in significant reductions in the CPC's ability to prevent corrosion. Also, the vendor of one product that Battelle tested in the 1994 study and was a very poor CPC changed its formula for the 2002 and is selling it as an improved formula, but it still is a poor CPC. In this most recent testing the water displacing, water immiscible, wide temperature liquid, thin film showed the MIL-L-87177A Grades A and B to be the best CPCs for conditions tested and Air Force requirements.

OTHER WEAPON SYSTEM SUCCESSES USING MIL-L-87177A

Other aircraft platform managers already have begun testing some of their LRUs to estimate the benefits from the CPC/Lube, and some have implemented the CPC/Lube to conquer corrosion problems they have experienced but had no solution but to overhaul parts frequently. The A-10 Generator Control Unit (GCU) which has had a MTBD of only 30-days. Water puddles in the unit and shorts the power. The GCU overhaul shop treated in overhaul, and they even treated one before overhaul by connecting it to the electrical test bench, found it worked okay, immersed it in a bucket of water in which it continued to operate perfectly. They CPC/Lube treat all their GCUs now after overhaul and not one treated unit has been returned for overhaul in more than six-months.

The National Stock Numbers and Part Numbers for the MIL-L-87177A Grades A and B are: Grade A, Super Corr A, NSN 6850-01-528-0653; Grade B, Super Corr B, NSN 6850-01-328-3617.

SUMMARY

The Corrosion Triangle can be conquered in electrical connectors by application of MIL-L-87177A Grades A or B for which National Stock Numbers have been established, and the Grade B has been in use by the Air Force for 17-years with extensive successful testing during that time.

The F-16 electrical connector corrosion preventive compound-lubricant treatment tests revealed the following results:

1. Significant reductions in the number of avionics LRU failures reported to the pilots;
2. Significant reduction in the number of LRU backshop CNDs;
3. Significant reduction in the number of avionics LRUs “exchanges” sent to be overhauled;
4. The average mean time between demands (MTBD) for the treated aircraft LRUs was greater than 2.6 times the universe rate.
5. The maintenance man hours (MMH) required to keep the treated aircraft “mission capable” (MC) was a third less than the universe MMH per aircraft.
6. No negative reports from the participating Bases. Instead the users universally have been delighted with the results of CPC/Lube treating their electrical connectors.
7. The only negative comments known were generated by groups who either had not used the CPC/Lube or had a vested monetary interest in assuring the AF did not reduce the number of exchanged LRUs. Instead, every report received from organizations that have tested MIL-L-87177 A (Super Corr B) to solve a corrosion problem on their equipment has demonstrated the excellence of this CPC/Lube, the improvement in their hardware reliability, the savings in maintenance efforts, the improved mission capability of their platforms, the reduction in costs, and everyone’s increased confidence in the condition of their equipment.

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