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Federal Aviation
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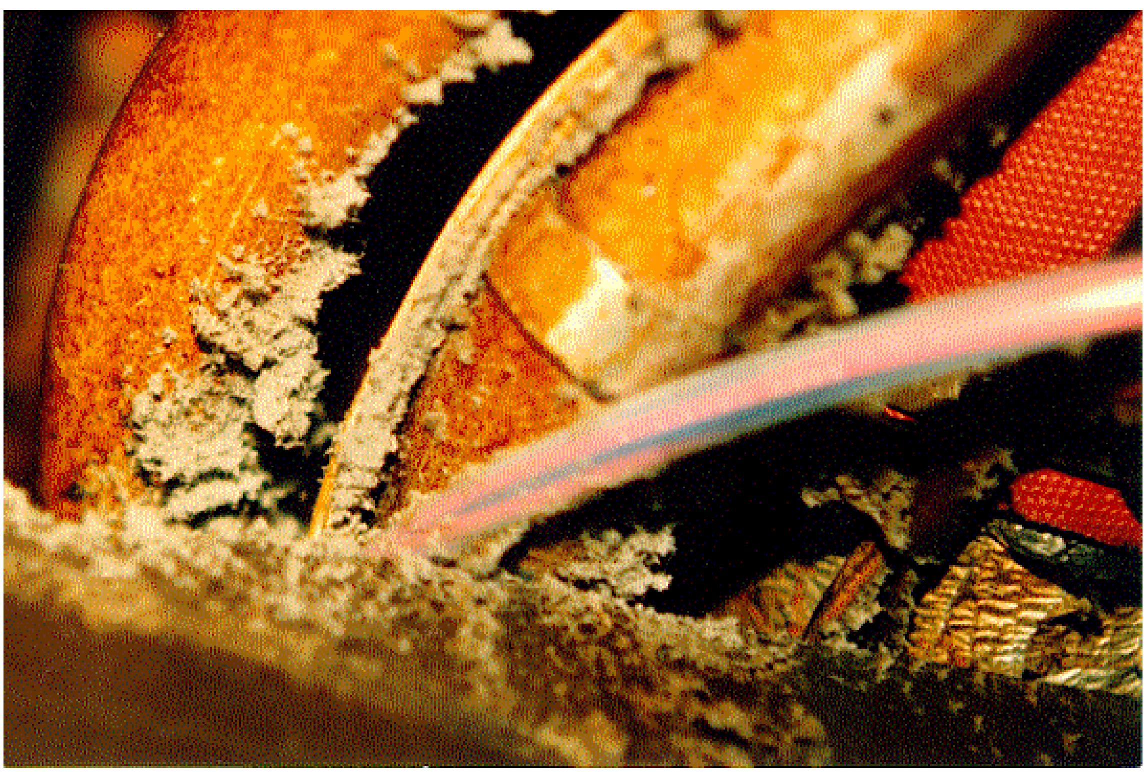
INSPECTION, PREVENTION, CONTROL, AND REPAIR OF CORROSION ON AVIONICS EQUIPMENT



Initiated by: AFS-300

U.S. Department of Transportation
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Subject: **INSPECTION, PREVENTION, CONTROL, AND REPAIR OF CORROSION ON AVIONICS EQUIPMENT**

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1. PURPOSE. This advisory circular (AC) contains methods, techniques, and practices acceptable to the Administrator for inspection, prevention, control, and repair of corrosion on avionics systems and equipment. The procedures in this AC are an acceptable means, but not the only means, of inspecting, preventing, controlling, and repairing avionics corrosion. This AC is intended to supplement the original equipment manufacturer's (OEM) published recommendations, or for use when there are no OEM repair or maintenance instructions. Operators having their own FAA-approved maintenance program may also include the guidance contained in this AC in the development of such programs.

2. BACKGROUND. 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.

Nicholas A. Sabatini
Director, Flight Standards Service

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CHAPTER 1. GENERAL

1. PURPOSE. This advisory circular (AC) contains methods, techniques, and practices acceptable to the Administrator for inspection, prevention, control, and repair of corrosion on avionics systems and equipment. The procedures in this AC are an acceptable means, but not the only means, of inspecting, preventing, controlling, and repairing avionics corrosion. This AC is intended to supplement the original equipment manufacturer's (OEM) published recommendations, or for use when there are no OEM repair or maintenance instructions. Operators having their own FAA-approved maintenance program may also include the guidance contained in this AC in the development of such programs.

2. BACKGROUND.

a. 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.

NOTE: In this AC, use of the term "avionics systems" shall refer to any device that uses or conducts electrical power.

b. Corrosion is a major cause of avionics equipment failures, particularly when the equipment is installed in the aircraft. Studies have shown that 20% of avionics equipment failures are a direct result of corrosion. Even minute amounts of corrosion can cause intermittent malfunctions or complete equipment failures. Past experience has shown that avionics equipment designers have compromised the corrosion resistance in their designs by selecting incompatible or corrosion-prone materials in order to obtain certain electrical characteristics. These compromises can lead to corrosion problems that are aggravated by the exposure to various environmental conditions, including changes in temperature, pressure, humidity, dust, dirt, and industrial pollutants in the atmosphere.

c. The types of corrosion that occur on avionics equipment are similar to those found on airframe structures. These different types of corrosion are discussed in chapter 2 and in AC 43-4A, Corrosion Control for Aircraft. The primary difference between avionics and airframe corrosion is that a small amount of corrosion in avionics equipment can cause intermittent malfunction or complete failure, while the same amount on the airframe structure usually has little or no immediate effect.

3. MILITARY SPECIFICATIONS.

a. Throughout this AC, materials recommended to prevent, control, and repair corrosion on avionics equipment will be listed. The materials listed will be identified using Military Specifications (MIL-SPEC). Appendices 1 and 2 list MIL-SPEC materials and equivalent commercially available products.

b. Military Specification materials have undergone rigorous testing and qualification at government laboratories, plus years of in-service use on military aircraft and equipment in the harshest environments. These products are capable of providing an acceptable means of preventing and controlling avionics corrosion.

c. Military Specification materials are not the only materials available on the commercial market. New materials are being developed by manufacturers each day. These products may also provide an acceptable means of preventing, controlling, and repairing avionics corrosion. These new products may eventually be qualified to a MIL-SPEC.

4. SCOPE AND ARRANGEMENT. This AC provides basic avionics corrosion prevention and control maintenance information for use by all segments of aviation. The AC consists of ten chapters, three appendices, and an index. Summary of the contents within this AC are as follows:

a. Chapter 1. Introduction.

b. Chapter 2. Corrosion Principles and Description. This chapter explains what avionics corrosion is, why it occurs, and the various forms it can take. Special emphasis is placed on the conditions causing corrosion and the peculiar aspects of environmental damage and fungal growth that apply to avionics equipment.

c. Chapter 3. Corrosion Control Program and Inspection. This chapter outlines a preventive maintenance program, explains how to recognize corrosion, and lists components most affected by corrosion.

d. Chapter 4. Cleaning and Preservation. This chapter describes the materials, equipment, and techniques recommended in the mechanical cleaning and preservation of avionics equipment.

e. Chapter 5. Corrosion Removal, Surface Treatment, Painting, and Sealing. This chapter describes materials and techniques used in the removal of avionics corrosion, and treatments and coatings that can be applied to various external and internal avionics equipment.

f. Chapter 6. Treatment of Specific Avionics Equipment. This chapter describes the materials and techniques recommended to remove corrosion from specific avionics equipment.

g. Chapter 7. Corrosion Control Measures for Electrical Bonding/Grounding. This chapter describes the materials and techniques for repairing or replacing existing bonding and grounding connections.

h. Chapter 8. Effect and Treatment of Corrosion on Electromagnetic Interference Shielding Devices. This chapter describes the electromagnetic environment in which avionics systems and equipment operate. The chapter reviews protection measures and techniques used to minimize electromagnetic interference (EMI).

i. Chapter 9. Effect and Treatment of Corrosion on Electrostatic Discharge Sensitive Equipment. This chapter describes the basic theory surrounding Electrostatic Discharge (ESD) and outlines some of the methods currently available to keep ESD from occurring.

j. Chapter 10. Emergency Action for Serious Corrosion of Avionics Equipment. This chapter outlines the recommended emergency procedures to be followed after avionics equipment has been exposed to fire extinguishing agents, water immersion, or saltwater.

k. Appendix 1. Consumable Supplies and Materials. This appendix lists corrosion control materials and applications.

l. Appendix 2. Specific Consumable Materials for Cleaning and Corrosion Prevention and Control. This serves as a supplement to Appendix 1 by providing a more detailed listing of selected products by product numbers (P/N) and manufacturer(s) of acceptable consumable materials for avionics cleaning and corrosion prevention and control.

m. Appendix 3. Definition of Terms. Contains a list of defined terms commonly used by avionics corrosion control personnel.

n. Comprehensive Index. The index locates specific subjects in this AC.

5. ENVIRONMENTAL CONCERNS. Federal and State laws concerning the environment and hazardous materials are constantly being revised and tightened. Additionally, local ordinances concerning the environment and hazardous materials vary from location to location. Therefore, throughout this AC, when a material is required for a specific task and that material is an Ozone Depleting Substance (ODS), the specific material will not be mentioned. For example, if a specific solvent is required for a cleaning operation, the term "approved solvent" will be used in place of a specific solvent call out.

6. SAFETY.

a. The following general safety precautions are not related to any specific task and may not appear elsewhere within this AC.

(1) Keep away from live circuits. Always remove power from, discharge, and ground a circuit before touching it.

(2) Do not service or adjust equipment alone. Maintenance personnel should not reach into, adjust, or service equipment, except in the presence of other personnel who are capable of rendering aid.

(3) Personnel working with or near high voltages should be familiar with modern methods of cardiopulmonary resuscitation (CPR).

(4) Personnel working in noise hazardous areas should wear proper hearing protection, and not exceed time limits for exposures to various sound intensities. Have periodic hearing ability checks.

(5) Use safety shields and glasses when working with power equipment. Adequate shielding for eyes and face should be used at all times.

b. Warnings and cautions contained within this AC are intended to notify personnel of potential equipment hazards and damage. Warnings are used to alert personnel of potential personal safety and health hazards. Cautions are used to alert personnel of conditions which could result in damage to equipment and property.

c. Responsibilities of supervisory personnel. The supervisor should receive training in and be knowledgeable about:

(1) Recognition and elimination of hazards,

(2) Occupational safety and health laws,

(3) Providing a safe work place,

(4) Accident investigation and reporting procedures, and

(5) Proper inspection and maintenance methods for personal safety and protective equipment.

d. Supervisors should also review Material Safety and Data Sheets (MSDS) for characteristics and hazards of the materials employees may be exposed to, and ensure that personnel use required protective equipment.

e. Maintenance personnel should use appropriate protective equipment while exposed to hazardous conditions to prevent accidents, injuries, and occupational illness. Maintenance personnel should not use personal safety and protective equipment that is not in satisfactory and serviceable condition. All personnel should review MSDS for characteristics of materials that they may be exposed to. All personnel should review and comply with occupational safety and health requirements.

f. Many of the materials and procedures outlined in this AC are potentially hazardous to personnel and can cause damage to aircraft and equipment if used improperly. When using maintenance chemicals such as paint strippers, detergents, solvents, conversion coatings, and paint, follow the correct procedures and read all warnings, cautions, and notes.

7. thru 200. RESERVED.

CHAPTER 2. CORROSION PRINCIPLES AND DESCRIPTION

201. OVERVIEW.

a. Maintenance of avionics equipment requires knowledge of aircraft electrical/electronic systems corrosion control. This knowledge requires the definitions and descriptions of the mechanisms that cause corrosion in avionics equipment. The definition of corrosion is “a chemical or electrochemical deterioration of a material, usually a metal, because of a reaction with its environment.” This deterioration can be complex because of the nature of the following: the different individual types of corrosion, simultaneous attack by several types of corrosion, and the design characteristics and maintenance factors that make avionics systems susceptible to corrosion attack.

b. Corrosion can cause intermittent malfunctions, undesirable changes in electrical characteristics, or complete equipment failures. Avionics equipment does not have to be installed, operated, or located in a particularly harsh environment to be affected by corrosion. Some forms of corrosion will be active in near ideal environments. Corrosion is the natural process of materials returning to their natural state. Avionics maintenance personnel should recognize that corrosion “never sleeps” and once started, corrosion continues its attack 24 hours a day, 365 days a year. Inadequate corrosion prevention and control will ultimately affect the equipment in down time and overall system reliability. Described in this AC are methods to prevent and control corrosion of avionics equipment.

202. CORROSION THEORY.

a. Definitions of terms:

(1) Element. A basic pure chemical substance. There are over 100 elements in nature, such as metals (e.g., titanium, gold, iron) and nonmetals (e.g., hydrogen, sulfur, nitrogen).

(2) Atom. The smallest unit of an element which is made up of a nucleus (protons and neutrons), and orbiting electrons.

(3) Electron. A negatively charged particle which orbits the nucleus of an atom. Electrons flow through an electrolyte only in the presence of ions.

(4) Ions. An atom that is either positively or negatively charged. A charged atom is called an ion. When ions move through an electrolyte an electric current is produced. Ions cannot move through metal conductors.

(5) Compounds. Substances made up of two or more elements that chemically combine.

(6) Anode. A conductive metal that has a tendency to corrode.

(7) Cathode. A dissimilar conductive material (usually a metal) which has less tendency to corrode.

(8) Electrolyte. A conductive liquid (usually water) that contains ions in solution. For example, saltwater is an electrolyte made up of water containing sodium and chlorine ions. The electrolyte solution is capable of carrying an electric current between the anode and cathode.

(9) Electron Conductor. Electrical contact between the anode and the cathode; for example, the different elements that make up an alloyed metal, or a fastener holding two pieces of metal (anode and cathode) together.

(10) Galvanic Couple. A cell consisting of two dissimilar metals (an anode and a cathode) in contact with each other through an electrolyte solution.

b. When a metal corrodes, electrons are lost from the atoms in the metal part, and these atoms become metal ions in the electrolyte. Once in solution, positively charged metal ions can combine with the negatively charged ions to form corrosion products.

c. A metal will corrode only when all four of the following exist: there is an anode, there is a cathode, there is an electrolyte containing ions, and the anode and cathode are connected by an electron conductor. Elimination of any one of these four items will slow the corrosion process.

203. FACTORS INFLUENCING CORROSION.

a. Basic Design. There are many design decisions and compromises to be made in the course of developing avionics equipment. The design specifications leave room for a wide range of engineering practices to meet not only the performance, cost and schedule, but also the reliability and maintainability requirements. Each piece of avionics equipment is designed to withstand its intended operational environment. However, some design compromises have to be made to provide the unique electrical, mechanical, and thermal characteristics of the equipment. These compromises can cause the equipment to be vulnerable to corrosion, especially during inoperative periods. Good design practices include:

(1) Shoe Box Type Lid Construction. When access to the equipment is from the top, use a shoe box type lid construction. Fasteners securing the shoe box lid should be from the sides and not through the top.

(2) Limited Openings in the Equipment Housing. To minimize moisture intrusion, keep the number of penetrations into the equipment to a minimum. When penetration is required, use “O” rings and gaskets for sealing. For wiring entry, use “L” type electrical connectors and mount them horizontally (through the vertical sides), and well above the bottom of the housing.

(3) Proper Electrical Connector Mounting. Electrical and coaxial connectors should be mounted horizontally (through the vertical sides). When electrical and coaxial connectors are mounted on the top of the equipment, there should be a raised area on the upper side of the equipment where the connector is mounted and an “L” type connector should be used. Electrical wiring should incorporate a drip loop into the wiring harness so the wiring is leading up to the connector.

(4) Proper Printed Circuit Board Mounting. Printed circuit board should be mounted vertically with the electrical connection also in a vertical position.

(5) Low Point Drains. Low point drains should be incorporated so that any moisture will drain from the equipment when the aircraft is in the flight position and when it is parked on the ground.

(6) Eliminating Moisture Traps. Avoid moisture traps or “bathtub” areas on the interior areas of the equipment. Design in drain paths to the low point drains. Avoid moisture traps in electrical wire bundles where anti-chaffing material or boots are incorporated.

(7) Cooling Air Systems. Cooling air systems should incorporate a system to remove moisture and particulate matter from the conditioned air. This is especially important when the conditioned air is forced directly towards active electronic elements.

