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US NAVAL AIR FORCE
AVIONIC AND ELECTRICAL SYSTEM CORROSION PREVENTION AND CONTROL MAINTENANCE

by

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1. A study of premature failures of installed avionics, electrical equipment, and systems experienced in US Fleet operational aircraft in the 1960s and early 1970s was reported in reference (1). These failures were caused by corrosion, water intrusion, and other contaminating agents. In order to reverse this trend the Commanders Naval Air Forces US Atlantic and Pacific Fleets (COMNAVAIRLANT) (COMNAVAIRPAC) requested that Commander Naval Air System Command (COMNAVAIRSYSCOM) develop a corrosion prevention and control program for avionics, electrical and installed systems used in naval aircraft. COMNAVAIRSYSCOM tasked the Naval Air Development Center (NAVAIRDEVCEN) to develop the program together with a technical manual. A conference with all interested parties was held in 1976 and action initiated to develop the program and technical manual for use by the fleet technicians.

2. A review was conducted to assess the overall problem.

a. How to clean avionics, remove corrosion, restore protective finishes; what corrosion preventives could be used on avionics without degrading performance of the equipment; who to reclaim equipment that had been exposed to corrosive agent. Each issue required answers.

b. The agents causing corrosion were identified, i.e., salt water, sea environment with 100% humidity, maintenance chemicals, stack gases, high temperature, cyclic temperatures, moisture, galvanic action in the operating environment between dissimilar materials, microbial, insect, bacteria, fungi producing environment, etc.

c. Metallic

What kinds of corrosion can we expect to see?

(1) Uniform surface attack (e.g. Fig.1)

(2) Galvanic (e.g. Fig.2)

(3) Pitting (e.g. Fig.3)

(4) Crevice (concentrated cell)

(5) Intergrannular

(6) Stress

(7) Exfoliation

(8) Erosion

(9) What does it look like? (See Table 1)

d. Non-metallic deterioration

(1) Mechanical failure

(2) Cracking

(3) Swelling

3. The results of corrosion or contamination can cause failure of the equipment or undesirable alteration of its electrical characteristics. The list of all types of material used in avionics would be extensive; most have an ability to function well individually and would last the life of the component. However, the synergistic effect when dissimilar materials are exposed to a corrosive environment is often corrosion.

a. Special Consideration. The control of corrosion in avionic systems is not unlike that in airframes, with procedures useful for airframes being applicable to avionics, with appropriate modifications. The general differences in construction and procedures between airframe and avionics relative to corrosion control are as follows:

(1) Less durable protection system

(2) Very small amounts of avionics corrosion can make equipment inoperative, as compared to airframes.

(3) Dissimilar metals are often in electrical contact.

(4) Stray currents can cause corrosion.

(5) Active metals and dissimilar metals in contact are often unprotected.

(6) Closed boxes can produce condensation during normal temperature changes during flight.

(7) Avionic systems have many areas to trap moisture.

(8) Hidden corrosion is difficult to detect in many avionic systems.

(9) Many materials used in avionic systems are subject to attack by bacteria and fungi.

(10) Organic materials are often used which, when overheated or improperly or incompletely cured, can produce vapors which are corrosive to electronic components and damaging to coatings and insulators.

b. Investigation revealed a second special consideration was microbial, fungi, insects and animals causing corrosion in avionics. See Table 2.

(1) **Microbial, Insect and Animal Attack**

(a) *General.* Microbial attack (which includes mold, bacteria and fungi) creates by-products that will cause corrosion. Modern avionic equipments, because of their complexity, dense packaging, and higher sensitivity, are more susceptible to damage from microbial attack than earlier systems. Mold, bacteria and fungi are living members of the plant world and, in most cases, must have water to live. The organisms causing the greater corrosion problems are bacteria and fungi. In addition to microbial attack, avionic equipment is susceptible to insect and animal damage which can result in corrosion.

(b) *Bacteria.* Bacteria may be either aerobic or anaerobic. Aerobic bacteria require oxygen to live. Oxygen can accelerate a corrosion atmosphere by oxidizing sulfur to produce sulfuric acid or by oxidizing ammonia to produce nitric acid. Bacteria living adjacent to metals will promote corrosion by deleting the oxygen supply or by releasing metabolic products. Anaerobic bacteria, on the other hand, can survive only when free oxygen is not present. The metabolism of these bacteria requires them to obtain part of their sustenance by oxidizing inorganic compounds such as iron, sulfur, hydrogen, and nitrogen. The resultant chemical reaction causes corrosion. Because of the acidic nature of bacterial microorganisms, metals are susceptible to microbial attack. Minor surface contamination can be accelerated into a major corrosion problem by local bacterial corrosion cells, or by additional acids liberated by the bacteria.

(c) *Fungus.* Fungus is a microorganism growth that feeds on organic materials and generally takes the form of molds, rusts, mildews, and smuts. Fungal growth requires specific environments and nutrients for survival. Fungi are commonly found in the following colors:

Black
Yellow
Green
Blue-Green

(d) *Fungi-Producing Environments.* While low humidity does not kill the fungi microbes, it slows their growth. Ideal growth conditions for most fungi microbes are temperatures between 68°F (20°C) and 104°F (40°C) and a relative humidity between 85 and 100 percent. It was formerly thought that fungal attack could be prevented by applying moisture-proof coatings to nutrient material or by drying the interior of compartments with desiccants. It is now known that some microorganisms remain in spore form for long periods, even under extremely dry conditions. Furthermore, electrical insulating varnishes and some moisture-proofing coatings are attacked by mold, bacteria, or other microbes, especially if the surfaces on which they are used are contaminated. Dirt, dust and other airborne contaminants are the least recognized contributors to microbial attack. Even small amounts of airborne debris can be sufficient to promote fungal growth.

(e) *Fungi Nutrients.* It has long been thought that materials such as wool, cotton, rope, feather, and leather were the only materials known to provide sustenance for fungi microbes. The increasing complexity of synthetic material makes it difficult or impossible to determine from the name alone whether a material will support the growth of fungus. Many otherwise resistant synthetics are rendered susceptible for fungi attack by the application of a plasticizer or hardener. The service life, size, shape, surface smoothness, and cleanliness of the equipment, its environment, and the type of fungi microorganism involved all determine the degree of fungal attack.

(f) *Damage.* Damage resulting from microbial attack can occur when any of three basic mechanisms or a combination of mechanisms is brought into play: Fungi are damp and have a tendency to hold moisture, which contributes to other forms of corrosion; because fungi are living organisms, they need food to survive. The food is obtained from the material on which the fungi are growing; these microorganisms secrete corrosive fluids that attack many materials, including some that are not fungi nutrient. Optical devices can also be damaged by microorganisms. Lens coatings are extremely susceptible to fungal attack which will take any of three forms: A spiderweb, a flat starfish shape which leaves a milky stain, or minute circular spots that etch the glass. Under proper atmospheric conditions, fungi can grow on almost any surface. (see Fig.4).

(g) *Corrosion Caused by Insects and Animals.* Damage to avionics equipment can be caused by small insects and animals, expecially in tropical environments. Equipment in storage is most susceptible to this type of attack, since insects and small animals may enter through vent holes or tears in packaging. In some cases insects have entered small openings, pitot lines and air vents in aircraft causing blockage. In the case of packaged equipment, they may build nests which tend to absorb moisture. This moisture, plus excretions and salts from the insects and animals, can cause corrosion and deterioration that goes unnoticed until the equipment or system is put to use and fails. Another type of damage can occur when electrical insulation, varnishes, and circuit board coatings become food for insects. Once bare wires or circuit components are exposed, more areas become available for corrosion and shorting to occur. See Table 3.

d. **Design, Packaging and Location of Avionics in Aircraft.** Prime contractor aircraft manufacturers allocate space inside aircraft for avionics equipment, and procure avionics from subcontractors. The subcontractor designs the equipment to meet allocated space and performance standards provided by the prime contractor. The equipment may require vented cooling or the equipment may be placed in the aircraft in an area susceptible to water leaks through airframes, resulting in water intrusion and equipment failure.

(1) Requirement. Each unit of avionics equipment must be designed to stand on its own in the operating environment and to be resistant to water intrusion, moisture, EMI and corrosion.

(a) Lids should be shoe box type.

(b) Fasteners should be located in vertical walls of the box vice on the lid.

(c) Cooling and venting should be designed to ensure that water cannot enter through cooling or venting duct holes.

(d) Cables connecting system to boxes must have drip loops.

(e) Avionics manufactures must get feedback information on reliability of equipment.

(f) Electrical connectors must be protected from the environment.

4. Lessons of the foregoing short history and findings of the assessment have been applied and have resulted in the development of a very successful avionics and electrical corrosion prevention and control program being conducted throughout the US Fleet.

5. We will now go through a standard maintenance cycle of a failed component. A failed component is removed from the aircraft and inducted into the second level of maintenance, the Aircraft Intermediate Maintenance Department (AIMD), to determine and correct the problem in the failed equipment. The equipment is opened and visually inspected for corrosion or contaminates. If corrosion is detected, the equipment is forwarded to the cleaning and corrosion work centers or shops. The equipment is disassembled by a trained technician. The corrosion is removed by miniature grinding tools, simple eraser, miniature grit blaster (Fig.5), or hand polisher. The mildest method is always used. General cleaning: The components are made ready to ensure water or cleaning agent does not damage interal components, (see Table 4.1 and 4.2). The component is then water washed, using a detergent water mix of nine parts water to one part detergent. Detergents used are under MIL-specification MIL-D-16791 (nonionic) or MIL-C-43616 with 16-1 mix, with a PH under 10. The clean components are then placed in a drying oven and dried at 130°F (54°C) where the drying time is dependent on the complexity of the equipment or component being dried — normally 3 to 4 hours are required. A hot air gun may also be used for spot drying. Table 5 contains basic avionics cleaning requirements, a list of cleaning chemicals, recommended cleaning process, and cleaning and drying restrictions.

a. Some component boxes, chassis, metal component may be cleaned using the ultrasonic cleaning method with solvent, i.e. *Trichortrifluoroethane* MIL-C-81302. Care must be taken not to expose the technician to this material as the material will remove oils from the body exposed to a solvent vapor and displaces oxygen. This material should always be used in small amounts in a well ventilated area. Face shield, rubber gloves and coveralls should be used when ultrasonic cleaning is conducted. An advantage to ultrasonic cleaning is drying time which is reduced to between 15 seconds and 3 minutes. A disadvantage to ultrasonic cleaning is that some frequencies in the cleaning unit can damage some circuits and components. Therefore components to be ultrasonically cleaned must be identified by engineering authority.

b. Hand cleaning with MIL-C-81302 can be accomplished by using a soft bristle brush.