(8) Proper Bonding and Grounding. Electrical bonding and grounding should be accomplished using straps rather than "sliding housing-to-rack" or tapered pin on housing-to-rack electrical contacts. Straps should be located for ease of maintenance and properly sealed because of the dissimilar metal (galvanic) couple.

(9) Proper Equipment Mounting. Avionics equipment should be mounted in such a manner that will allow sufficient airflow around the equipment and keep the equipment a least 1/2 inch above the compartment floor.

b. Material Selections and Uses. Proper material selection is critical for protecting avionics equipment against the environment. Many types of corrosion that occur in avionics equipment also occur in the airframe structure. However, the range of material call outs in avionics equipment is greater than in the airframe. Several new types of corrosion problems are therefore unique to avionics equipment. The following indicate the uses of different materials in the construction of various electrical and electronic components.

(1) Copper and copper based alloys are generally used in avionics systems as contacts, springs, leads, connectors, printed circuit boards (PCB), conductors, and wire.

(2) Iron and steel are used as component leads, magnetic shields, transformer cores, brackets, racks, and general hardware.

(3) Magnesium alloys are used extensively throughout avionics systems as antenna structures, chassis, supports, and frames (radar).

(4) Nickel and tin plating are used for protective coatings and for material compatibility purposes. Tin is also one of the components of solder. Tin plating is also used on radio frequency (RF) shields, filters, and automatic switching devices.

(5) Silver is used as a protective plating material over copper in wave guides, miniature and micro-miniature circuit boards, tank circuits, and RF shielding.

(6) Aluminum and aluminum alloys are widely used, because of their light weight, in equipment housings, chassis, mounting racks, supports, and electrical connector shells.

(7) Cadmium is used as a sacrificial coating on ferrous hardware, such as bolts, nuts, washers, and screws.

(8) Ion vapor deposition (IVD) of aluminum is also used as a sacrificial coating on hardware and is a nonhazardous replacement for cadmium.

(9) Gold is commonly used on electrical connectors, contacts, and edge connectors where the lowest electrical resistance is required.

c. Material Compatibility. Due to the complexity of the material process used in modern electronic assemblies, it is sometimes difficult to predict if potential problems will be created by the reaction between two or more nonmetallic materials in a circuit assembly. Incompatibility of materials can result in the release of chemicals or gases that will react with other circuit components. In some cases, the incompatibility of cleaning solutions will cause reactions in substances that are corrosive to associated circuitry. The following list contains several of the potential problems:

(1) The heating of conformal coating for the purpose of removal or repair may cause an outgassing that can be corrosive to metal components.

(2) Some commercial coating strippers contain acids that attack PCB laminates, and discolor or corrode copper.

(3) Certain room-temperature vulcanizing (RTV) silicone sealants contain acetic acid that is highly corrosive to metal components in avionics circuits. See chapter 5, paragraph 505d (4) through (6), and table 5-2.

(4) Some potting compounds revert to a liquid form under certain conditions. This reversion process reduces moisture protection in electrical connectors. See chapter 5, paragraph 505b.

(5) Degradation of polyvinyl chloride gives off acetic fumes which are corrosive to most metals used in avionics equipment.

(6) Shrinkable elastomers (heat shrink) tubing, although not a problem directly, can cause damage to adjacent circuitry when heat guns are applied to shrink the tubing.

(7) Some dry film lubricants contain graphite, which is an excellent lubricant, but graphite is also corrosive. Graphite is cathodic to metals and, in the presence of moisture, promotes galvanic corrosion. Other dry film lubricants contain molybdenum disulfide which in the presence of moisture and heat can form a corrosive sulfuric acid.

(8) Certain oils, especially silicones and greases, creep as temperature increases, causing contamination of organic coatings and attraction of dust.

d. Moisture Intrusion. Moisture intrusion can take several forms: accidental dousing, or immersion; or normally as a gas in the form of water vapor (i.e., humidity), or finely divided droplets of liquid (i.e., mist or fog). The normal type of moisture often contains pollutants such as particulates, smog, industrial contaminants, and chlorides from salt laden air. Except for hermetically sealed or pressurized avionics equipment, most avionics equipment breathes. This allows the free passage of this polluted moisture in and out of the equipment. The polluted moisture collects on the internal electrical and structural components through condensation. The following are methods of minimizing moisture intrusion.

(1) Hermetic Sealing. Hermetic sealing provides the greatest resistance to moisture intrusion by providing adequate seals (solder or glass fusion joints) on the equipment and filling the interior compartment with a dry inert gas. Hermetically sealed avionics equipment provides for a seal integrity check by a built-in visual indicator. Cooling requirements, size, and container penetrations will often preclude this type of moisture intrusion protection.

(2) Pressurization of Equipment. The next best avionics equipment moisture intrusion protection is through pressurization of the equipment or the equipment compartment. The introduction of pressurized dry air into a semi-sealed area greatly reduces the intrusion of moisture. However, the additional weight required to achieve the necessary equipment rigidity largely precludes the use of this method of moisture intrusion reduction.

(3) Sealing of Equipment. For avionics equipment that cannot be hermetically sealed or pressurized, protection from moisture intrusion can best be achieved by applying a sealant. Two types of sealant are available. Current technology uses polysulfide and RTV silicone sealants. Polysulfide sealants are two part component sealants, whereas RTV sealants are single component. For avionics equipment, RTV sealants that have a vinegar odor are not authorized. This type of sealant contains an acetic acid used for curing the sealant. The acid will cause corrosion.

e. Manufacturing Process.

(1) Surface Treatments. Avionics equipment cases are manufactured from aluminum, and occasionally magnesium, because of weight considerations, cooling efficiency, and cost. Surface treatments, commonly called pre-treatments, are an important first step in the overall protection of the equipment. The most common surface treatments for aluminum are anodizing and chemical conversion coating. Anodizing is normally applied by the original avionics equipment manufacturer on interior and exterior surfaces. Chemical conversion coating is normally a pre-treatment process applied by repair facilities. The MIL-SPEC for chemical conversion coating is MIL-C-5541, Class II and Class III. Class II is used for aircraft structural components, avionics cases, and at any location where electrical bonding is not a consideration. Class III is an avionics grade chemical conversion coating and provides adequate electrical continuity while providing some corrosion protection. The pre-treatment for the repair of magnesium is a chemical conversion coat conforming to MIL-M-3171, Type VI.

(2) Organic Coatings. The exterior paint system on avionics equipment consists of a primer and a topcoat. The primer promotes adhesion and contains corrosion inhibitors. The topcoat provides durability to the paint system, including weather and chemical resistance. Environmental concerns, as well as local and state air pollution regulations have implemented strict controls on the amount of volatile organic compounds (VOC) (solvent) contained in primers and topcoats. The majority of all new avionics equipment is painted with VOC compliant water-based primers and topcoats.

(3) Conformal Coatings. Conformal coatings offer the same protection to electrical components within the avionics equipment as the primer and topcoat offer to the exterior of the same equipment. Conformal coatings are generally a clear plastic coating applied over the electrical components, conforming to MIL-SPEC MIL-I-46058. Conformal coatings offer several advantages: protection from moisture and corrosion, and enhanced resistance to shock and vibration. Generally, there is no field level repair for conformal coated components.

(4) Plating Systems. Metal plating is used in avionics equipment to provide sacrificial protection, barrier protection, and as a neutral nonreactive metal between two dissimilar metallic surfaces. Gold and tin are the two most widely used plating metals. Gold plating requires another metal (base) to be plated under the gold, usually nickel, silver, or copper. A nonporous gold plating is required to eliminate galvanic corrosion with the base-plated metal. Special corrosion conditions can be set up between gold and silver-copper plating if damaged. This special galvanic corrosion condition for gold is referred to as red plague. A special galvanic corrosion condition, known as purple plague, can form between gold and aluminum in the presence of silicone.

204. ENVIRONMENTAL CONDITIONS.

a. Within the Aircraft. Maintenance personnel often assume that, once installed within the aircraft cockpit, cabin, and/or equipment bays, avionics equipment will be protected from water or fluid intrusion and, therefore, free of significant corrosion. In-service use has shown that this is not the case. Airframe flexing combined with in-service use and handling damage can lead to seal deterioration and violation of the water tightness of the airframe and avionics equipment.

b. Operational Environments. The operational environment of today's aircraft consists of two main conditions: periods of in-service use and periods of non-operation. When avionics equipment is operating, the heat generated by the equipment tends to drive off or at least minimize moisture intrusion or entrapment. The ability of corrosion to start or continue will be reduced. Conversely, when avionics equipment is not in operation moisture can collect on the electrical components, increasing the opportunity for corrosion to start.

205. CORROSIVE CONDITIONS.

a. General. Corrosion is a major contributing cause to the reduction of avionics equipment reliability. Moisture is the single most important contributor to corrosion in avionics systems. The following paragraphs discuss environmental factors that have a major effect in the amount of corrosion on the equipment.

b. Moisture. Moisture can be either a gas, water vapor (humidity), or finely divided droplets of liquid (mist or fog). This moisture generally contains industrial pollutants, particulates, smog, and chlorides from salt laden air. Moisture enters all areas of an aircraft and avionics equipment exposed to air. All enclosed areas that are not sealed allow moisture laden air to enter and leave while the difference in pressure between the inside and outside of the equipment changes. These pressure differences occur when the aircraft changes altitude, when atmospheric weather changes occur, and when the temperature changes within the equipment. Cooling air can also introduce moisture into the equipment.

c. Condensed Moisture. Airborne moisture will condense when the air temperature drops below the dew point or when the air comes in contact with any surface colder than the dew point temperature. Water droplets on the outside of a cold drinking glass are an example of this condition. Condensed moisture usually evaporates as the surrounding air warms. When this occurs, the contaminants that were brought in by moisture-laden air and distributed on the equipment during condensation are left behind.

d. Residual Contaminants. Residual contaminants usually consist of industrial pollutants, dusts, and salts. Industrial pollutants include: carbon from internal combustion engines, nitrates from agricultural fertilizers, ozone from electrical motors and welding processes, sulfur dioxide from turbine engines, industrial and ship exhausts stacks, and sulfates from automobile exhausts. Dusts include sand, dirt, and volcanic ash. Figure 2-1 shows dust and dirt accumulation. The contaminants found in industrial areas often contain a number of tar products, ashes, and soot. The primary sources of salt are the world's oceans. The oceans contain between 3.5% and 3.9% salt. Normal sea winds can carry from 10 to 100 pounds of sea salt per cubic mile of air inland up to 100 miles.

e. Other Fluids. Many fluids can be present in various areas of an airframe. Table 2-1 lists the type of fluid intrusion and possible effects. Fluids can be from external sources, internal leaks, or servicing spills. Some of these fluids are corrosive to metals, while others are destructive to seals. Destruction of seals can lead to fluid intrusion into areas that were considered, by the design, protected from corrosive fluids.

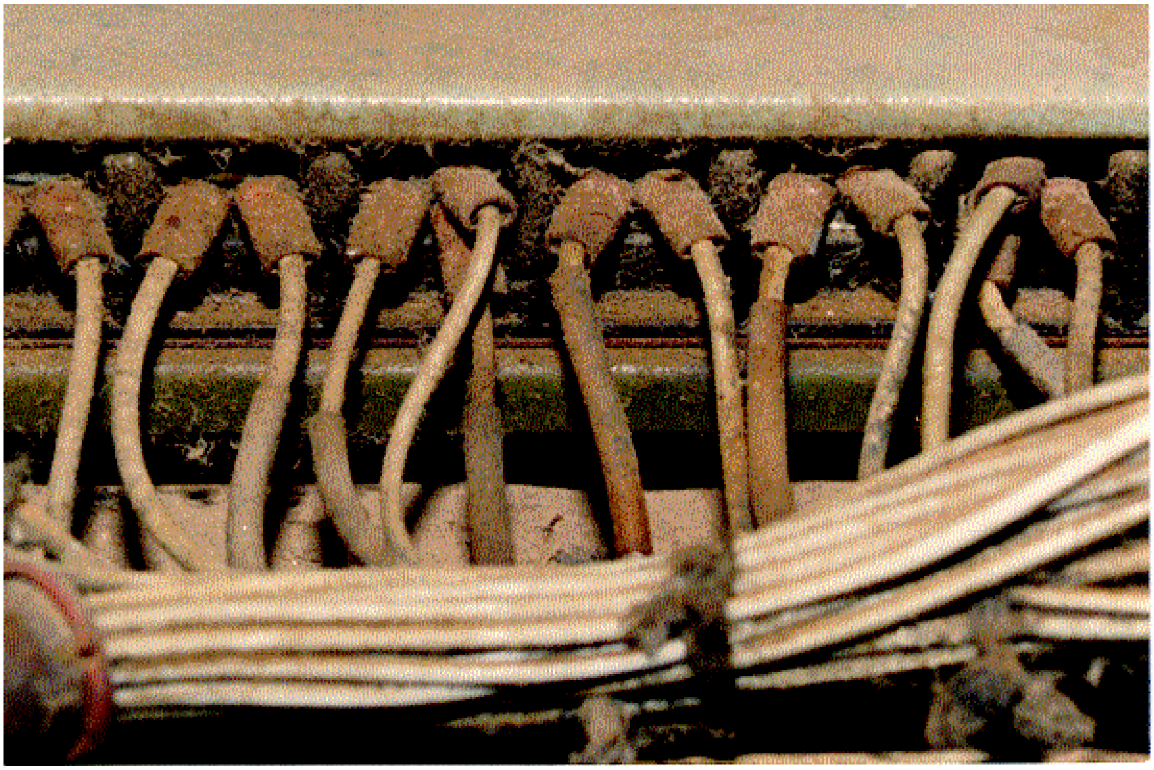

FIGURE 2-1. DUST AND DIRT ACCUMULATION ON TERMINAL STRIP

TABLE 2-1. EFFECTS OF AIRFRAME FLUID INTRUSION

Type of fluid intrusion	Effects or deterioration
Engine fuel	Softening or swelling of some polymers.
Hydraulic fluid	Reduced paint adhesion, and introduction of insulated films on electrical connector contact surfaces.
Lubricants	Attack some seal and gasket material.
Dielectric Coolant	Attacks organic seals.
Anti-icing fluids	Increased condensation and attacks on electrical wiring.
Aqueous contaminates (free water, urine, condensation, desiccants)	Increased condensation causing pooling of fluids in bilge areas; corrosive attack of unprotected dissimilar metal couples; introduction of insulated films on electrical contact surfaces.
Maintenance fluids (solvents, detergents, cleaners, strippers)	Softening and/or reduced adhesion of some organic coatings and cracking of insulation on some electrical wiring.

f. Temperature. High temperature may improve or impair the performance of avionics equipment, depending on other conditions. Corrosion and other harmful processes (outgassing, decomposition, etc.) increase as the temperatures rise. In some instances, moderate rises in temperature prevent condensation of moisture laden air. Most fungal growth is inhibited by temperatures above 104° F (40°C). Low temperatures pose no direct threat of corrosion, except that as temperature drops, relative humidity rises. Extremely low temperatures can cause shrinkage and embrittlement of seals and gaskets, resulting in leakage and fluid intrusion.

g. Pressure. Most avionics equipment is designed to operate at low pressure (high altitude). Low pressure causes outgassing of plastics and other organic materials, which can change the physical and chemical properties of those materials. Another problem created by pressure is pressure cycling (high altitude/low altitude). These varying pressure changes can cause breathing from leaky seals and gaskets. Breathing promotes condensation of moisture laden air and creates a corrosive environment.

h. Micro-organism, Insect, and Animal Attacks. Condensed moisture can cause conditions that promote the growth of mold, bacteria, and fungi. Once mold, bacteria, and fungi are established, they absorb and hold moisture. As living creatures, they secrete wastes which are acidic. This acid is a strong electrolyte which corrosively attacks metal. Non-metals, such as sealants, provide nutrients which can accelerate their growth. Many factors determine the degree of the fungal attack. Table 2-2 lists materials and the deterioration from microbial attack. Damage to avionics systems and equipment can also be caused by small insects and animals. This condition is most prevalent in tropical environments. Avionics equipment in storage is also susceptible to this condition. Insects and animals may enter through vent holes, open cabinets, or torn packaging material. Once inside the equipment, they can build nests which will hold moisture. This moisture plus excretions can cause corrosion. Another type of damage possible on the interior of the avionics equipment happens when an insect or animal eats electrical insulation, varnishes, or conformal coatings. This removes the environmental protection coating, allowing direct corrosive attack on the underlying surface.

i. Man-made Environments. Man-made environments include repair station work, equipment handling, packaging, storage, and shipment. Avionics equipment undergoing repair can be contaminated by the surrounding environment. Fumes and vapors from adjacent repair operations such as soldering, paint spraying, and solvent cleaning can become trapped in the equipment. Failure to remove soldering flux residues after a repair can cause corrosion. Removal of avionics equipment from an aircraft for maintenance or inspection can expose the equipment to various environments. Removal of components from the equipment without proper protection from the environment can subject that component to corrosion. Improper shipping containers such as in wooden or fiberboard containers can subject that material to corrosion from vapors released by the container. Changes in temperature and pressure while en route can allow the intrusion of moisture. Finally, the improper storage of avionics equipment awaiting installation can cause corrosion. Storage of avionics equipment on wooden shelving can subject the equipment to vapors released by the shelving material.