c. When the equipment has been cleaned and any corrosion discovered has been removed and arrested the equipment is returned to the repair and check technician. The equipment is repaired and tested if required and corrosion prevention compound MIL-C-81309 type 3 class 2 aerosol is applied to internal areas of the equipment (see Fig.6 and Table 5). The material is spread on and the excess is wiped off leaving a thin nonconductive film of water displacing corrosion preventive compound. If contact points are involved points must be wiped to ensure nonconductive film is removed. The equipment is then closed and sealing materials are used as required to ensure water or corrosive fluids of any form can not enter the box. Three basic sealants are used meeting MIL-specific MIL-S-8802, MIL-S-81733 or room temperature vulcanizing (RTV) MIL-A-46146. Normally sealed areas are lids around fasteners and connector ports. The Ready for Issue (RFI) compponment is then packaged and returned to the user or held in a store room until needed. (See Fig.7 and Table 6).

d. The first maintenance level (squadron) receives the RFI component and begins installing the component in the aircraft. The technician opens the access panel and inspects the area in whicht the component is to be installed (usually in a shock mounted rack) to ensure the area and shock mounted rack are clean and free from corrosion or contaminates. When satisfied the area is clean, the component is installed. The technician then inspects and hand cleans the electrical connector. The female connector is treated using MIL-C-81302 and a soft bristle brush after cleaning. MIL-C-81309 Type 3 Class 1 avionics grade water displacing corrosion prevention compound is applied to the female connector and the excess is wiped off and the connector is connected to the component. The component is then tested using aircraft power to complete the installation.

6. Electrical connectors: Electrical connectors have historically been prone to corrosion problems, as discussed in reference (1). However, since the avionics corrosion prevention and control program has been implemented, the problems are disappearing. Periodic maintenance is conducted on all aircraft connectors ranging from daily to 180 days or longer in some installations. Maintenance of connectors consists of keeping the connectors clean and dry, free from corrosion internally and externally. This is accomplished as follows:

a. Connectors Directly Exposed to the Environment. The connector is opened and inspected if corrosion is detected on pins or body of the connector, it is removed by the mildest method possible. The connector is then inspected with a 10X glass to ensure all corrosion product has been removed; the connector is then cleaned using an acid brush and MIL-C-81302. The female end of the connector is sprayed with MIL-C-81309 Type 3 Class 2 water displacing corrosion prevention compound; the excess is wiped off. It is reconnected and wiped off with a clean rag wet with MIL-C-81302 to remove body oils, fingerprints, etc. The external area of the closed connector is spread with MIL-C-85054 AMLGARD. The AMLGARD is allowed to dry 30 minutes and a second coat is applied. In extreme cases the connector is wrapped with electrical insulating tape painted with RTV 3140. (See Fig.7.)

b. Test connector treated in this manner has been exposed on aircraft carriers for as long as 18 months with no degradation to the connector (see Fig.8).

7. Connectors internal to the aircraft are cleaned in the same manner as described above for the external connector. With MIL-C-81309 Type 3 Class 2 applied inside the connector frequency of preventative maintenance is dictated by operating environment.

a. Additional connector maintenance — sealing: Sealing the back shell of multi pin environmental connectors becomes necessary under some conditions, i.e., when side loads are applied to pins, when wetting agents are used in the connector back shell areas. When these conditions exist, the back shell of the connector is sealed as follows: The retainer ring and backshell are loosened and slid up the wire bundle exposing the rubber grommet containing wire receptacles.

b. The area of the rubber grommet is cleaned using an acid brush and MIL-C-81302, verifying that sealing plugs (dog bones) are installed in unused wire receptacle cavities. Sealant is applied (RTV-3140 alcohol cure), to the back side of the rubber grommet, working the nozzle of the applicator through the wire bundle to ensure complete coverage (see Fig.7). Sealant thickness should not exceed 1/16" (1.59 mm). Additional sealant may be added. However, at no time shall sealant exceed 1/8" (3.2 mm) thickness. Position connector face parallel to the floor/deck for 30 minutes for initial cure of sealant. After 30 minutes, the connector may be reconnected; however, the sealant will require 24 hours for complete cure.

8. When this procedure was developed RTV-118, which is an acetic acid cure material, was selected because it is clear, allowing the electronic technician to read pin numbers on the sealed back of the grommet. Wires can be changed with sealant in place using standard tools. When a wire is replaced a drop of sealant is placed in the area where work is accomplished. RTV-118 has been replaced with clear RTV-3140 which is a clear alcohol cure material eliminating the corrosive acetic acid. RTV-118 can be used, but time for a full 24 cure must be used to which requires connector to remain open preventing corrosion caused by gas off of the acetic acid. The only acetic acid cure material in use is RTV-730 which is a white high temperature material with a working temperature of 550°—600°F (287°—315°C). Use of RTV-730 must be authorized by engineering authority.

9. EMI Bonding Corrosion: Over the past 20 years, the electronic world has made tremendous advances in technology. In the development of low power microelectronic systems, the new equipment is light in weight, small in size, ideal for use in aircraft where weight and size are factors. The new systems are generally very dependable and are replacing the more cumbersome mechanical systems used in today's and earlier aircraft, i.e., fly by wire, autopilots, weapons control systems, etc. However, the new low power microelectronic equipment and systems are susceptible to electromagnetic interference (EMI) caused by high power electronic/electrical sources external to the affected system or equipment, resulting in system/equipment malfunction. To prevent EMI problems, the equipment/systems are shielded and grounded by bonding to the aircraft. Most of the materials selected for bonding by the electronic engineers have been good conductors of electricity but are cathodic to the aluminum substrate they are attached to, causing galvanic cells to be formed, resulting in corrosion (see Fig.9).

Facts

a. Corrosion of the airframe is caused by bonding material.

b. Airframe corrosion requires correction or structural repair.

c. Bond is lost, making the bonded equipment and system susceptible to EMI as bond cannot be maintained due to corrosion product.

d. EMI protection systems are required to ensure operation of modern microelectronic systems.

Some bonding systems that have been used:

a. Berrylium copper strips (see Fig.9).

b. Silver filled epoxy bonding material which is hydroscopic.

c. Aluminum to steel, etc. (see Fig.10).

d. Silver loaded silicon rubber EMI seals.

Action needed:

a. Development of EMI protective systems/materials that will provide required protection that will not cause corrosion in the operating environment.

b. Development of electronic systems that will stand on their own in an EMI environment.

10. The US Navy is investigating a and b above to determine the best, most economical method to provide required protection to electronic systems and stop the corrosion from occurring.

As stated above, this successful program is established throughout the US naval aviation community. It was established in accordance with Chief of Naval Operations (CNO) Instructions 4790.2C and amplified by COMNAVAIRLANT/COMNAVAIRPAC instructions. Technical information is provided in the Avionics Cleaning and Corrosion Prevention/Control Manual NAVAIR 16-1-540. Training is provided to supervisors and electronic technicians and mechanics by Naval Air Maintenance Training Detachment (NAMTRADET), Naval Air Rework Facilities

(NAVAIREWORKFAC) and on-site Naval Aviation Engineering Service Units (NAESU). Detailed requirements for AIMD and operational squadrons are contained in COMNAVAIRLANT/COMNAVAIRPAC instructions as follows.

a. Each activity shall establish an avionics cleaning and corrosion prevention/control program that will function on a day to day basis.

b. Avionics corrosion team members shall receive NAMTRADET training before they are considered qualified.

c. Avvionics Office shall have NAMTRADET training.

d. Establish an avionics equipment emergency reclamation team in each fleet activity. Emergency reclamation shall consist of electronic technicians who are trained to recover avionics equipment that have been explosed to unusually severe corrosive condition e.g., salt water immersion, fire extinguishing agents, battery acid, etc.

11. In order to ensure future designs for avionics components are more corrosion resistant, the Chief of Navy Material has issued guidelines for prevention and control of avionics corrosion (NAVMAT P 4855-2 dated June 1983). This document was developed and made available to industry.

12. **Conclusion**

a. Avionics corrosion damage can be minimized on aircraft and other military equipment by a dynamic corrosion prevention/control program.

b. Detailed training of involved personnel must be provided.

c. As new material becomes available the occurrence of avionics corrosion can be reduced through designing boxes that will not leak and material selection, i.e., non-corrosive materials for construction of component/equipment. ~~(See~~ Fig.11.)

d. Close cooperation between ~~all facets~~ i.e. the avionics/aerospace community, is needed to insure that the most durable, reliable avionics/electronics are provided to the armed forces.

REFERENCES

(1) G.T.Browne — COMNAVAIRLANT US Fleet Aircraft Corrosion AGARD CP-315 1981.

(2) — US Naval Air Systems Command Avionics Cleaning and Corrosion Prevention/Control Manual N/A 16-1-540.

(3) Irving S.Shaffer — NAVAIRDEVCEN Warminster PA Corrosion in Naval Aircraft Electronic Systems AGARD CP-315 1981.

Table 1: Corrosion of Metals — Nature and Appearance of Corrosion

Alloy	Type of attack to which alloy is susceptible	Appearance of corrosion product
Aluminum Alloy	Surface, pitting and intergranular.	White or gray powder.
Titanium Alloy	Highly corrosion resistant. Extended or repeated contact with chlorinated solvents may result in embrittlement. Cadmium plated tools can cause embrittlement of titanium.	No visible corrosion products.
Magnesium Alloy	Highly susceptible to pitting.	White powder snowlike mounds, and white spots on surface.
Carbon and Low Alloy Steel (1000—8000 series)	Surface oxidation and pitting, surface and intergranular.	Reddish-brown oxide (rust).
Stainless Steel (300—400 series)	Intergranular corrosion. Some tendency to pitting in marine environment (300 series more corrosion resistant than 400 series)	Corrosion evidenced by rough surface; sometimes by red, brown or black stain.
Nickel-Base Alloy (Inconel)	Generally has good corrosion-resistant qualities. Sometimes susceptible to pitting.	Green powdery deposit.
Copper-Base Alloy (Inconel)	Surface and intergranular corrosion.	Blue or blue-green powder deposit.
Cadmium (used as a protective plating for steel)	Good corrosion resistance. Will cause embrittlement if not properly applied.	White, powdery corrosion products.
Chromium (used as a wear-resistant plating for steels)	Subject to pitting in chloride enviroments.	Chromium being cathodic to steel, does not corrode itself, but promotes rusting of steel where pits occur in the coating.
Silver	Will tarnish in presence of sulfur.	Brown to black film.
Cold	Highly corrosion resistant.	Deposits cause darkening of reflective surfaces.
Tin	Subject to whisker growth.	Whisker-like deposits.