TABLE 2-2. EFFECTS OF MOISTURE AND FUNGI ON VARIOUS MATERIALS

Part of Material	Effects of moisture and fungi
Fiber: washers, supports, etc.	Moisture causes swelling that can lead to misalignment and binding of 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	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, switchboard panels, connectors, tube sockets and coil forms, etc.	Machined, sawed, or ground edges of surfaces support fungi, causing shorts and flashovers. Fungi growth can reduce resistance between parts mounted on plastic to such an extent that the parts are useless.
Cotton linen, paper, and cellulose derivatives: insulation covering webbing, belting, laminations, dielectrics, etc.	Insulating and dielectric properties are lost or impaired, causing arcing, flashovers, and crosstalk. Destroyed by fungi.
Wood: cases, houses and plastic fillers, masts, etc.	Dry rot, swelling, and delaminated housings caused by moisture and fungi.
Leather: straps, cases, gaskets, etc.	Moisture and fungi destroy 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 that are not clean support the growth of fungi, cause destruction of insulating and protective qualities, and permit entrance of moisture that destroys parts and unbalances electrical circuits.
Metals	High temperature and moisture vapor cause 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 conductors, etc., which in turn leads to noise, loss of sensitivity, and arc-over.
Metals, dissimilar	Metals may have different corrosion 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.

206. TYPES OF CORROSION.

a. General. Many different forms of corrosion occur on avionics equipment, depending on the type of material, configuration of the materials, and their environment. The rate and magnitude of the corrosion attack is also dependent upon those same materials and environment. A corrosion attack on equipment may involve several types of corrosion occurring simultaneously. This section describes the individual types of corrosion common to most avionics equipment.

b. Uniform Surface Corrosion. Uniform surface corrosion is probably the most common type of corrosion and results from a direct chemical attack on a metal surface. This type of corrosion appears uniform because the chemical elements that make up an alloyed metal are different and thereby become anodes and cathodes. These anodes and cathodes are very small and constantly shift from one area of the surface to another. A dull or etched surface is usually the first indication of uniform surface corrosion. Continued attack is followed by roughness and a “frosty” or powdered surface.

c. Crevice Corrosion. Crevice corrosion, also called concentration cell corrosion, occurs between the two mating surfaces in the presence of an electrolyte that has a different concentration/potential from one area to another. The electrolyte inside the crevice has a lower oxygen level and a higher metal ion concentration than the area just outside the crevice. As a result, the metal surfaces, even though they may be of the same material, have different potentials, and corrosion occurs. Figure 2-2 shows evidence of crevice corrosion on a lower fuselage skin at an antenna mounting. This type of corrosion may also occur when one of the mating surfaces is nonmetallic. There are three types of crevice/concentration cell corrosion: metal ion concentration cells, oxygen concentration cells, and active passive cells.

(1) Metal Ion Concentration Cells. Stagnant electrolytes under mating/faying surfaces normally have a high concentration of metal ions compared to the metal just outside the mating/faying surface. The area of high metal ion concentration will be cathodic, while the area with a lower concentration will be anoxic and suffer corrosion.

(2) Oxygen Concentration Cells. Electrolytes normally contain dissolved oxygen. Stagnant electrolytes under mating/faying surfaces contain less dissolved oxygen and are more anoxic than the adjacent area outside the mating surface. Corrosion occurs in the area of lower oxygen concentration.

(3) Active Passive Cells. Metals which depend on tightly adhering oxide films for corrosion protection, such as an anodized surface on aluminum, are prone to a rapid corrosion attack by active passive cells. An active passive cell occurs when the oxide film is broken from a scratch. The difference in potential between the small area of exposed parent metal (anoxic area) and the larger oxide film (cathodic area) is high and the onset of corrosion is rapid.

d. Pitting Corrosion. Pitting corrosion is a severe form of concentrated cell corrosion and is localized to a specific area. Pitting corrosion can be found on thin sheets of metal, such as plated PCB paths. The attack can be so severe that perforation of the plated PCB paths can occur. Pitting usually occurs along grain boundaries and at porous finished areas on the metal. Porous gold plating on copper contacts is a common location for pitting corrosion. The plating pores create small corrosion cells that continue to expand and deepen until a pit is created.

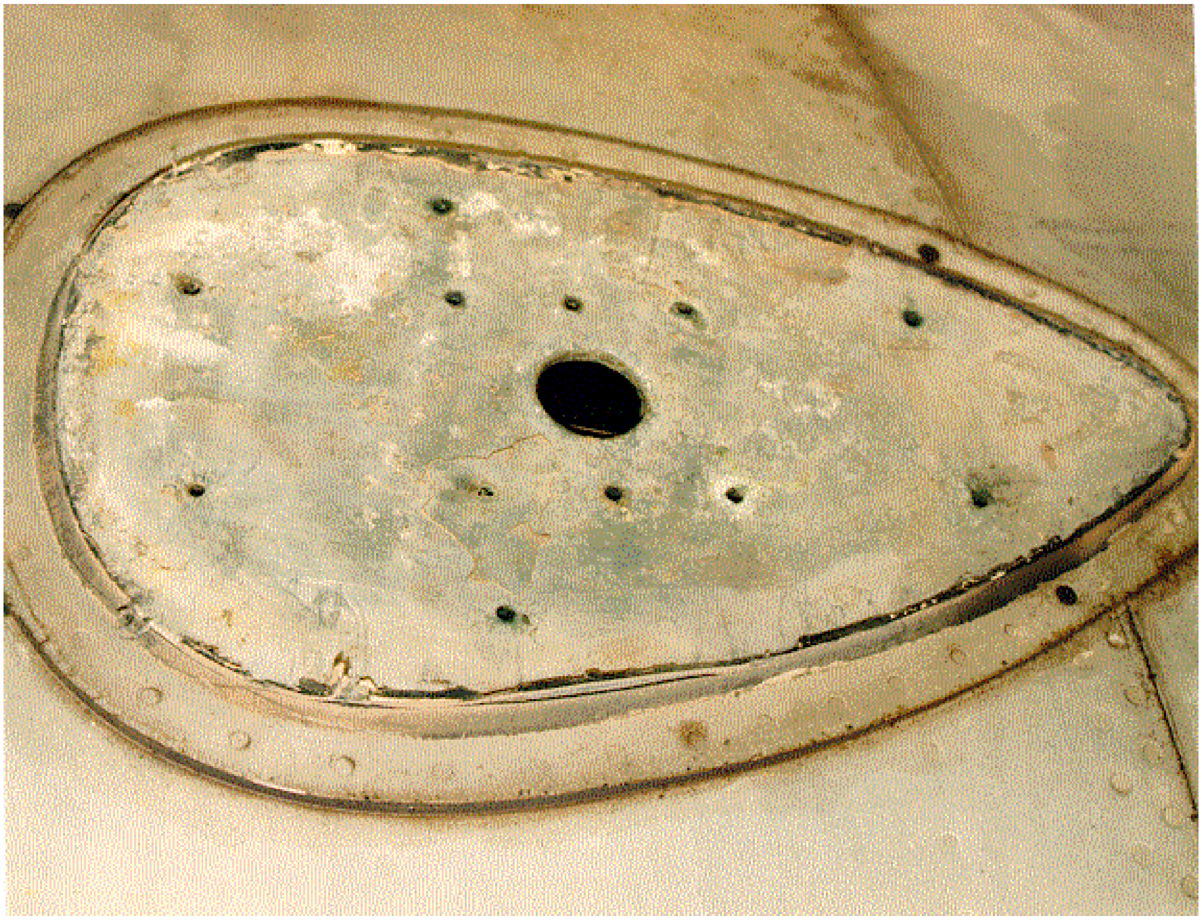

FIGURE 2-2. EVIDENCE OF CREVICE CORROSION ON LOWER FUSELAGE SKIN AT AN ANTENNA MOUNTING

e. Fretting Corrosion. Fretting corrosion occurs when there is slight relative movement between two materials (usually metals) and an electrolyte is present. This corrosion is typical of close fitting, highly loaded interfaces. Fretting corrosion can occur on all metals, with aluminum, stainless steel, and titanium alloys being the most susceptible. These metals depend on an oxide surface film to inhibit further corrosion. With small movements between the two mating surfaces under pressure, the exposed oxide surface film is abraded away, exposing new parent metal. This new metal surface oxidizes again and the cycle repeats. The oxides that were abraded away locate themselves in the crevices of the parent metal. The oxides are harder than the parent metal, and, as the abrasion continues, they will act as an abrasive grit which further attacks the parent metal.

f. Galvanic Corrosion. Galvanic corrosion occurs when different metals are in contact with each other in the presence of an electrolyte. Galvanic corrosion is characterized by a buildup of corrosion deposits on the mating active (anoxic) surface. The rate of corrosion of a galvanic couple is a function of the difference between the reactivity of the metals. The galvanic series for metals with salt water as the electrolyte is outlined in Table 2-3. The farther apart two metals are on the galvanic series chart, the faster the active (anode) metal will corrode in the presence of the electrolyte. In contrast, the closer the two metals are on the galvanic series chart, the slower the active (anode) metal will corrode in the presence of the electrolyte.

TABLE 2-3. GALVANIC SERIES OF METALS AND ALLOYS IN SEAWATER

CORRODED END (ANOXIC, ACTIVE, OR LEAST NOBLE)
Magnesium Alloys
Zinc (plate)
Beryllium
Cadmium (plate)
Uranium (depleted)
Aluminum Alloys
Indium
Tin (plate)
Stainless Steel 430 (active)
Lead
1010 Steel
Cast Iron
Stainless Steel 410 (active)
Copper (plate)
Nickel (plate)
AM 350 (active)
Chromium (plate)
Stainless Steel 350, 310, 304 (active)
Stainless Steel 430, 410 (passive)
Stainless Steel 13-8, 17-7 PH (active)
Brass, Yellow, Naval
Stainless Steel 316L (active)
Bronze 220
Copper 110
Stainless Steel 347 (active)
Copper-Nickel 715
Stainless Steel 202 (active)
Monel 400
Stainless Steel 201 (active)
Stainless Steel 321, 316 (active)
Stainless Steel 309, 13-8, 17-7 PH (passive)
Stainless Steel 304, 301, 321 (passive)
Stainless Steel 201, 316L (passive)
Stainless Steel 286 (active)
AM355 (active)
Stainless Steel 202 (passive)
Carpenter 20 (passive)
AM355 (passive)
Titanium Alloys
AM350 (passive)
Silver
Palladium
Gold
Rhodium
Platinum
Carbon/Graphite
PROTECTED END (CATHODIC, PASSIVE, OR MORE NOBLE)

g. Stress Corrosion. Stress corrosion or stress corrosion cracking occurs when stresses on a metal part and corrosion combine to produce damage greater than either one applied separately. The stresses on the part can be internal (residual) or externally applied. Stress corrosion cracking of metal parts occurs along (intergranular) or across (transgranular) boundaries. Stress corrosion failures can be catastrophic and occur without warning. For example, cracking can occur in stressed copper alloys exposed to ammonia and its compounds.

h. Corrosion Fatigue. Corrosion fatigue is normal fatigue combined with corrosion. Normal fatigue (in a non-corrosive environment) is caused by repeated stress cycles at a level below the maximum stress the material can withstand. The fatigue (endurance) limit is the maximum cyclic stress at which a material will not sustain any fatigue damage (will not fracture). The combination of corrosion and fatigue reduces the fatigue limit of a material. Corrosion fatigue will eventually produce a failure regardless of how minimal the applied stress.

i. Intergranular Corrosion. Intergranular corrosion is a chemical attack that occurs at the grain boundaries of a metal. A highly magnified view of a metal surface shows individual grains. Along the grain boundaries of the primary metal are individual grains of the metallic elements that make-up the alloy. These other metals have a different corrosion potential than the primary metal. Often, the grain boundaries are anoxic and tend to corrode more easily than the grains of the primary metal. When an electrolyte is present, rapid selective corrosion at the grain boundary occurs.

j. Exfoliation Corrosion. Exfoliation corrosion is an advanced form of intergranular corrosion. Exfoliation corrosion causes the metal grains to separate at the grain boundaries due to the force of the expanding corrosion products. This type of corrosion is most often visible as a swelling or lifting of an exposed edge in extruded sections of metal. It is primarily found in aluminum sheets around steel fasteners.

k. Nonmetallic Deterioration. Nonmetallic materials also deteriorate. This deterioration includes: swelling, distortion, disintegration, cracking, out gassing, and changes in electrical characteristics. The deterioration is caused by a change in the environment of the avionics equipment. These changes include: weather, moisture intrusion/entrapment, heat, UV light, fungal growth, etc.

207. thru 300. RESERVED.

CHAPTER 3. CORROSION CONTROL PROGRAM AND INSPECTION

30l. GENERAL. Investigations over the past ten years have revealed that corrosion is a major factor in avionics equipment failures. As much as 20% of commercial/general aviation avionics failures are attributable to corrosion, and that figure rises to between 30% and 40% for the military. This excessive failure rate continues despite continued improvement in the overall reliability of avionics equipment and systems. The scope of this problem outlines the need for an effective preventive maintenance program.

FIGURE 3-l. DUST AND LINT ACCUMULATION IN THE CROWN AREA

302. PREVENTIVE MAINTENANCE PROGRAM.

a. Program Requirements. Successful avionics cleaning and corrosion prevention/control efforts depend on a coordinated, comprehensive preventive maintenance program. Everyone involved with the operation, repair, and maintenance of avionics equipment must take an “all hands” approach to cleaning, inspection, and corrosion prevention and control. Figure 3-1 shows dust and lint accumulation in the crown area. The basic philosophy of a preventive maintenance program should consist of the following:

(1) Personnel adequately trained in the recognition of corrosion, including conditions, detection and identification, cleaning, treatment, and preservation;

(2) Thorough knowledge of corrosion identification techniques;

(3) Proper emphasis on the concept of “all hands” responsibility for corrosion control;

(4) Inspection for corrosion, deteriorated seals, and proper routing on a scheduled basis;

(5) Routine cleaning of all wiring and the exterior surfaces of components;

(6) Keeping drain holes open;

(7) Early detection and repair of damaged protective coatings;

(8) Prompt corrosion treatment after detection;

(9) Accurate record keeping and reporting of material or design deficiencies; and

(10) Use of appropriate materials, equipment, and technical publications.

b. Corrosion Prevention Philosophy. Corrosion and environmental conditions are natural phenomena that adversely affect avionics equipment. Although they can never be totally eliminated, the problems these phenomena cause can be minimized so that they are more manageable. This can be achieved only by understanding the equipment failure mechanisms, implementing a preventive maintenance program, and using corrosion control techniques and materials.

303. CORROSION-PRONE AREAS.

a. General. There are certain corrosion-prone areas common to all aircraft. For example, bilge areas are particularly susceptible to moisture intrusion/entrapment. The bilge area is where cables run, and wire bundles, coaxial cables, lights, and antennas are installed. It is almost impossible to prevent moisture intrusion/entrapment in these areas. Other corrosion-prone areas include areas in and around the engine exhaust, battery compartments, lavatories, buffets, galleys, entrances at cargo and passenger doors, and wheel wells and landing gear.

b. Moisture and Other Fluid Intrusion Sources. Moisture, fluid intrusion, and fluid movement within the aircraft are caused by many factors, including:

(1) The flexibility of aircraft structure, which prevents complete and effective airframe sealing at skin joints and around fasteners;

(2) Numerous openings, such as equipment bay doors, access panels, ducts, and static pressure sensors, which can allow moisture intrusion;

(3) Moisture from many sources, such as rain and aircraft wash, and fluids from leaking hydraulic, fuel, oil, and coolant lines; and

(4) Moisture and fluid migration within the aircraft along air condition ducts, fuel and hydraulic lines, and cable and wire bundles. As a result of these conditions, moisture and other fluids can enter, migrate, and be trapped in areas of the aircraft where avionics equipment may be installed, which are normally considered protected.