Table 2: Effects of Moisture and Fungi on Various Materials

Part or Material	Effect of Moisture and Fungi
FIBER: Washers, supports, etc.	Moisture causes swelling which causes the support to misalign, resulting in binding of support parts. Destroyed by fungi.
FIBER: Terminal strips and insulators.	Electrical leakage paths are formed, causing flashovers and crosstalk. Insulating properties are lost. Destroyed by fungi.
LAMINATED PLASTICS: Terminal strips and boards, switchboard panels, etc., tube sockets and coil forms and connectors.	Insulating properties are lost. Leakage paths cause flashovers and crosstalk. Delamination occurs and fungi grow on surface and around edges. Expansion and contraction under extreme temperature changes.
MOLDED PLASTICS: Terminal boards, switchboards panels, connector, etc., tube sockets and coil forms.	Machined, sawed or ground edges of surfaces and supporters of fungi, causing shorts and flashovers. Fungi growth reduces resistance between parts mounted on plastic to such an extent that the parts are useless.
COTTON LINEN, PAPER AND CELLULOSE DERIVATIVES: Insulation, coverings, webbing, belting, laminating dielectrics, etc.	Insulating and dielectric properties are lost or impaired, causing arcing, flashovers and crosstalk. Destroyed by fungi.
WOOD: Cases, houses and housings, plastic fillers, masts, etc.	Dry rot, swelling and delamination caused by moisture and fungi.
LEATHER: Straps, cases, gaskets, etc.	Moisture and fungi destroying tanning and protective materials, causing deterioration.
GLASS: Lenses, windows, etc.	Fungi grow on organic dust, insect track, insect feces, dead insects, etc. Dead mites and fungi growth on glass obscure visibility and corrode nearby metal parts.
WAX: For impregnation.	Fungi-inhibiting waxes which are not clean support the growth of fungi, cause destruction of insulating and protective qualities, and permit entrance of moisture which destroys parts and unbalances electrical circuits.
METALS:	High temperature and moisture vapor cause rapid corrosion. Fungus and bacterial growth produce acid and other products which speed corrosion, etching of surfaces and oxidation. This interferes with the operation of moving parts, screws, etc., and causes dust between terminals, capacitors, plates or air condensers, etc., which in turn causes noise, loss in sensitivity and arc-overs.
METALS, DISSIMILAR:	Metals may have different potentials. When moisture is present, one of the metals (anode) corrodes.
SOLDERED JOINTS:	Residual soldering flux on terminal boards holds moisture, which speeds up corrosion and growth of fungi. Soldering iron should not come in contact with wire insulation.

Table 3: Effects of Corrosion on Avionic Equipment

Component	Failure Mode
Antenna Systems	Shorts 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 effectiveness.
Control Box Mechanical and Electrical Tuning Linkage and Motor Contacts	Intermittent operation and faulty frequency selection.
Water Traps	Structural deterioration.
Relay and Switching Systems	Mechanical failure, shorts, intermittent operation and signal loss.
Plugs, Connectors, Jacks and Receptables	Shorts, increased resistance, intermittent operation and reduced system reliability.
Multi-Pin Cable Connectors	Shorts, increased 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.
Waveguides	Loss of integrity against moisture, pitting, reduction of efficiency and structural deterioration.
Radar Plumbing Joints	Failure of gaskets, pitting and power loss.
Printed Circuits and Microminiature Circuits	Shorts, increased resistance, component and system failures.
Batteries	High resistance at terminals, failure of electrical contact points and structural deterioration of mounting.
Bus Bars	Structural and electrical failures.
Coaxial Lines	Impedance fluctuations, loss of signals and structural deterioration of connectors.

Table 4.1: Basic Avionics Cleaning Requirements

Always use the Mildest Cleaning Method

1. Pre-Cleaning:
   a. Disconnect power supply
   b. Ensure all drain holes are open
   c. Remove covers, etc.
   d. Disassemble where practical
   e. USE ONLY AUTHORISED MATERIALS
   f. Assure compatibility of material before use
   g. Mask, protect accessories, components to prevent entrance of water, solvent/cleaning component

2. Cleaning equipment hand cleaning tools for hand cleaning:
   a. Cotton lint free cloth
   b. Cheesecloth
   c. Cotton tip applicators (Q tips)
   d. Acid Brush
   e. Toothbrush

3. Cleaning equipment installed/materials:
   a. Spray cleaning booth
      (1) Water
      (2) Water detergent
      (3) Solvent
   b. Ultrasonic
      (1) Aqueous
      (2) Chemical

Table 4.2: Avionic Cleaning Material

Description	Characteristics	Application	Restrictions
Cleaning Compound, Aircraft Surface, MIL-C-43616, Class 1, or Class 1A* or equivalent	General cleaning agent for light soil and dirt in equipment bays, on external cases and covers, and antenna assemblies	Mix one part cleaner in 16 parts water and apply with Cleaning Cloth. Rinse with fresh water and wipe dry.	Do not use around oxygen, oxygen fittings, or oxygen regulators since fire or explosion may result.
	Heavy concentration of surface grime, oil, exhaust smudge and fire extinguishing chemicals in equipment bays and on external cases and covers.	Mix one part cleaner in 9 parts water and apply with Cleaning Cloth. Rinse with fresh water and wipe dry. Cotton cloth.	Never use full strength nor ever allow to dry on surface. Refer to Section IX for emergency cleaning procedures after immersion or exposure to gross amounts of salt water, fire extinguishing chemicals soot, smoke or vaporous gases.
Detergent, Liquid Nonionic MIL-D-16791, Type 1	Cleaning of transparent and acrylic plastics and cockpit indicator glass covers. Also used in the water-based Solvent Spray Cleaning Booth and the Aqueous Ultrasonic Cleaner for removing contaminants.	For hand cleaning, apply with Flannel. Let dry, then remove with dry flannel cloth. Cloth.	Mix 1 fluid oz. per gal. water.

WARNING

Solvents are flammable and solvent vapors are toxic. Keep solvents away from open flames and use only in a well-ventilated area. Avoid solvent contact with skin.

Description	Characteristics	Application	Restrictions
Cleaning and Lubricating Compound, Electrical Contact, MIL-C-83360, Type I	A cleaner-lubricant compatible with potting compounds, rubbers and insulations. Contains 3 to 5 percent silicone. May be used for cleaning and lubricating electrical contacts.	Apply by spraying an even film to the surface. Wipe clean with Disposable Applicator, or Pipe Cleaner.	Do not use as a substitute for MIL-C-81302 Type I or Type II. Avoid application to area requiring soldering or coating.
Cleaning Compound, Solvent Trichlorotri-fluoroethane, MIL-C-81302, Type I (Ultra-Clean)	General cleaner for light to medium surface dust, dirt and contaminants on precision equipment, instruments, etc., where ultra-clean solvent is required. Use in cleanroom applications. May be used to clean dirt and dust from areas where critical soldering is required.	Apply by wiping or scrubbing on affected area with Acid Brush or Toothbrush. Air dry or oven dry, as applicable.	Do not use on acrylic plastics and acrylic conformal coatings. Do not use on unsealed aluminum electrolytic capacitors. Damage may result to end caps and cause leakage.
Cleaning Compounds, Solvent Trichlorotri- MIL-C.81302, Type II	General cleaner for light to medium surface dust, dirt and contaminants on all internal areas of avionic equipment. May be used to clean dirt and dust from areas where soldering is required.	Same as above.	Same as above.

* Aerosol can be used as packaged without additional dilution.

Description	Characteristics	Application	Restrictions
Dry cleaning Solvent, P-D-680, Type II (High Flash Point)	General purpose cleaner for medium to heavy dirt, dust, contaminants and fire extinguishing chemicals in equipment bays and on external cases, covers structural hardware, mounts, racks, etc.	Apply by wiping or scrubbing affected area with Cleaning Cloth, Cheesecloth or Brush, Typewriter, as appropriate. Wipe clean with Cleaning Cloth.	Do not use around oxygen, or oxygen fittings, or oxygen regulator since fire or explosion may result.
	Cleaner for smoke damage removal on internal chassis components.	Apply by scrubbing affected area with Cleaning Cloth, Cotton, Toothbrush, or Brush, Typewriter, as appropriate. Wipe clean with Cleaning Cloth.	When used for smoke damage removal, always follow-up with solution of one part deionized water and one part Isopropyl Alcohol, TT-I-735.
	Cleaner for smoke damage removal on circuit components and laminated circuit boards.	Apply by wiping or scrubbing affected areas with Cleaning Cloth, Cotton or Toothbrush. Wipe clean with Cleaning Cloth.	May cause swelling of silicone rubber seals in equipment exposed to immersion for long periods.
	Cleaner for removal of Water-Displacing Corrosion Preventive Compounds, MIL-C-81309, Type III, MIL-C-81309, Type II, MIL-C-85054; and Corrosion Preventive Compound, MIL-C-16173, Grade 4.	Apply with Brush, or Toothbrush, as appropriate. Wipe clean with Cleaning Cloth, Cotton.	May soften some plastics, wire harness tubing, or plastic coating on wiring. Test affected area for adverse reactions prior to general application.
Isopropyl Alcohol, TT-I-735	General purpose cleaner and solvent for removal of salt residue and contaminants common to internal avionic equipment. General cleaner for internal chassis components.	Apply a solution of one part deionized or distilled water and one part Isopropyl Alcohol, TT-I-735, to the affected area with Cleaning Cloth or Toothbrush	Isopropyl Alcohol, TT-I-735, is highly flammable. All applications of Isopropyl Alcohol, TT-I-735, and water may be air dried or dried by portable air blower or ovens
	Solvent cleaner for solder flux residue in all applications of electronics, electrical equipment and microminiature circuits.	Apply a solution of one part deionized or distilled water to three parts Isopropyl Alcohol, TT-I-735 and scrub the solder joint and adjacent area with Acid Brush or Toothbrush. Wipe clean with Cleaning Cloth, Cotton.	
	Cleaner for fingerprint removal on metals and non-metallics.	Apply a solution of one part deionized or distilled water and one part Isopropyl Alcohol, TT-I-735, to affected area with Cleaning Cloth, Cotton. Wipe clean.	

Description	Characteristics	Application	Restrictions
	Cleaner for bacteria and fungi attack on all metals and non-metals.	Apply a solution of one part Solvent Trichlorotrifluoroethane, MIL-C-81302, Type II and one part Isopropyl Alcohol, TT-I-735, to affected area with Cleaning Cloth, Cotton. Wipe clean. Air dry.	
	Cleaner for salt-water immersion and fire extinguishing chemicals on all internal circuit boards.	Apply a solution of one part Isopropyl Alcohol, TT-I-735, and nine parts Solvent Trichlorotrifluoroethane, MIL-C-81302, Type II to affected area with Cleaning Cotton Cloth, Acid Brush or Toothbrush, as appropriate.	
	Cleaner for electrical contact surfaces.	Apply a solution of one part deionized or distilled water and one part Isopropyl Alcohol, TT-I-735, to affected area with Acid Brush or Pipe Cleaner. Wipe clean and air dry.	
Water, Distilled	Cleaner for solder flux residue in all applications of electronics, electrical equipment and microminiature circuits.	Apply a solution of one part deionized or distilled water to three parts Isopropyl Alcohol, TT-I-735 and scrub joint and adjacent area with Acid Brush or Toothbrush. Wipe clean with Cleaning Cotton Cloth.	Deionized water, obtainable from commercially available processing units that are plumbed into some shore activity shops, is an authorized substitute.