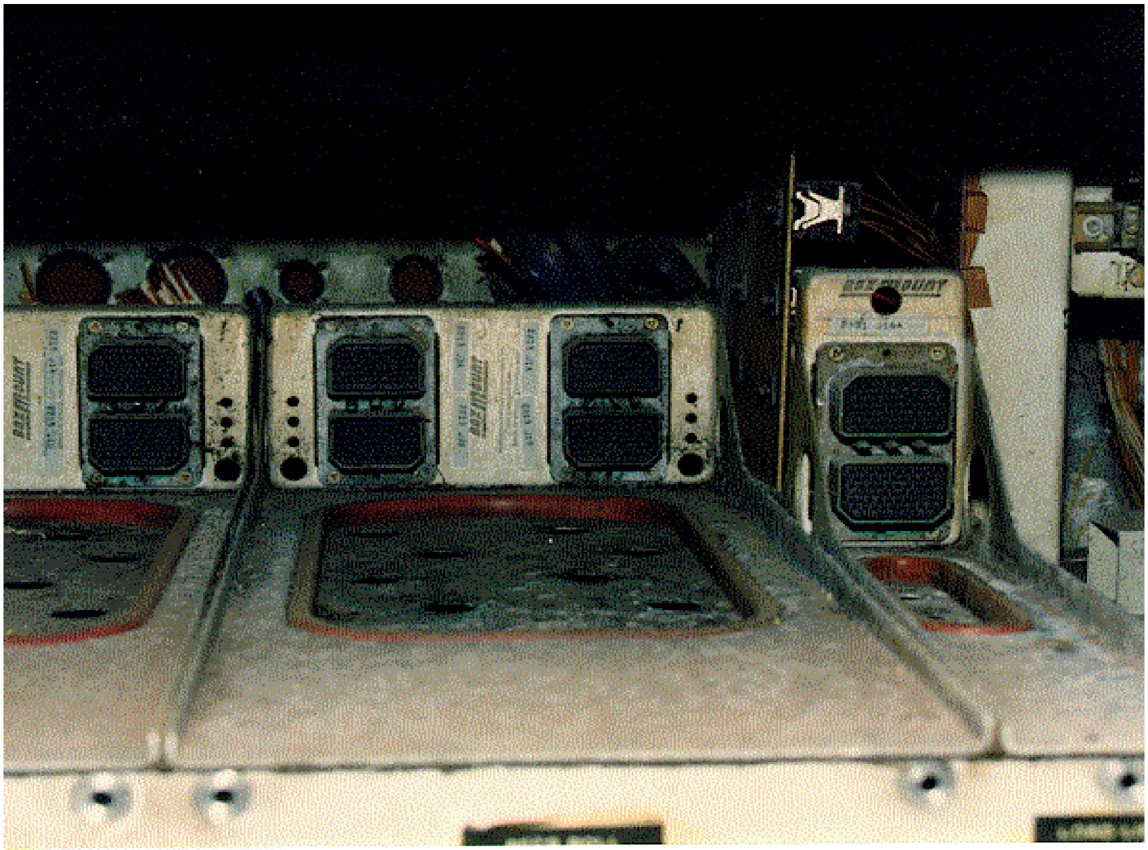

FIGURE 3-2. SURFACE CORROSION ON AN AVIONICS MOUNTING RACK

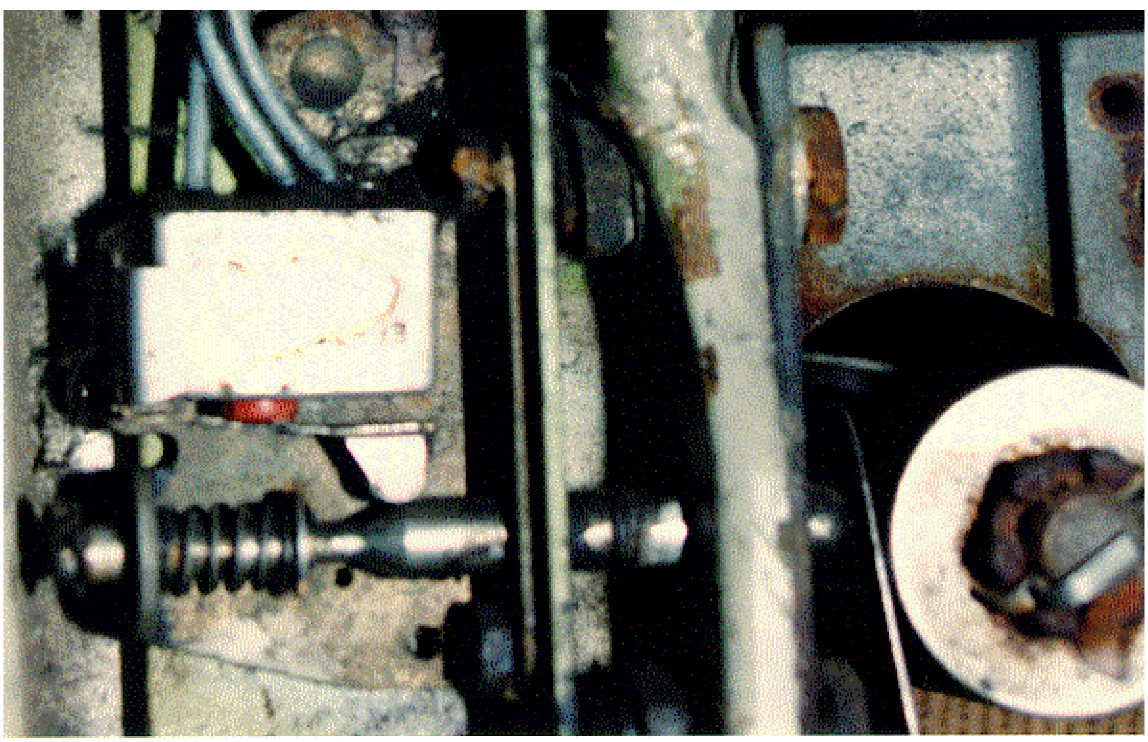

FIGURE 3-3. CORROSION AND LINT ACCUMULATION
ON CARGO DOOR MICRO-SWITCH

TABLE 3-1. EFFECTS OF CORROSION ON AVIONICS EQUIPMENT

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.

c. Structural. Structural parts include housing covers, supports, brackets, cabinets, and chassis, which require structural support and equipment protection. Corrosion on these parts should be cleaned and treated and the protective finish restored to eliminate long-term deterioration. Severe corrosive damage usually results from damage to the protective finish and subsequent attack to the exposed metal. The protective finish is usually damaged from an environmental attack, handling damage, or microbial growth. Figure 3-2 shows surface corrosion on an avionics mounting rack. Severe corrosion damage requiring major repairs should be accomplished by an authorized repair station. Minor corrosion damage and damaged protective coatings are normally repaired by an authorized certificated person.

d. Electromechanical. Motion is an integral function of electromechanical switches, relays, potentiometers, motors, generators, and synchronous components. Storage or non-operation in certain environments tends to promote corrosion of these devices. The principal causes of malfunction are dust, condensation products, resultant corrosion products (oxides), and organic contaminate films. Failure of these devices does not normally occur during operation. The friction generated during operation usually keeps the critical surfaces clean enough to permit operation. On the other hand, during non-operations, insulating films form which prevent startup operation of the equipment.

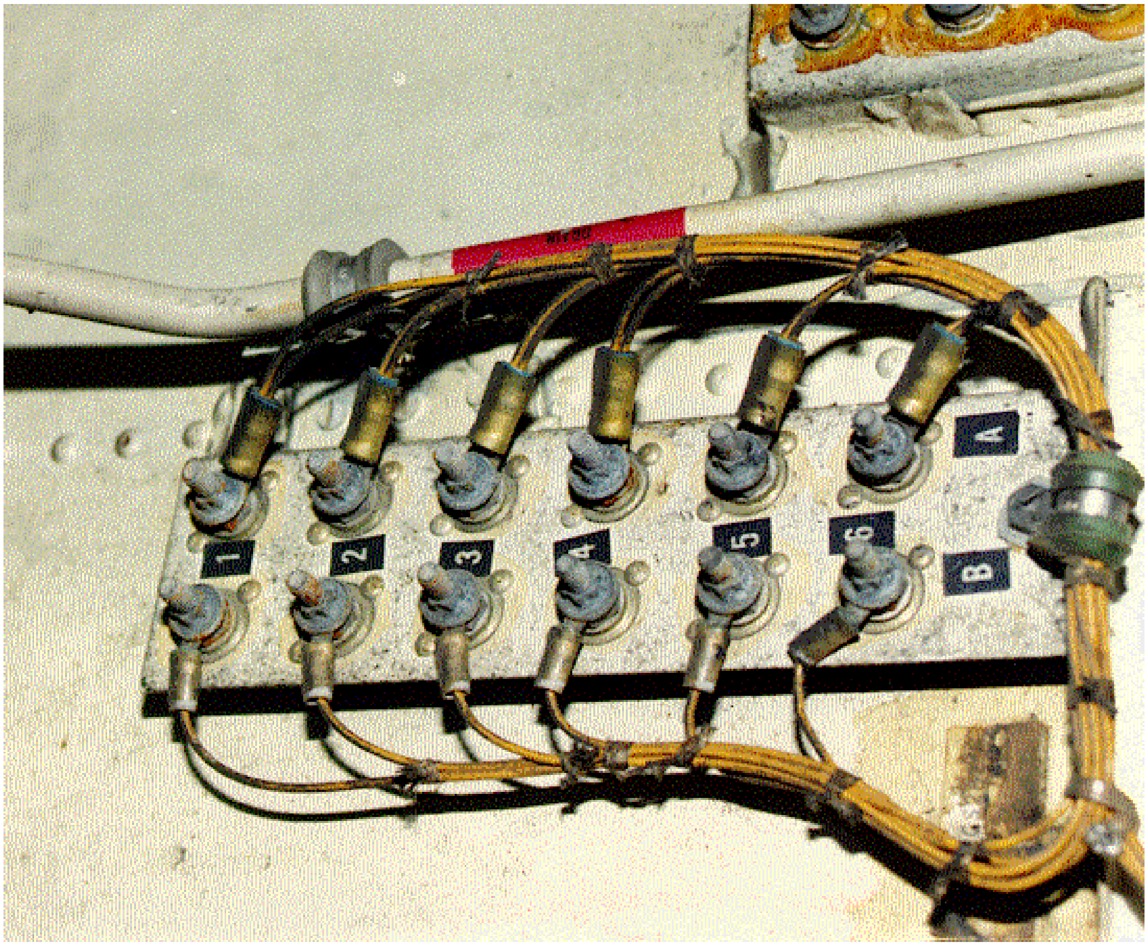

FIGURE 3-4. CORRODED HARDWARE ON TERMINAL BOARD

e. Electronics. Moisture and contaminates penetrate electronic equipment, causing many detrimental effects, such as corrosion. In most modern electronic systems, circuit areas have been minimized for faster signal processing and higher density. In addition, integrated circuits use low voltage for operation. This means that most circuit paths are thin, or small in cross-sectional area, and that individual circuit paths are close together. In these systems, trace amounts of moisture and contaminates may cause systems failures. Table 3-1 lists the typical effects of corrosion on avionics equipment.

f. Special Considerations. The control of corrosion in avionics equipment is like that in the airframe. Procedures used on the airframe are applicable to avionics with appropriate modifications. Figures 3-4, 3-5, and 3-6 show examples of corrosion moisture traps. The general differences in construction and procedures for corrosion control on airframe and avionics are as follow:

(1) Avionics rely on less durable protection systems.

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

(3) Dissimilar metals are often in electrical contact.

(4) Stray electrical currents can cause corrosion.

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

(6) Vented avionics boxes can be subject to condensation due to normal temperature changes during flight.

(7) Avionics systems have many areas that trap moisture.

(8) Corrosion on internal components is difficult to detect in many avionics systems.

(9) Many materials used in avionics 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. These vapors are corrosive to electronic components and damaging to coatings and insulators.

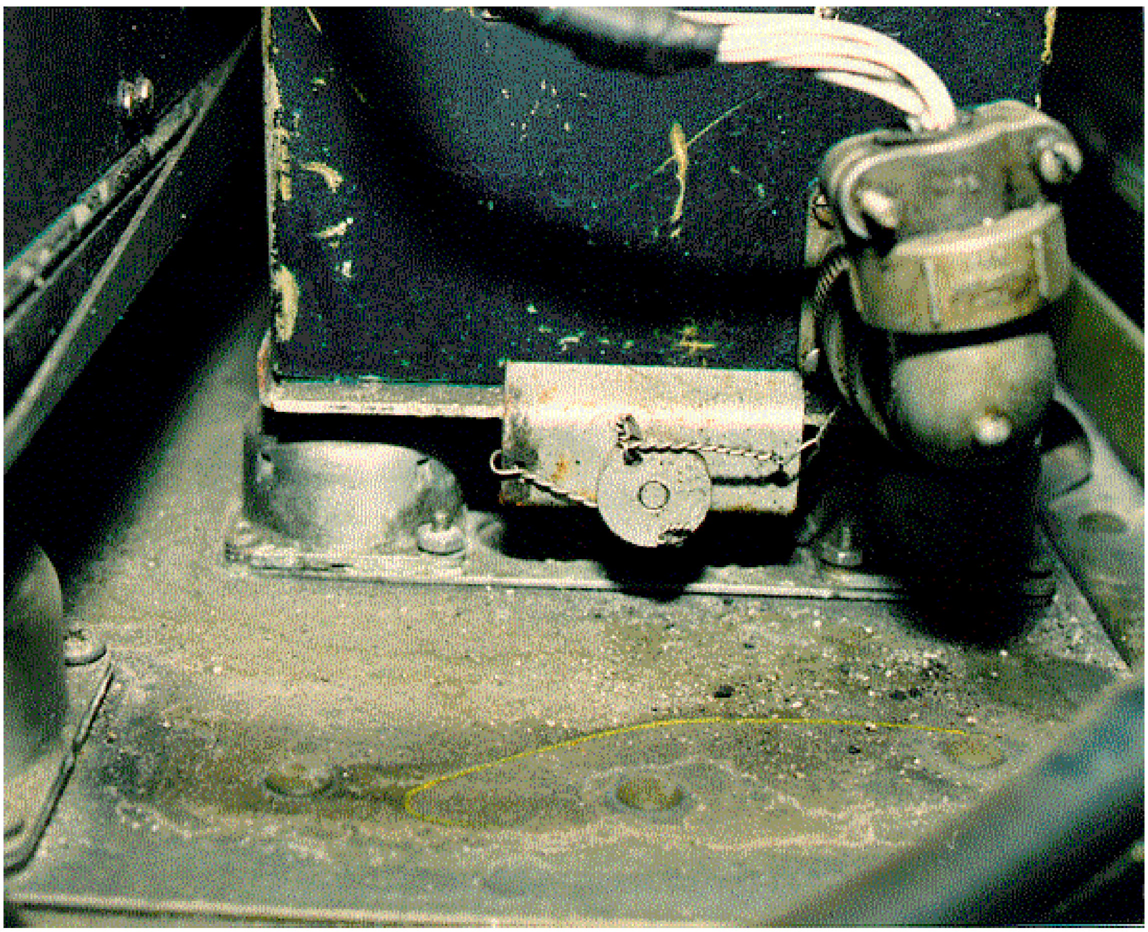

FIGURE 3-5. CORRODED SHOCK MOUNT AND MOISTURE TRAP AREA

FIGURE 3-6. LINT ACCUMULATION ON AVIONICS RACK COOLING AIR MANIFOLD

304. INSPECTION PROCESS.

a. General. Frequent corrosion inspections are essential to the overall success of a corrosion control program. Through detection, identification, and treatment, the costs resulting from corrosion are minimized. Without regular systematic inspections, corrosion will seriously damage avionics equipment. The following paragraphs describe some of the basic aspects of visual inspection for corrosion and the telltale signs associated with various types of corrosion damage.

b. Inspection Factors. Calendar-based "check" maintenance inspections should be in accordance with the manufacturer's or operator's instructions. However, extreme environmental and operating conditions should be considered when determining the frequency of corrosion inspections. The following are factors to consider when developing or using a local inspection interval:

(1) Operational environment;

(2) Known corrosion-prone areas, such as battery components and compartments, and electrical bonds;

(3) Length of storage time, with respect to the storage environment and the avionics equipment or component;

FIGURE 3-7. CROWN AREA INSPECTION

(4) The amount of time the equipment is nonoperational, especially for low usage aircraft or equipment;

(5) Non-pressurized avionics components and equipment bays;

(6) Antennas and externally mounted avionics packages; and

(7) Avionics equipment mounted in susceptible water entrapment and intrusion entry areas.

c. General Inspection Procedures. The following general procedures are recommended for an avionics corrosion inspection:

(1) Clean area or component to be inspected.