Table 5.1: Recommended Cleaning Process Versus Type of Avionic Equipment

Type Equipment	Aqueous Ultrasonics	Solvent Ultrasonics	Water Base Spray Booth	Abrasive Tool	Mini-Abrasive	Hand Clean
HOUSING/COVERS	X	X	X	X	X	X
CHASSIS	X	X	X	X	X	X
RACKS/MOUNTS	X	X	X	X	X	X
CONTROL BOXES	X	X(1)	X	X	X	X
INSTRUMENTS					X(1)	X
LIGHT ASSEMBLIES	X	X	X	X(1)	X	X
WAVEGUIDES	X	X	X	X(1)	X	X
WIRE HARNESSES			X		X	X
SERVOS/SYNCHROS					X(1)	X
ANTENNAS, BLADE	X	X	X		X	X
ANTENNAS, DOME	X(1)	X(1)	X	X(1)	X	X
ANTENNAS, RADAR			X	X(1)	X	X
ANTENNAS, ECM					X	X
MOTORS	X	X(1)	X	X(1)	X	X
GENERATORS	X	X(1)	X	X(1)	X	X
BATTERIES						X
CIRCUIT BREAKER PANELS	X	X	X		X	X
GYROSCOPES			X(1)		X(1)	X
PLUGS AND CONNECTORS			X		X	X
HIGH DENSITY CONNECTORS					X	X
EDGE CONNECTORS			X		X	X
COAXIAL CONNECTORS					X	X
PRINTED CIRCUIT BOARDS			X			X

Table 5.2: Cleaning and Drying Restrictions

Component	Problem	Solution
Transformers	Trap solution in housing	Seal
Synchros & Servos	Removes lubricant from bearing	Seal or Remove
Meters & Instrument Gauges	Trap solutions through open back	Seal
Sliding Attenuators (RF)	Trap solution in slide housing	Seal or Remove
Tunable Cavities	Trap solution in cavity area	Seal or Remove
Variable Attenuators (Microwave)	Trap solution in housing	Seal or Remove
Waveguide (Microwave)	Trap solution in guide housing (when installed)	Seal or Remove
Rotary Switches	Trap solution through open housing	Seal
Potentiometers	Trap solution through open housing	Seal
Delay Lines (Physical)	Trap solution in housing	Seal or Remove
Klystron Cavity	Trap solution in sockets	Remove tube and seal socket
Fan Motors	Trap solution in housing	Seal or Remove
Paper Capacitors	Disintegrate	Seal
Printed Circuit Board	Trap solution (when installed)	Remove (clean separately)
Vacuum Tubes	Shock damage	Remove
Sliding Cam Switches	Shock damage to cam	Remove or hand clean only
Crystal Detectors	Heat damage from oven	Dry at 130°F (54°C) maximum
APC Connectors (Microwave)	Shock damage to center conductor	Seal and hand clean only
Wire Wrap Connections	Shock damage	Hand clean only
Gyroscopes	Trap solution in housing	Seal

Table 6

Description	Characteristics	Application	Restrictions
Corrosion Preventive Compound, Water-Displacing, Ultra-Thin Film, Avionics Grade, MIL-C-81309, Type III	General preservative for internal areas of avionic equipment; internal areas of electrical connectors, plugs, receptacles; and solder joints. Contains water-displacing properties.	Apply by spraying an even, thin film to the surface.	Not intended for use on exterior surfaces of avionic equipment. Deposits a thin, nonconductive film which must be removed for proper function of contact points and other electromechanical devices where no slipping or wiping action is involved. Do not use around oxygen, oxygen fittings, or oxygen regulators, since fire or explosion may result. Can be removed with Dry Cleaning Solvent, P-D-680, Type II.
Corrosion Prevention Compound, Water-Displacing, Ultra-Thin Film, MIL-C-81309 Type II	General preservative for internal and external areas of chassis, equipment covers, hardware, mounting brackets, latches, hinges, terminal boards, bus bars, ground straps, and internal/external areas of junction boxes.	Apply by spraying an even, thin film to the surface.	Not intended for use in interior surfaces of electrical connectors, plugs, and receptacles. Do not use on interior surfaces of coaxial connectors. Deposits a thin, nonconductive film which must be removed for proper function of contact points and other electromechanical devices where no slipping or wiping action is involved. Do not use around oxygen, oxygen fittings, or oxygen regulators, since fire or explosion may result. Can be removed with Dry Cleaning Solvent, P-D-680, Type II.
Corrosion Preventive Compound, Water-Displacing, Clear MIL-C-85054	General preservative for external surfaces exposed to elements and moisture, including: chassis, equipment covers, hardware, mounting racks, equipment racks, shelving, brackets, radar plumbing, antenna hardware, latches, terminal boards, bus bars, ground straps, junction boxes, fasteners, and exterior surfaces of electrical connectors, coaxial connectors, plugs and receptacles.	Apply by spraying an even, thin film or brushing onto the surface. Material presents a thin, non-tacky, clear film.	Not intended for use on interior surfaces of avionic equipment. Do not use on interior surfaces of electrical connectors, coaxial connectors, plugs, or receptacles. Do not use around oxygen, oxygen fittings, or oxygen regulators, since fire or explosion may result. Can be removed with Dry Cleaning Solvent, P-D-680, Type II or Isopropyl Alcohol, TT-I-735.

Table 6 (Continued)

Description	Characteristics	Application	Restrictions
Corrosion Prevention Compound, Solvent Cutback, Cold-Application MIL-C-16173 Grade	General preservative for external surfaces exposed to elements and moisture, including: mounting racks, shelving, brackets, radar plumbing, shock mounts, rigid mounts, antenna hardware, general hardware, hinges fasteners, ground straps; and exterior surfaces of electrical connectors, coaxial connectors, plugs and receptacles.	Apply by brush or spraying an even thin film to the surface. Material presents a semi-transparent film.	Not intended for use on interior surfaces of avionic equipment. Do not use around oxygen, oxygen fittings, or oxygen regulators, since fire or explosion may result. Can be removed with Dry Cleaning Solvent, P-D-680, Type II. Must be applied over Water-Displacing Corrosion Preventive Compound, MIL-C-81309, Type II, to accomplish a complete "water-displacing and preservative system" on all areas exposed to elements and moisture.