(2) Visually examine the overall condition of the equipment or component using an appropriate light source. Suspected areas or corrosion-prone areas should be examined using a l0X magnifying glass and an appropriate light source to determine the extent of corrosion or if other damage exists. Miniature or microminiature circuit boards or avionics components should be examined using the appropriate microscope and light source, as necessary.

(3) Refer to applicable service manual for damage limits.

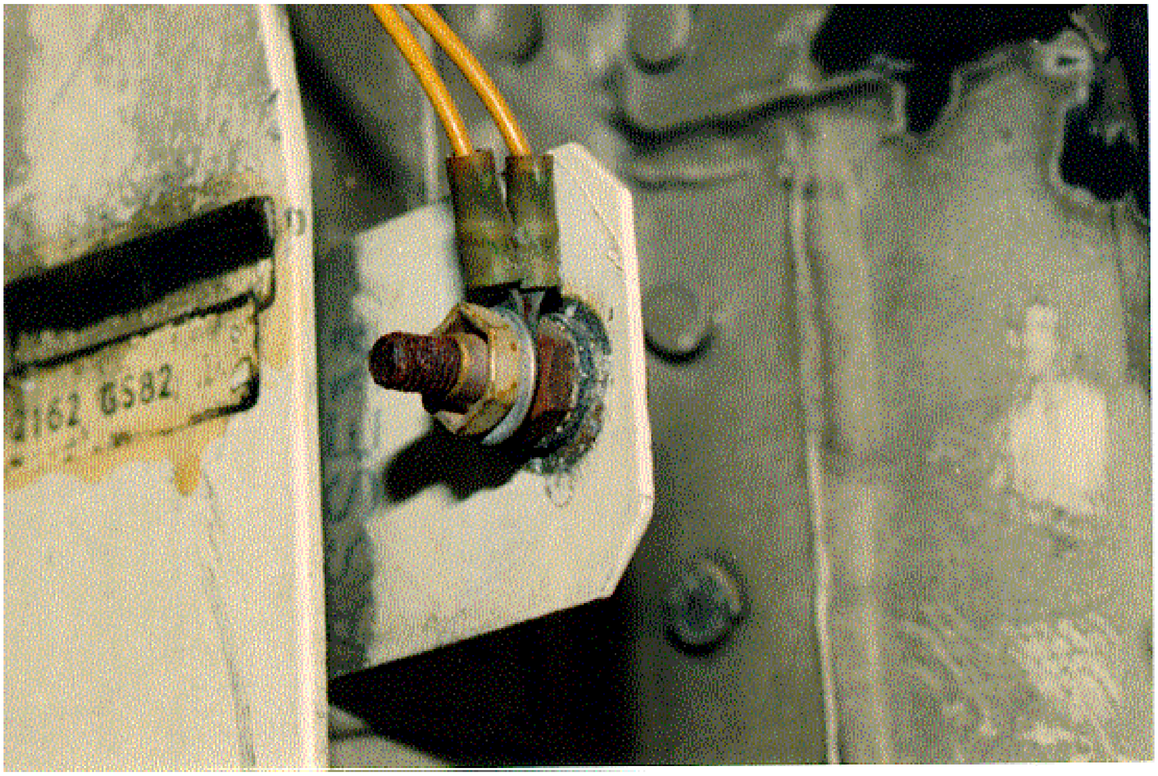

FIGURE 3-8. CORRODED HARDWARE FOR BONDING STRAP

d. Water Intrusion Inspection. Maintenance personnel who routinely inspect the aircraft and equipment should inspect the interior of equipment bays for evidence of water intrusion and entrapment. Any evidence of water stains or entrapped water will require a thorough inspection of mounted equipment and the surrounding structures for corrosion. Additionally, the source of water intrusion will need to be determined and eliminated. The following are suggested areas and procedures for a water intrusion inspection:

(1) Verify installation of required fasteners in avionics equipment, airframe, and surrounding structure.

(2) Inspect condition of gaskets, form-in-place seals, and pre-formed seals.

(3) Verify drain holes are open and clear in avionics equipment and airframe structure.

(4) Inspect condition of doors, electronic rack drip shields, and covers and panels for material condition, especially warping.

(5) Prepare the compartment for a water intrusion test by installing "witness material" such as blotter paper, paper towels, etc. The witness material should be placed in all suspected areas of water intrusion in a manner that will indicate the leakage path.

(6) Close or secure compartment doors, panels, or covers.

CAUTION: Do not direct the stream of water at components with bearings and shaft seals.

(7) Apply fresh water with a hose in a stream to the exterior surface of the airframe for approximately five minutes.

(8) Allow approximately three to five minutes for the water to penetrate and drain.

(9) Open or remove compartment doors, panels, or covers.

(10) Visually examine "witness" material for signs of water and source of water intrusion.

(11) Accomplish repairs in accordance with applicable repair service manual.

(12) Close or secure compartment doors, panels, or covers.

(13) Repeat water intrusion test, subparagraph (5) and subsequent, along with the appropriate repairs until water intrusion leaks are no longer observed.

305. RECOGNIZING AVIONICS CORROSION.

a. General. Recognizing the appearance of corrosion or corrosion products for specific metals is an important part of an avionics corrosion prevention and control program. Metals are susceptible to corrosion because all metals have a tendency to return to their natural forms. For example, iron tends to return to iron oxide (rust). Avionics systems make use of many metals not normally considered for airframe structures. Some of the rarer metals are found in avionics components, in transistors, miniature and microminiature circuits, and integrated circuits. Table 3-2 lists the metals most often used in electronics and avionics components. In addition to recognizing the appearance of corrosion or corrosion products for specific metals, maintenance personnel must be able to recognize a corrosive attack from solder flux, microbes, insects, and animal attack. Table 3-3 describes the appearance of corrosion for specific metals and different corrosive attacks.

b. Corrosion Effects on Metals. Deterioration (corrosion) of a metal is caused by a chemical reaction with its environment. The corrosive effect can be accelerated by many of the factors that were discussed in chapter 2. No metal can have a perfect environmental integrity, and therefore will corrode. Corrosion of a specific metal will take on many different forms as the corrosive attack progresses. The following paragraphs provide a description of corrosion with respect to the most commonly used metals in avionics systems.

(1) Iron and Steel. Iron and steel are used in avionics components as leads, magnetic shields, transformer cores, brackets, racks, and general hardware. Some of these components are plated with nickel, tin, or cadmium. Corrosion of steel is easily recognized because the corrosion product is red or black iron oxide (rust). When iron based alloys corrode, dark corrosion products usually form first. This material will promote further attack by absorbing moisture from any water source, including ambient air. The most practicable means of controlling corrosion on non-plated steel or iron is complete removal of the corrosion product (rust) by the least harsh method. Iron and steel surfaces are normally protected by applying a plating system, paint system, or application of a preservative compound.

(2) Corrosion Resistant Steel. Stainless steel is used for mountings, racks, brackets, and hardware in avionics systems. Stainless steel is not readily susceptible to corrosion because of a tough chromium oxide film on the surface. However, exposure to a salt water environment will cause pitting. Stainless steel is corrosion resistant, but is susceptible to crevice corrosion. The corrosion product of stainless steel is a roughened surface with a red, brown, or black stain. Corrosion treatment for stainless steel to remove the red, brown, or black stain should be limited to cleaning with stainless steel wool or a stainless steel brush.

(3) Aluminum Alloys. Aluminum and aluminum alloys are widely used in avionics systems for electrical connectors and back shells, cabinets, housings, chassis, structures, and mounting fixtures. Corrosion of aluminum and aluminum alloys is indicated by a white or gray powder (aluminum oxide). In most environments, especially moist salt-laden air, aluminum alloys are subject to many types of corrosive attack and therefore require protection. Aluminum surfaces are protected by an entire paint coating system composed of a chemical conversion coat, primer, and topcoat. Painted aluminum surfaces, even with the recommended protection system, tend to mask any corrosion attack to the aluminum. Corrosion damage to the aluminum surface will show up in the paint coating as filiform corrosion showing signs of blistering, flaking, chipping, lumping, or other irregularities.

TABLE 3-2. METALS MOST COMMONLY USED IN AVIONICS SYSTEMS

Aluminum	*Gold	*Platinum
Antimony	Indium	*Rhodium
Arsenic	*Iridium	Selenium
Beryllium	Iron	*Silver
Bismuth	Lead	*Stainless Steel (CRES)
*Brass	Lead-Tin Alloy	Steel
*Bronze	Magnesium	*Tantalum
Cadmium	Mercury	*Tin
Cobalt	*Monel	Tungsten
*Copper	*Nickel	
Germanium	*Palladium	

* Usually considered corrosion-resistant

(4) Magnesium. Magnesium alloys are used throughout avionics systems because of their light weight. Magnesium alloys can be found in antennas, component structures, chassis, supports, and frames. Magnesium is highly susceptible to corrosion when exposed to any environment without a protective coating. Magnesium forms a strong (anoxic) galvanic cell with every other metal and is always the metal that will suffer the corrosive attack. Magnesium is subject to almost all types of corrosion mentioned in chapter 2, and once started, the corrosive attack will spread rapidly. Corrosion on magnesium alloys is recognized by white, powdery, snow-like mounds. When corrosion is found on magnesium, prompt corrective action is required. Magnesium surfaces are protected from corrosive attack by a paint coating system composed of a chemical conversion coat, primer, and topcoat.

(5) Copper. Copper and copper based alloys are used extensively in avionics systems. Copper and copper based alloys are used for wiring, contacts, springs, connectors, and printed circuit boards. Copper and copper based alloys (brass and bronze) are quite resistant to corrosion. Copper is cathodic to most of the other metals used in avionics equipment. The corrosive attack to copper and copper based alloys is a uniform surface tarnish of a green-gray color that remains relatively smooth. This uniform surface tarnish is the result of the formation of a fine-grained, airtight copper oxide. The copper oxide offers good protection from further corrosion attack to the underlying metal in ordinary situations. However, exposure to moist salt-laden air or salt spray causes the formation of blue-green salts which indicate an active corrosive surface. Copper and copper based alloys are generally not protected by a paint coating system.

TABLE 3-3. NATURE AND APPEARANCE OF CORROSION PRODUCTS ON METALS

Alloy	Type of attack to which alloy is susceptible	Appearance of corrosion product
Aluminum alloy	Surface, pitting, and intergranular corrosion	White or gray powder
Titanium	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 corrosion	White powder, snow-like mounds, and white spots on surface
Carbon and low alloy steel (1000-8000 series)	Surface oxidation and pitting	Reddish-brown oxide (rust)
Stainless steel (300-400 series)	Intergranular corrosion; some tendency towards pitting in a marine environment (300 series more corrosion-resistant than 400 series)	Rough surface; may show red, brown, or black stain
Nickel base alloy (Inconel)	Generally has good corrosion-resistance qualities; sometimes susceptible to pitting	Green powdery deposit
Copper base alloy (Monel)	Surface and intergranular corrosion	Blue or blue-green powder deposit
Cadmium (used as a protective plating for steels)	Uniform surface corrosion	White to brown to black mottling of the surface
Chromium (used as a wear-resistant plating for steels)	Subject to pitting in chloride environments	Chromium, being cathodic to steel, promotes rusting of steel where pits occur in the coating
Silver	Will tarnish in presence of sulfur	Brown to black film
Gold	Highly corrosion-resistant	Deposits cause darkening of reflective surfaces
Tin	Subject to whisker growth	Whisker-like deposits
Electroless nickel (used as a plating on aluminum connectors)	Pitting and flaking of surface plating	Nickel, being cathodic to Aluminum, does not corrode itself, but promotes corrosion of the aluminum base metal where pits occur in the plating.

(6) Cadmium. Cadmium is used primarily in avionics equipment as a plating on hardware (nuts, bolts, etc.) and electrical connectors. It is also used to provide a compatible surface for parts in contact with other material. Cadmium, when plated over steel, is anoxic to the steel and protects the steel as a sacrificial coating. Corrosion on cadmium is evidenced by white to brown to black mottling of the surface. Cadmium plating on steel hardware is still protecting the steel until signs of rust on the steel appear. Care should be taken not to remove any of the cadmium plating adjacent to a rusted area on the base material.

(7) Silver. Silver is normally used as plating material over copper in wave guides, miniature and microminiature circuits, wiring, and contacts. It is also used on RF shielding. Silver does not corrode in a normal sense, but it will tarnish in the presence of sulfur. The tarnish (silver sulfide) appears as a brown to black film. Corrosion treatment should be limited to cleaning.

(8) Red Plague. When silver plating over copper is damaged, there can be an accelerated corrosive attack of the underlying copper. The "red plague" is readily identifiable by the presence of a brown-red powder deposit on the exposed copper. In the case of wiring, the problem is compounded by the wire insulating material. The insulating material can prohibit detection of the damaged silver plating until the damage to the copper is extensive.

(9) Gold. Gold is the best plating material for electrical connections because of its corrosion resistance and the ease with which it can be soldered. Gold is used on printed circuits, semiconductor leads and contacts, and is usually plated over nickel, silver, or copper. Gold is a noble metal and does not normally corrode; however, a slight tarnish will appear as a darkening of its normally reflective surface. When gold is plated over silver or copper, accelerated corrosion can occur at pin holes or pores in the gold plating. This tarnishing of the gold over silver is readily identified by a brown to black film. The tarnishing of the gold over copper is identified as a blue-green film. The methods employed in tarnish removal are critical on gold-plated components because the plating is very thin (typically 0.00015 inch thickness).

(10) Purple Plague. Purple plague is a brittle gold-aluminum corrosion product formed when a gold-plated component and an aluminum component are mechanically attached or bonded together. Microelectronic circuit failures can occur at the interconnecting mechanical bond as this gold-aluminum corrosion product grows.

(11) Tin. The use of tin in solder is a well-known application. Tin is also used as a plating on RF shields, filters, crystal covers, and automatic switching devices. Tin is the best solder and corrosion-resistant coating of the available metallic coatings. The problem with tin is its tendency to grow "whiskers" on tin-plated wire and other tin-plated devices. Tin whiskers can grow to an extent that they will cause shorting across microelectronic circuits.

(12) Black Plague. Black plague is a black substance that forms in the liquid cooling systems of high power radars. This substance adheres to the walls of tubing and components in the cooling system and affects the heat transfer characteristics of the system. Corrosion removal for these components is the same as for the base metal.

(13) Nickel. Nickel is primarily used as an electroless nickel coating and is subject to pitting corrosion. Flaking of the nickel coating can also occur when the underlying metal corrodes.

306. CORROSION EFFECTS ON NONMETALS. Deterioration of nonmetallic subassemblies and other hardware costs commercial and private operators millions of dollars per year in replacement material costs and loss of equipment availability. In most cases, the deterioration of the nonmetallic material permits the intrusion of moisture into the equipment. This deterioration creates physical swelling, distortion, mechanical failure through cracking, altering of electrical characteristics, etc. The most common nonmetals used in avionics systems and the nature and appearance of their deterioration are listed in tables 3-4 and 3-5 respectively.

TABLE 3-4. NONMETALS MOST COMMONLY USED IN AVIONICS SYSTEMS

Acrylics	Encapsulates	Paper
Adhesives	Felt	Plastics
Asbestos	Glass	Polymers
Ceramics	Graphite	Potting Compounds
Cloth	Laminates	Primers
Conformal Coatings	Leather	RTV
Cork	Lubricants	Sealants
Elastomers	Paint	Tapes

TABLE 3-5. NATURE AND APPEARANCE OF DETERIORATION ON NONMETALS

Material	Type of attack to which material is susceptible	Appearance of deterioration
Acrylics	UV light, moisture, solvents	Discoloration, cracking
Adhesives	Dirt, UV light, solvent, moisture	Cracking, peeling
Ceramic	Extreme heat	Discoloration, cracking
Cloth	Dry rot, mildew	Discoloration, tears, dust
Conformal coating	Moisture, scratches	Peeling, flaking, bubbling
Cork	Moisture, mildew, dry rot	Discoloration, dust, peeling
Elastomers	Heat, UV light, excessive cycling	Cracks, crazing, discoloration
Encapsulant	UV light, moisture	Cracking, peeling, disbonding
Felt	Moisture, mildew	Discoloration, looseness
Glass	Heat	Cracks, discoloration
Laminates	UV light, moisture, solvents	Discoloration, disbonding, delamination
Paint	Moisture, heat, humidity	Bubbling, peeling, cracking
Plastic	UV light, heat, humidity	Discoloration, cracks, deformation
Polymers	Extreme heat, solvents	Discoloration, deformation
Potting Compound	UV light, moisture, heat	Discoloration, cracks, deformation
RTV (noncorrosive)	Moisture, UV light, heat	Peeling, disbonding, discoloration
Sealants	Moisture, UV light, heat	Peeling, disbonding, discoloration

307. CORROSION EFFECTS OF SOLDER FLUX. Solder flux residues may be conductive and corrosive. They are often "tacky," collecting dust which can absorb moisture and create current leakage paths. Solder flux resin appears as an amber-colored globule, drip, or tail at or near the solder joint. Under ultraviolet light, traces of flux appear as a fluorescent yellow to light brown residue. When soldering, use the lowest acid content flux possible (even "neutral" fluxes have some acid in order to remove metal oxides) and provide a reducing atmosphere to prevent oxide formation during soldering. After soldering, all flux residue must be completely removed by cleaning. Complete removal can be verified by the use of the ultraviolet light. The light source should conform to MIL-L-9909.

308. EFFECTS OF MICROBIAL ATTACK. Bacteria and fungi not only feed on organic material, but also release acids which are corrosive. Bacteria and fungi may be found on encapsulates, conformal coated circuit boards, rubber gaskets, thermoplastics, optical lenses, etc. The presence of bacteria and fungi can be readily identified by damp, slimy, and bad-smelling growths. These growths vary in color from black, blue-green, and green to yellow.

309. EFFECTS OF INSECT AND ANIMAL ATTACK. Small insects and animals may enter packaged equipment and feed on various organic materials such as polyethylene and wire insulation. This attack can result in system or equipment failure. The presence of nests, holes in packaging, and excrement indicate animal or insect attack. This problem is generally more severe in equipment that is in storage or has been out of service for a long period of time. Figures 3-9, 3-10, and 3-11, show the effects of animals. Frequent inspection of the equipment or shipping containers is the best method of controlling this problem.