Fig.1 Uniform surface attack on a connector

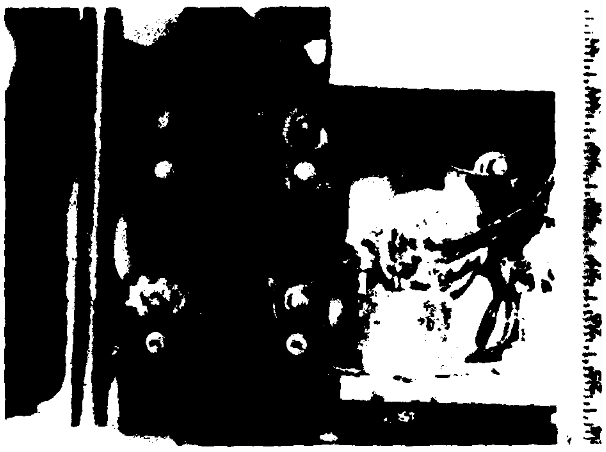

Fig.2 Galvanic corrosion of a wire connection

Fig.3 Pitting and general attack of circuit board and connections

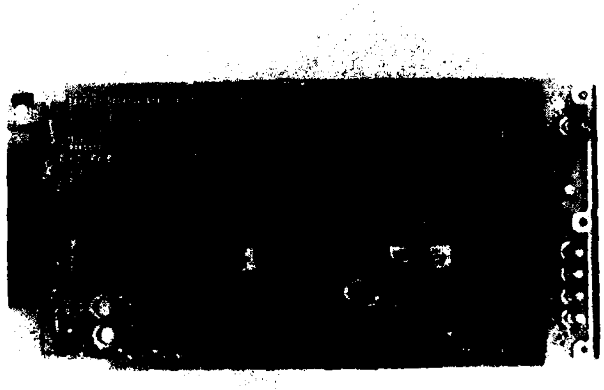

Fig.4 Fungus growth on electronic circuit board

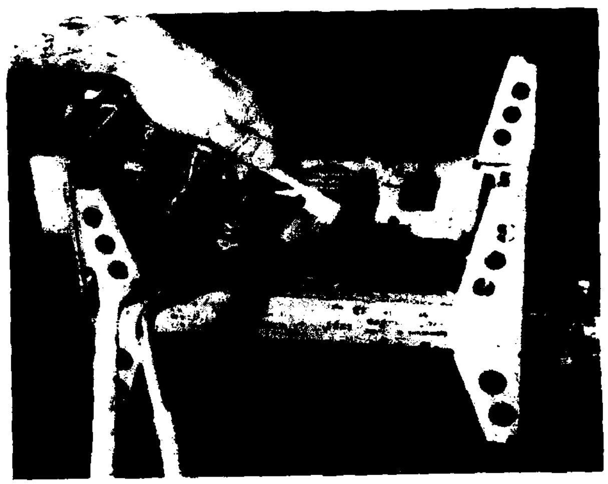

Fig.5 Miniature grit blast cleaning of circuit board

Fig.6 Corrosion resistant primer coating being applied to avionics enclosure

Fig.7 Application of RTV sealant to an electrical connector

Fig.8 Electrical connector exposed on carrier based aircraft for over 18 months

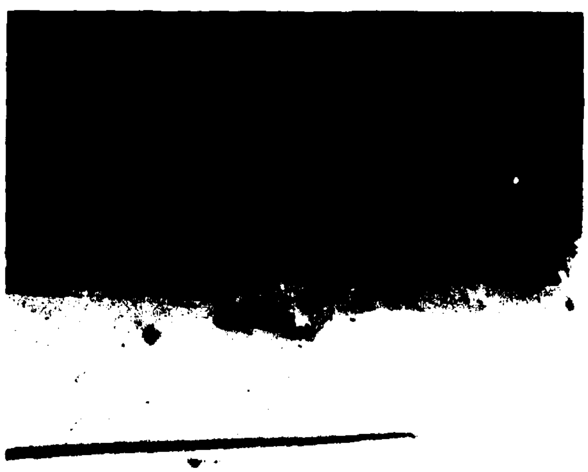

Fig.9 Corrosion adjacent to beryllium copper EMI strips

Fig.10 Disimilar (aluminum to steel) connector showing galvanic corrosion

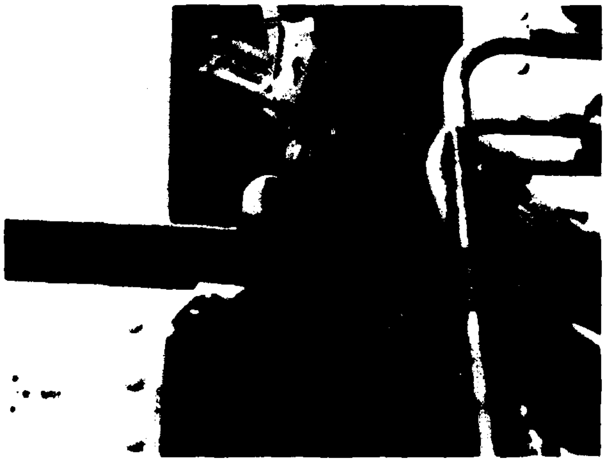

Fig.11 New non-metallic electrical connector shell shows no corrosion after extended exposure to the carrier environment