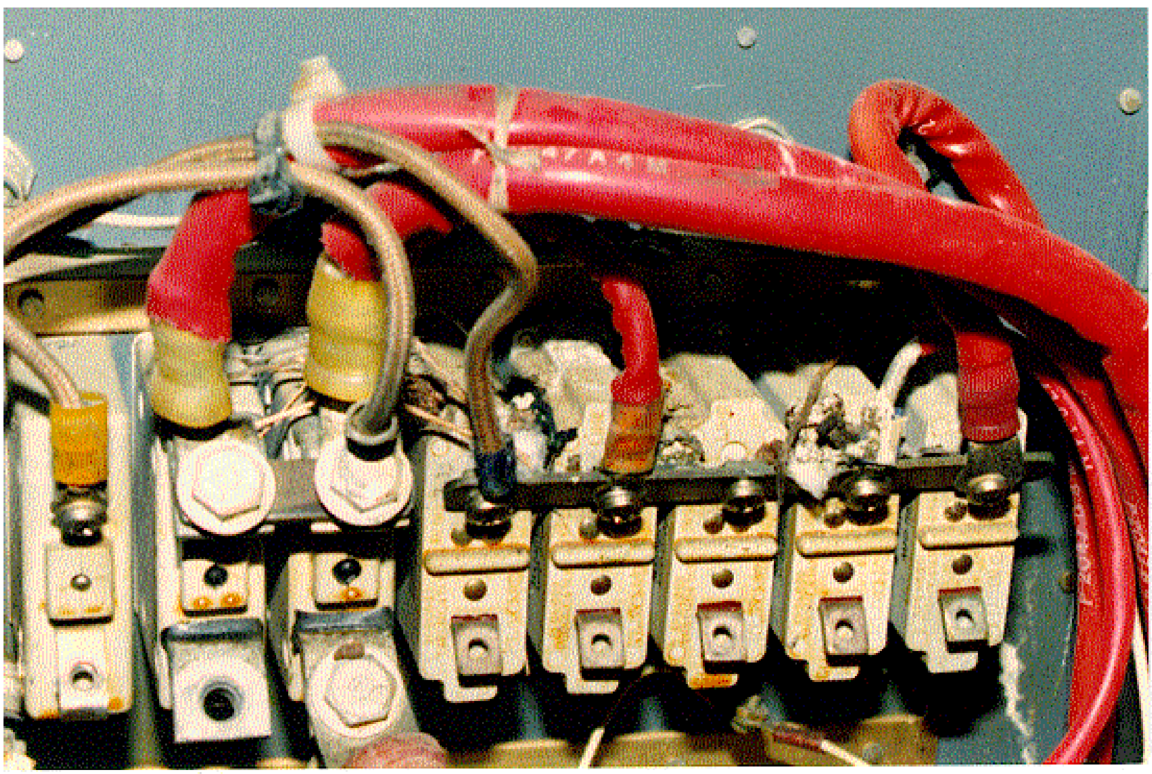

FIGURE 3-9. ANIMAL DROPPINGS ON ELECTRICAL COMPONENTS

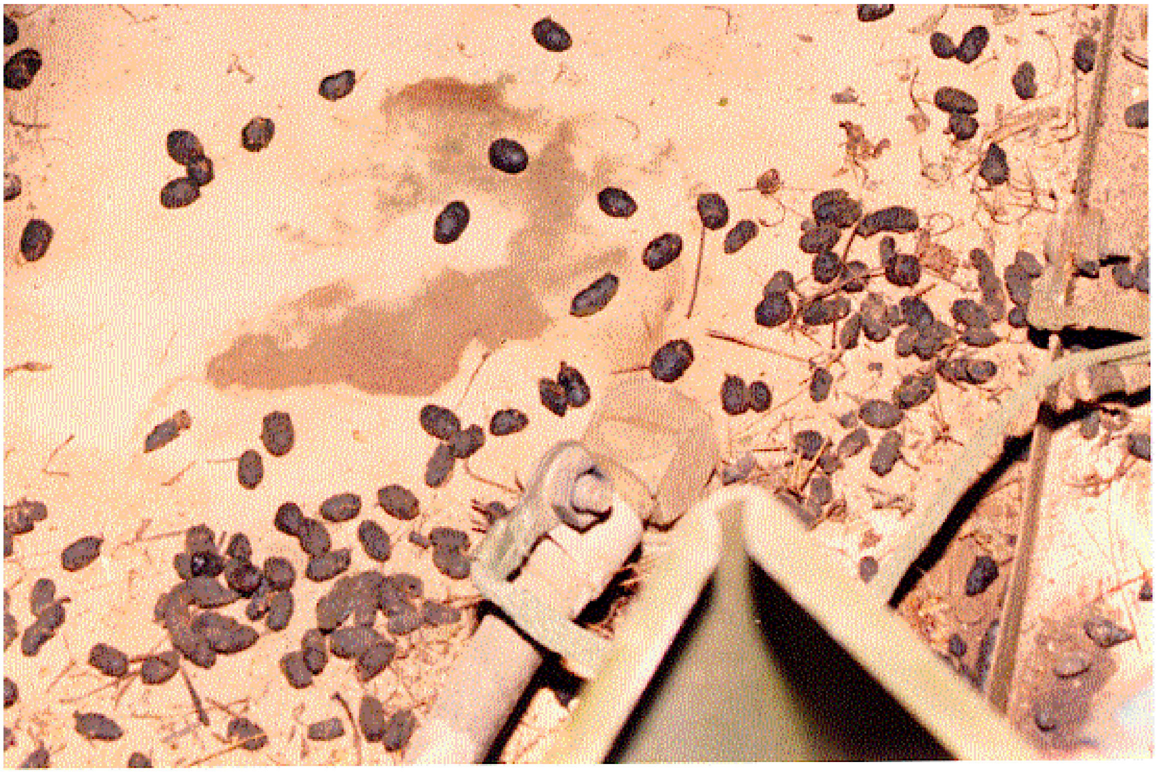

FIGURE 3-10. RODENT DROPPINGS IN BILGE AREA

FIGURE 3-11. BIRD NEST IN ENGINE PYLON

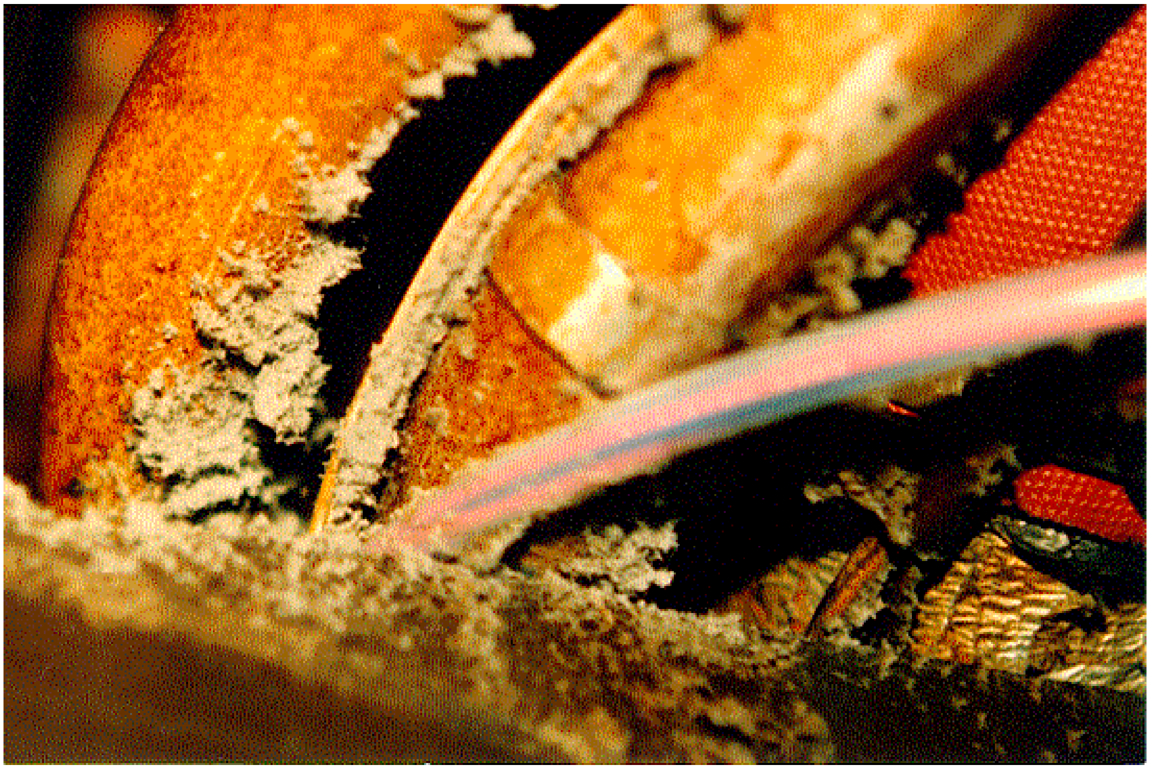

FIGURE 3-12. LINT ACCUMULATION IN CROWN AREA

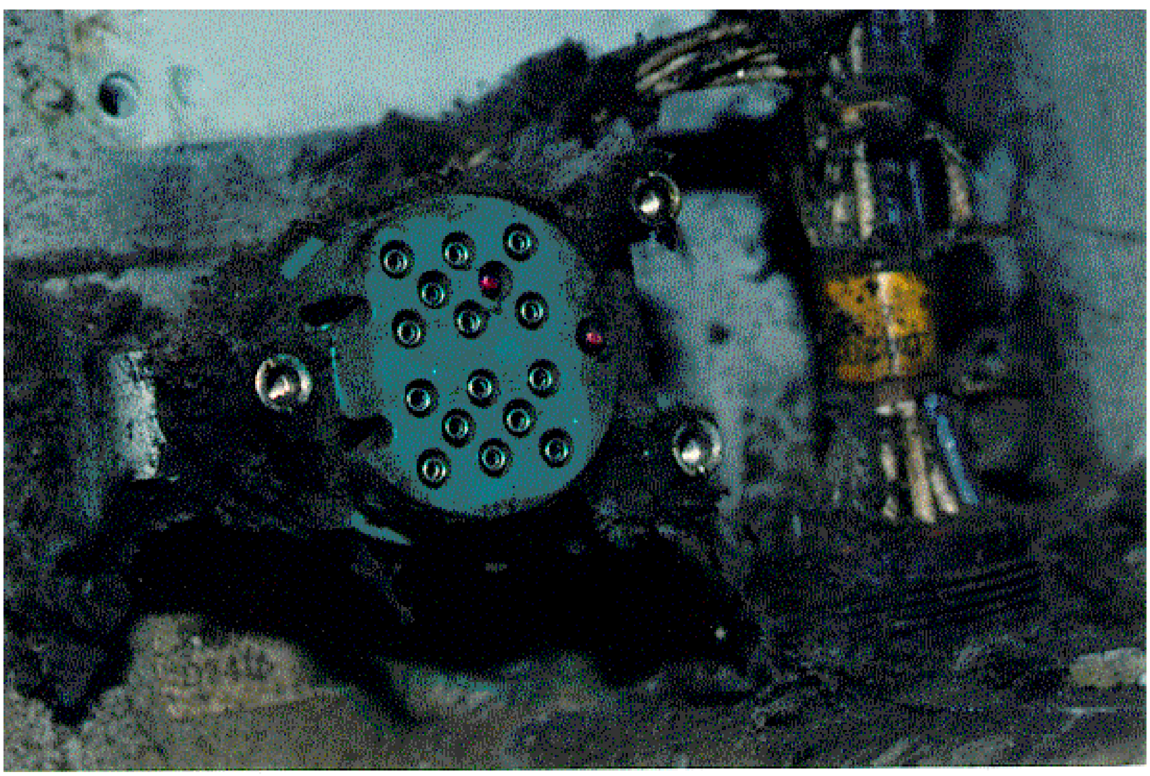

FIGURE 3-13. LINT ACCUMULATION ON ELECTRICAL CONNECTOR

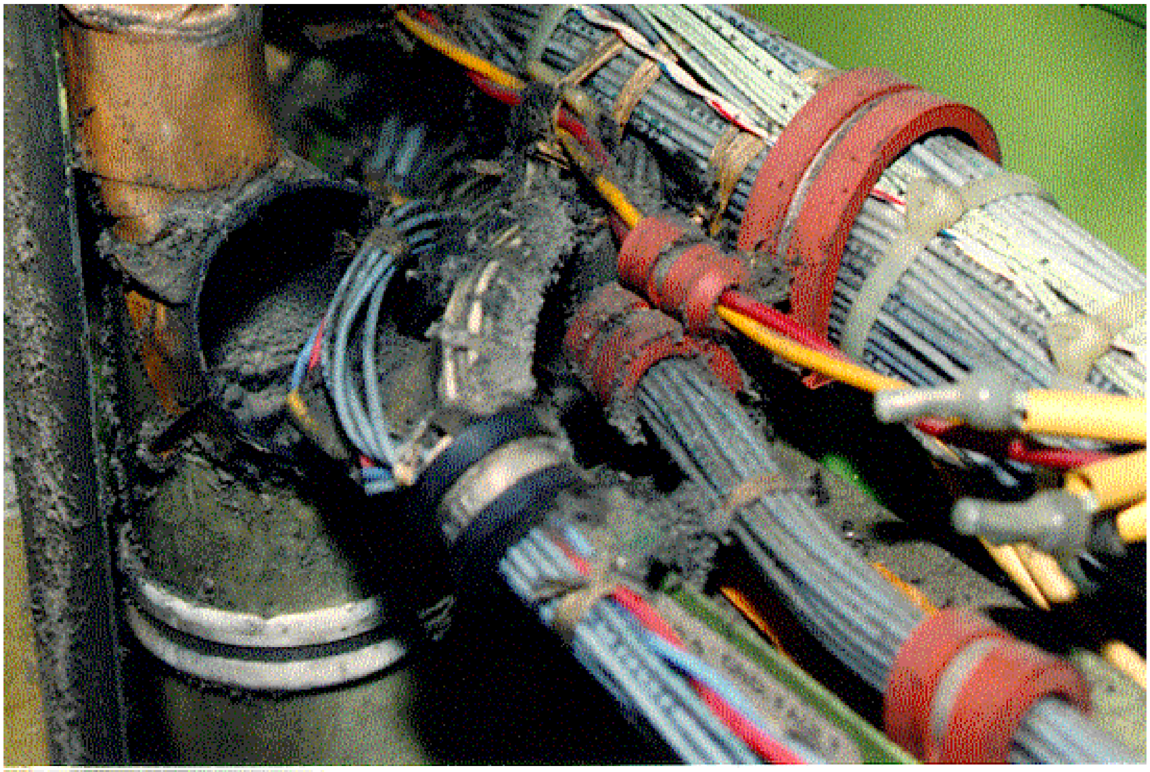

FIGURE 3-14. LINT ACCUMULATION ON WIRING BUNDLE

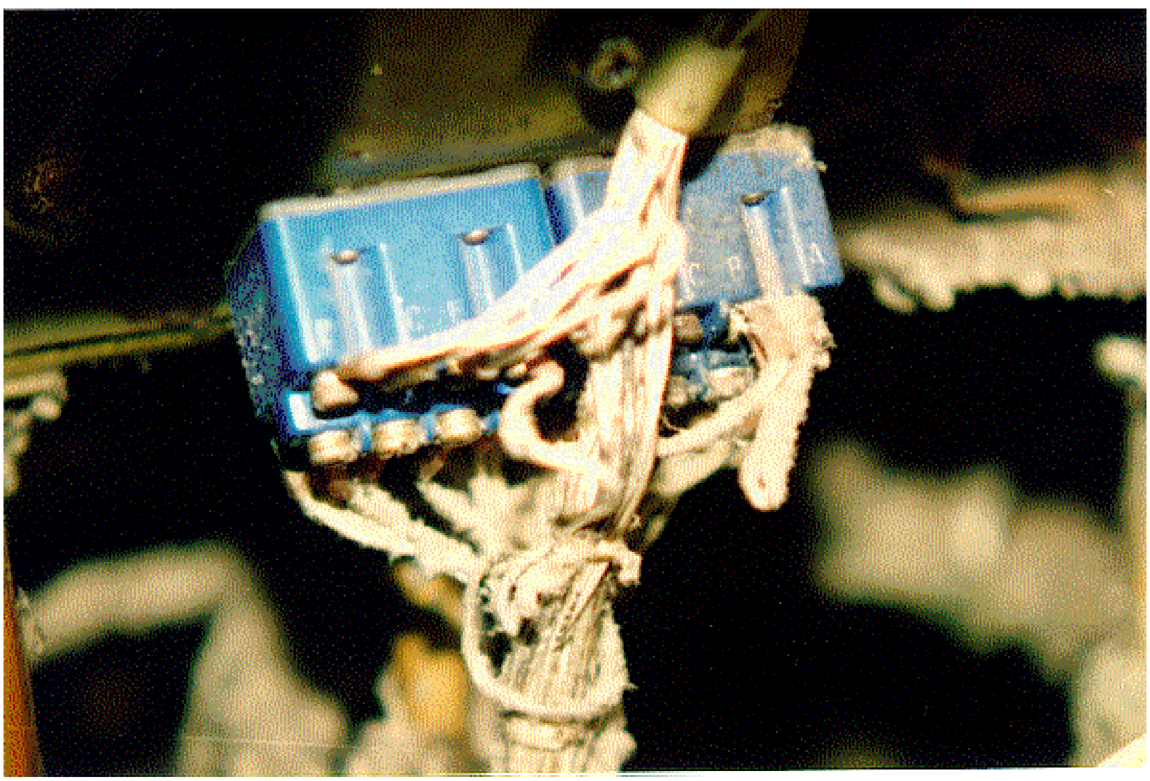

FIGURE 3-15. LINT ACCUMULATION ON ELECTRICAL SWITCH

310. EFFECTS OF DUST/LINT ACCUMULATION. Avionics equipment is subject to dust and lint accumulation. This condition is generally evident when the equipment has been installed for long periods of time and can become more severe with forced cooling air. In addition to the dust and lint accumulation from the movement of air, dust and lint can be attracted by magnetic fields from electric currents surrounding wiring and equipment. Dust can also accumulate on the surfaces of components and on the interior surfaces of components if that equipment has ventilating holes and louvers. The problem with accumulation of dust and lint is it will trap and hold moisture which can provide the electrolyte for corrosion and fungus growth (see chapter 2, paragraph 205, Corrosive Conditions). Additionally, dust and lint can degrade avionics equipment by being a conductor or an insulator. When dust and lint act as a conductor in the presence of moisture, they can provide a path for a current flow to either ground as a short or an unwanted circuit path between components. When dust and lint act as an insulator the avionics equipment can overheat causing premature failure. Severe accumulations of dust can appear as long stringy clumps (similar to Spanish moss hanging from trees, but on a smaller scale). Figures 3-12 through 3-15 show examples of dust and lint accumulation. Frequent inspections and general cleaning of equipment will control the accumulation of dust and lint.

311. thru 400. RESERVED.

CHAPTER 4. CLEANING AND PRESERVATION

401. GENERAL. The materials, equipment, and techniques described in this chapter are intended to assist the avionics technician at an avionics repair facility. This chapter discusses avionics cleaning and repair facility requirements, specialized support equipment to support cleaning, corrosion removal, drying of avionics equipment, and the different processes of cleaning, drying, preserving, packaging, handling, and shipping avionics equipment.

402. AVIONICS CORROSION CLEANING FACILITY. An avionics cleaning and repair facility should include as a minimum the following resources for the cleaning, drying, preserving, packaging, handling, and shipping of avionics equipment:

a. Adequate lighting and a temperature/humidity controlled ventilation system.

b. Adequate space for safe operation of avionics cleaning and corrosion control equipment.

c. Operating instructions for each piece of equipment.

d. All hazardous material and Safety Data sheets for materials used.

e. Safety equipment and protective personal equipment as required by local, state, and federal ordinances.

f. Personnel trained in the recognition of corrosion on avionics equipment as specified in this AC.

g. Personnel trained in the safe and proper operation of support equipment.

h. Quality assurance inspectors trained in the operational characteristics and restrictions of each piece of support equipment.

i. Avionics technicians who can recognize the various electrical and electronic equipment and components.

403. MATERIALS AND SUPPORT EQUIPMENT REQUIREMENTS.

a. General. Avionics technicians must understand the functions, capabilities, and restrictions associated with each piece of specialized support equipment, and the hazards of the cleaning and corrosion removal products and preservation materials. This knowledge will prevent injury to personnel and damage to avionics equipment and support equipment.

b. Materials. Consumable cleaning and corrosion removal products and preservation materials listed in Appendix 1 and Appendix 2 may be used as specified on avionics equipment if none were identified by the original equipment manufacturer or equipment operator.

c. Materials Used For Cleaning. Table 4-1 contains a list of the various cleaning compounds and solutions, their characteristics, application, mixing instructions, and restrictions. The cleaning of avionics equipment can be accomplished using the following processes:

CAUTION: Some of the materials identified in table 4-1 can create hazardous conditions or damage equipment unless used strictly in the applications and manner described.

CAUTION: Some of the materials identified in table 4-1 are chlorofluorocarbons (CFCs), an ozone depleting substance (ODS). These materials may be banned from use by environmental restrictions.

(1) Solvents are effective in dissolving greases and oils. Solvents can be applied by wiping, brushing, soaking, or spraying.

(2) Detergent and water in varying concentrations are used to remove dust, dirt, salt deposits, greases, and oils. Detergent and water cleaning mixtures can be applied by wiping, brushing, soaking, and spraying.

TABLE 4-1. AVIONICS CLEANING MATERIALS

Description	Characteristics	Application	Restrictions
Cleaning Compound, Aircraft Surface, MIL-C-85570, Type II	General cleaning agent for light soil and dirt in equipment bays, on external cases, covers, and antenna assemblies.	Mix per manufacturer's instructions or 1 part cleaner in 10 parts distilled water. Apply with cleaning cloth. Rinse with fresh water and wipe dry.	Do not use around oxygen fittings or oxygen regulators as fire or explosion may result.
	Heavy concentrations of surface grime, oil, exhaust smudges, and fire extinguishing chemicals in equipment bays and on external cases and covers.	Mix per manufacturer's instructions or 1 part cleaner in 6 parts distilled water. Apply with cleaning cloth. Rinse with fresh water and wipe dry.	Never use full strength. Do not allow to dry on surface.
Detergent, Liquid, Nonionic MIL-D-16791, Type 1	Cleans transparencies, acrylic plastics, and glass. Also used in the water-based Solvent Spray Cleaning Booth and Aqueous Ultrasonic Cleaner for removing contaminants.	For hand cleaning, apply with flannel cloth. Let dry; then remove with dry flannel cloth.	Mix per manufacturer's instructions or 1 fluid oz. per gallon of water.
Cleaning and Lubricating Compound, Electrical Contact, MIL-C-83360, Type 1	A cleaner-lubricant compatible with potting compounds, rubbers, and insulation. Contains 3% to 5% silicon. 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 areas requiring soldering or coating.
Cleaning Compound, Solvent, Trichlorotrifluoroethane, MIL-C-81302, Type II	General cleaner for light to medium to heavy dirt, dust, contaminants, and fire extinguishing chemicals.	Used in the Solvent Ultrasonic Cleaner.	Do not use on acrylic plastics and acrylic conformal coatings. Do not use on unsealed aluminum el lytic capacitors. Damage may result to end caps and cause leakage.

TABLE 4-1. Continued

Description	Characteristics	Application	Restrictions
Dry Cleaning Solvent, P-D-680, Type II	General purpose cleaner for 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. Wipe clean with cleaning cloth.	Do not use around oxygen, oxygen fittings, or oxygen regulator as fire or explosion may result.
	Cleaner for smoke damage removal on internal chassis components.	Apply by scrubbing affected area with cleaning cloth, toothbrush, or typewriter brush. Wipe clean with cleaning cloth.	When used for smoke damage removal, always follow up with a solution of 1 part deionized water and 1 part Isopropyl Alcohol, TT-I-735.
	Cleaner for smoke damage removal on circuit components and laminated circuit boards.	Apply by wiping or scrubbing affected area with cleaning cloth or toothbrush. Wipe clean with cleaning cloth.	May cause swelling of silicone rubber seals in equipment exposed for long periods.
	Cleaner for removal of Water Displacing Compound, MIL-C-81309, Type II or Type III, MIL-C-85054, and Corrosion Preventive Compound MIL-C-16173, Grade 2, 3, and 4.	Apply by brush or toothbrush. Wipe clean with cleaning cloth.	May soften some plastics, wire harness tubing, and plastics coating on wiring. Test affected area for adverse reaction prior to general application.
Isopropyl Alcohol, TT-I-735	General purpose cleaner and solvent for removal of salt residue and contaminants common to internal avionics equipment. General cleaner for internal chassis components.	Apply a solution of 1 part deionized or distilled water and 1 part Isopropyl Alcohol, TT-I-735, to 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 oven.
	Solvent cleaner for solder flux residue in all electronics, electrical equipment, and micro-miniature circuit. applications.	Apply a solution of 1 part deionized or distilled water and 3 parts Isopropyl Alcohol, TT-I-735, and scrub the solder joint and adjacent area with an acid brush or toothbrush. Wipe clean with cleaning cloth.	

TABLE 4-1. Continued

Description	Characteristics	Application	Restrictions
	Cleaner for bacteria and fungi attack on all metals and nonmetals.	Apply a solution of 1 part solvent Trichloro-trifluoroethane, MIL-C-81302, Type II, and 1 part Isopropyl Alcohol, TT-I-735, to affected area with cleaning cloth. Wipe clean and air dry.	
	Cleaner for saltwater immersion and fire extinguishing agents on all internal circuit components and laminated circuit boards.	Apply a solution of 1 part Isopropyl Alcohol, TT-I-735, and 9 parts solvent Trichlorotrifluoroethane, MIL-C-81302, Type II, to affected area with cleaning cloth, acid brush, or toothbrush.	
	Cleaner for electrical contact surfaces.	Apply a solution of 1 part deionized or distilled water and 1 part Isopropyl Alcohol, TT-I735, to affected area with acid brush or pipe cleaner. Wipe clean and air dry.	
Water, distilled	Cleaner for solder flux residue in all electronics, electrical equipment, and microminiature circuit applications.	Apply a solution of 1 part deionized or distilled water to 3 parts Isopropyl Alcohol, TT-I-735, and scrub joint and adjacent area with acid brush or toothbrush. Wipe clean with cleaning cloth.	Deionized water is an acceptable substitute.

(3) Distilled or fresh water is used to dilute Isopropyl Alcohol or detergents for use in cleaning and as a final rinse. Water may also be used to remove dust, dirt, salt deposits, and cleaning solutions. Application is by wiping, brushing, soaking, and spraying.

d. Hazardous Chemicals and Waste Generation. Many of the materials identified in this AC are hazardous and toxic to personnel not using appropriate personal protective equipment. These materials can also be potentially damaging to avionics equipment and aircraft if used in improper concentrations or misapplied. Prior to using any chemicals such as paint strippers, detergents, solvents, conversion coatings, primers, or paints, personnel should review the appropriate Material Safety Data Sheets (MSDS) for Warnings and Cautions or the hazardous material identification labels on the containers. Figure 4-1 provides a simple system of readily recognizable and easily understood markings which will give, at a glance, the general idea of the inherent hazards of any hazardous material. Additionally, the use of materials identified in this AC can, if improperly used or disposed of, create a hazard and contaminate the environment. Avionics technicians should use only the proper amount when mixing materials, close containers when not in use, use only the required amount to complete the intended procedure, and properly dispose of all materials in accordance with all federal, state, and local regulations.

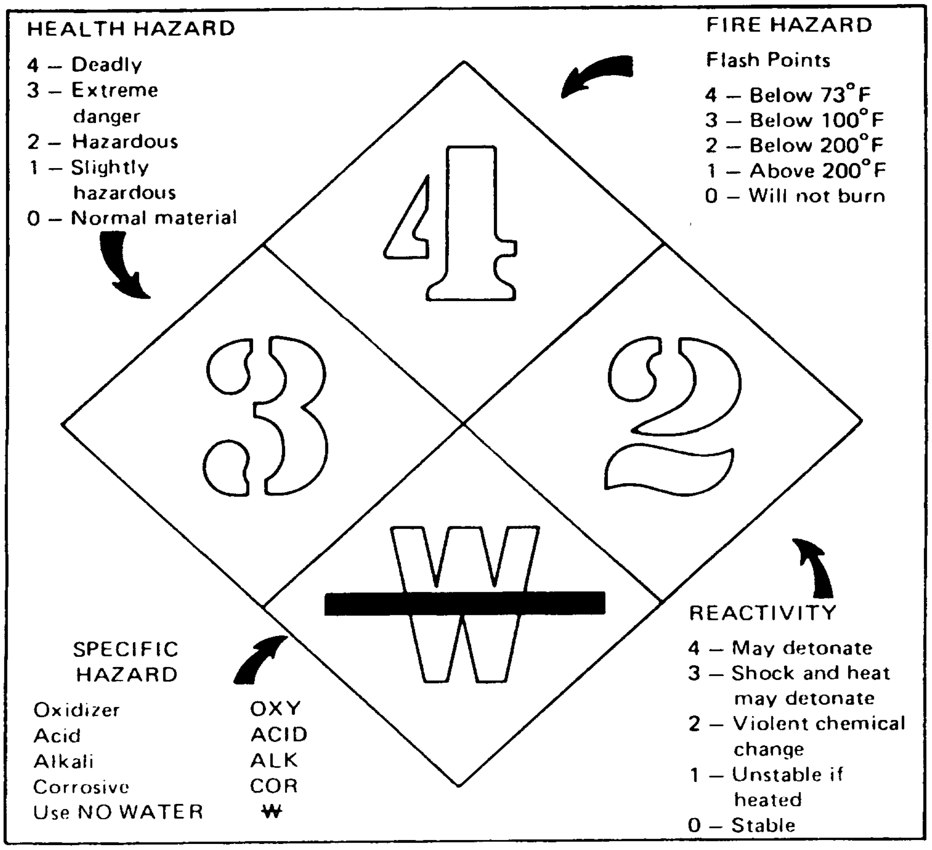

FIGURE 4-1. NFPA 704 WARNING SYSTEM LABEL

404. AVIONICS CLEANING EQUIPMENT.

a. The following paragraphs identify the different types of avionics cleaning equipment and list their uses and specific restrictions for those pieces of equipment. Table 4-2 lists the recommended cleaning process versus the type of avionics equipment.

NOTE: Avionics Technicians should refer to the appropriate equipment service manual for specific operating instructions. Ultrasonic cleaning of printed circuit boards (PCB) is generally not authorized due to the difficulty in determining which component on the board will be susceptible to damage.

CAUTION: Miniature and microminiature PCBs may be susceptible to damage from the ultrasonic frequency, power level, or both.

b. Cleaning Booth, Water Base Solvent Spray. The water base solvent spray booth is used for the removal of dirt, dust, salt spray deposits, and loose corrosion deposits. The cleaning action is accomplished by a detergent and spray system.

TABLE 4-2. RECOMMENDED CLEANING PROCESS VERSUS TYPE OF AVIONICS EQUIPMENT

Type of Equipment	Aqueous ultrasonic	Solvent ultrasonic	Water base spray booth	Abrasive Tool	Mini-abrasive	Hand clean
Housings/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
Instruments					X(1)	X
Light assemblies	X	X	X	X(1)	X	X
Wave guides	X	X	X	X	X	X
Servos/synchros					X(1)	X
Antenna, blade	X	X	X		X	X
Antenna, dome	X(1)	X(1)	X	X(1)	X	X
Antennas, radar			X	X(1)	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, connectors			X		X	X
High density connectors					X	X
Edge connectors			X		X	X
Coaxial connectors			X		X	X
Printed circuit boards			X			X

Note: (1) External use only

(1) The spray equipment provides an air pressure powered spray of a detergent/water solution through a hand held spray gun. The water used can be either filtered or tap water. The equipment can also deliver rinse water or a drying jet of air through the gun.

(2) The spray booth may provide for a turntable which allows 360-degree rotation of the avionics equipment being cleaned or rinsed.

(3) The spray booth operation may be used as a "pre-cleaner" prior to placing the component in another cleaning process.

(4) The spray booth operation may be used to rinse components after other cleaning processes.

NOTE: Increasing the proportion of detergent in the cleaning solution does not necessarily increase the cleaning power of the detergent. This action can, in some cases, reduce cleaning effectiveness and cause corrosion.

(5) The preferred detergent for the water base solvent spray booth should conform to MIL-SPEC MIL-D-16791, listed in Appendix 1. The detergent solution should be mixed in accordance with the manufacturer's instructions or one ounce per gallon of water.

(6) Sealed bearings, synchro and servo bearings, instrument bearings, and similar devices with permanently lubricated (sealed) bearings can experience cleaning solution intrusion and the removal of the lubricant. These components could be rendered useless unless the processing procedures protect those components from degeneration or the lubricant is replaced.

(7) Sealed components (other than hermetically sealed) can trap the detergent and water solution. This may cause drying problems. In each case, the sealed component should be opened and inspected for trapped detergent and water solution.

c. Aqueous Ultrasonic Cleaner. The aqueous ultrasonic cleaner is used for the removal of dirt, dust, salt spray deposits, and loose corrosion deposits. The cleaning action is accomplished by the ultrasonic scrubbing action of the detergent and water solution.

(1) The maximum operating temperature should not exceed 130°F (54°C). The maximum operating frequency used should be 20 kHz.

(2) Presoaking avionics equipment and components prior to the ultrasonic function is an additional function of this equipment.

(3) The preferred detergent for the aqueous ultrasonic cleaner conforms to MIL-SPEC MIL-D-16791.

(4) Paper capacitors and paper bound components disintegrate in the detergent and water solution.

(5) Sealed bearings, synchro and servo bearings, instrument bearings, and similar devices should be treated per paragraph 404b(6).

(6) Sealed components (other than hermetically-sealed) should be treated per paragraph 404b(7).

(7) Thin metal foil types of gummed labels can loosen and separate.

d. Solvent Ultrasonic Cleaner. The solvent ultrasonic cleaner is used to remove light to heavy oil, grease, and hydraulic fluid contamination by ultrasonic scrubbing in a solvent solution.

(1) Use only an approved solvent in the solvent ultrasonic cleaner. The maximum operating temperature should be the solvent's boiling point. The maximum operating frequency used should be 40 kHz.

(2) Solvent degreasing, solvent vapor rinsing, and solvent vapor drying are additional functions of the solvent ultrasonic cleaner. Solvent degreasing is performed by solvent ultrasonic action in the degreaser tank. Solvent vapor rinsing (part of the degreasing function) is performed by a solvent vapor cloud. The solvent vapor cloud is created by a cooling coil placed near the top of the degreaser tank. Solvent vapor drying is also performed by the solvent vapor cloud.

(3) The solvent ultrasonic cleaner normally has a solvent degreaser tank. The solvent vapor rinse and solvent vapor drying function do not use the ultrasonic frequency function. Therefore, they may be used to rinse and dry PCBs.

(4) Some acrylics may be susceptible to damage from the solvents used in solvent ultrasonic cleaners. Coaxial connector gaskets and other neoprene rubber components are susceptible to damage by some solvents. Refer to the manufacturer's instructions or use another non-solvent cleaning process. Refer to table 4-3 for other restrictions.

(5) Sealed bearings, synchro and servo bearings, instrument bearings, and similar devices with permanently lubricated bearings should be treated as described in paragraph 404b(6).

(6) Sealed components (other than hermetically-sealed) should be treated as described in paragraph 404b(7). The sealed component should be opened and inspected for trapped solvent.

e. Abrasive Cleaning Tools. Abrasive cleaning tools such as portable mini-abrasive units and blast cleaning cabinets are used to remove corrosion and corrosive products.

(1) The abrasive blast medium used in abrasive cleaning tools can easily be trapped in miniature and micro miniature female edge connectors. When working on components where these connectors are installed, the connectors should be sealed with pressure sensitive tape. Upon completion of the cleaning process, ensure the tape is removed.

(2) Delicate metal surfaces, such as metal plating, are susceptible to damage from indiscriminate, unauthorized use of abrasive cleaning tools. Only properly trained personnel are authorized to use abrasive cleaning tools on avionics equipment.

(3) Some miniature/micro miniature PCBs contain electrostatic discharge sensitive (ESD) devices (chapter 9). These ESD sensitive devices may be destroyed by the static charge created in the rapid movement of air and abrasive agents in the abrasive cleaning tools. Therefore, abrasive cleaning tools are not authorized on components where ESD sensitive devices are installed.

405. AVIONICS CLEANING PROCEDURES.

a. General. Corrosion products and contamination by other sources previously described in chapter 2 and this chapter are responsible for numerous problems and failures in avionics equipment. Proper cleaning can prevent many of these problems and is the next logical step after the initial inspection. Cleanliness is very important in maintaining the functional integrity and reliability of the avionics system and components. Corrosion products and contaminants can be either conductive or insulating. As a conductor they may provide undesirable electrical paths, and as an insulator they may interfere with the avionics equipment or systems operation. The following paragraphs contain information and suggested procedures for the cleaning of avionics equipment.

b. Cleaning Method Selections Criteria. The best technique for selecting a cleaning method is to select the mildest cleaning method that will accomplish the task. The selection of the cleaning method is a decision that may be outlined in an original equipment manufacturer's (OEM) maintenance manual or made by authorized personnel at the avionics equipment repair station. The decision on the mildest cleaning method should consider the following:

(1) Certain circuit components can be damaged by support equipment and cleaning solutions and solvents;

(2) Type and extent of the corrosion damage or contamination;

(3) Accessibility to the corrosion damage or contamination; and

(4) Type of avionics equipment.

c. Hazards of Cleaning. As previously mentioned, it is a good maintenance practice to use the mildest cleaning method that will ensure the removal of the corrosion or the contamination. It is also important that the correct cleaning solutions and cleaning materials be used to avoid further damaging the avionics equipment. The following items are offered to emphasize some of the hazards that can occur during cleaning of avionics equipment:

(1) Cleaning solvents or other cleaning materials can become trapped in crevices or seams of components or chassis. These trapped cleaning materials could then interfere with the application of protective coatings and result in the initiation of corrosion.

(2) Vigorous or prolonged scrubbing of laminated circuit boards can cause damage to the boards.

(3) Certain cleaning solvents can soften conformal coatings, wire insulation, acrylic panels, and PCBs.

d. When to Clean. The immediate removal of corrosion or contaminants on avionics equipment and the surrounding structure is always a high priority in a good corrosion control program. Therefore, immediate cleaning should be accomplished on avionics equipment and components if they have been exposed to adverse weather, salt water immersion or spray, fire extinguishing agents, spilled battery electrolytes, other acids, high pH alkaline cleaners, mercury, and corrosion products during component repair.

e. Pre-cleaning Criteria and Cautions.

(1) Disconnect electrical and other power sources (mechanical/hydraulic).

(2) Ensure the work area and equipment are safe for maintenance.

(3) Ensure drain holes are open.

(4) Remove covers and panels for accessibility.

(5) Disassemble where practicable.

(6) Use only authorized materials.

(7) Ensure compatibility of materials prior to use.

(8) Mask and protect accessories or components to prevent intrusion of water, solvents, and cleaning solutions.

f. Cleaning and Drying Restrictions. Certain circuit components create potential problems during cleaning and drying. These problems can generally be overcome prior to cleaning the equipment by carefully masking those components likely to trap and hold cleaning liquids due to their construction. Table 4-3 lists different components and describes techniques to avoid problems. Mechanical, shock, and heat damage are other types of damage that can occur during cleaning and drying. The following suggestions are provided to avoid trapping water and solvent during cleaning:

(1) Seal small components with pressure sensitive tape. Ensure tape and any tape residue are removed using an approved solvent prior to drying the component.

(2) Seal large components in static free plastic bags or other water and vapor proof barrier material. Place the plastic bag or barrier material around the component and seal with pressure sensitive tape. Ensure tape and any tape residue are removed using an approved solvent prior to drying the component.

(3) When possible and if authorized, remove subassembly components and clean separately.

TABLE 4-3. CLEANING AND DRYING RESTRICTIONS

Component	Problem	Solution
APC connections (microwave)	Shock damage to center conductor	Seal and hand clean only
Crystal detectors	Heat damage from ovens	Dry at 130°F (54°C) maximum
Delay lines	Trapped solution in housing	Seal or remove
Fan motors	Trapped solution in housing	Seal or remove
Gyroscopes	Trapped solution in housing	Seal
Klystron cavity	Trapped solution in sockets	Remove tube and seal
Meters and instrument gauges	Trapped solution through open housing	Seal
Paper capacitors	Disintegrate	Seal
Potentiometers	Trapped solution in open housing	Seal
Printed circuit	Trapped solution (when installed)	Remove (clean separately)
Rotary switches	Trapped solution in open housing	Seal
Sliding attenuators (RF)	Trapped solution in slide housing	Seal or remove
Sliding cam switches	Shock damage to cam only	Remove or hand clean
Synchros and servos	Lubricant removed from bearing	Seal or remove
Transformers	Trapped solution in housing	Seal
Tunable cavities	Trapped solution in cavity area	Seal or remove
Vacuum tubes	Shock damage	Remove
Variable attenuators (microwave)	Trapped solution in housing	Seal or remove
Wave guide (microwave)	Trapped solution in housing (when installed)	Seal or remove
Wire wrap connections	Shock damage	Hand clean only

g. Hand Cleaning Methods. Hand methods should be used for cleaning small, delicate, confined surfaces where parts cannot tolerate other cleaning methods. Also, hand cleaning methods should be used when accessories/facilities for other methods are not available. The following list contains some of the equipment that may be utilized for hand cleaning:

(1) Lint free cloth;

(2) Cheesecloth;

(3) Cotton tip applicator;

(4) Acid brush;

(5) Toothbrush;

(6) Other soft bristle brushes; and

(7) Plastic manual spray bottle.

h. Fingerprint Removal. The salts and oils from human fingerprints are highly corrosive. The following paragraphs list the material and procedures for their removal:

(1) Apply a mixture of 1 part Isopropyl Alcohol, TT-I-735, or other approved solvent and 1 part distilled water to the affected area with a clean cloth, cheesecloth, acid brush, or toothbrush as appropriate;

WARNING: Do not use synthetic fiber wiping cloths with Isopropyl Alcohol, TT-I-735, due to its low flash point. Dry fiber wiping cloths will cause a static charge to build up and can result in a fire.

(2) Wipe or scrub affected area until contaminants have been removed;

(3) Remove residue by wiping or blotting with clean cheesecloth or cotton tip applicator as required. Inspect area for signs of residue or contaminants;

(4) Discard contaminated cheesecloth or cotton tip applicators and solvents in an approved container after cleaning operations to avoid contamination of other components; and

(5) Repeat process as required until all evidence of contamination is removed.

i. Cleaning and Removal of Solder Flux Residue. Solder flux residue is present in all soldering operations. This residue will cause corrosion if an electrolyte is present. Use of an approved cleaning solvent or diluted Isopropyl Alcohol, TT-I-735, is required. These solvents should not damage associated wiring circuit components or laminated circuit board coatings. The presence of soldering flux can be detected by using ultraviolet light conforming to MIL-L-9909. Under the presence of ultraviolet light, traces of solder flux appear as a fluorescent yellow to brownish residue. Clean solder flux residue as follows:

WARNING: Lead contained in solder can rub off onto a person's fingers from a soldered joint. Lead and lead oxide are toxic and cannot be eliminated from the body. This toxic poison will accumulate in the body. Touching solder followed by smoking or eating is a potential means of ingesting trace amounts of lead. Wash hands thoroughly following any soldering or desoldering operation.

(1) Solder flux residues should be removed from circuit boards and circuit components using the general procedures described in paragraph 405h. Use a solution of 1 part distilled water to 3 parts Isopropyl Alcohol, TT-I-735, to clean the affected area. After a soldering operation, clean the affected area and one inch around the solder point to ensure complete decontamination.

CAUTION: Prior to using the ultraviolet light for inspection to ensure complete removal of soldering flux residue, examine the piece of equipment for Erasable Programmable Read Only Memory (EPROM) components. EPROM have windows that are usually covered with an aluminum foil mask or black tape. Visually examine to ensure the tape or foil has not lifted from the window.

NOTE: Ultraviolet light from an ultraviolet light inspection light source is very intense and can degrade EPROM devices.

(2) Visually inspect circuit boards and circuit components for evidence of soldering flux residue using an ultraviolet light source conforming to MIL-L-9909. Repeat cleaning process as required until all evidence of solder flux is removed.

j. Cleaning and Removal of Silicone Lubricant. Remove silicone residue from surfaces coated with silicone lubricant as follows:

(1) Wipe or scrub contaminated surface with a cleaning cloth, cheesecloth, acid brush, or cotton tip applicator dampened with an approved solvent or Naphtha, TT-N-95, until surface is clean;

(2) While surface is still wet, wipe area dry with clean cheesecloth or cotton tip applicator as appropriate; and

(3) Discard contaminated cheesecloth, cotton tip applicators, or other cleaning devices, and solvents in an approved container after cleaning operations to avoid contamination of other components.

k. Cleaning and Removal of Bacteria and Fungi. Dust, dirt, and other airborne contaminants are leading contributors to bacterial and fungal (microbial) attack. The best defense against this form of attack is to maintain cleanliness and, where possible, low humidity. Remove fungi and bacteria as follows:

(1) Mask air capacitors, relay contacts, open switches, tunable coils, and other components affected by solvents with pressure sensitive tape; and

(2) Treat affected areas with materials and instructions described in paragraph 405h.

l. Cleaning and Removal of Dust. Dust, dirt, grease, and oil should be removed from components as follows: (Figures 4-2 and 4-3 show dirt accumulation in an engine compartment.)

(1) For dust and dirt, apply a solution of 1 part Aircraft Cleaning Compound, MIL-C-85570, Type II, to 9 parts of distilled water;

(2) For grease and oil, apply a solution of 1 part Aircraft Cleaning Compound, MIL-C-85570, Type II, to 4 parts of distilled water;

(3) Wipe or scrub affected areas or components with cleaning cloth, cheesecloth, acid brush, toothbrush, or cotton tipped applicator until surface is clean; and

(4) Rinse affected area or component with fresh water and dry with a clean cloth or cheesecloth.

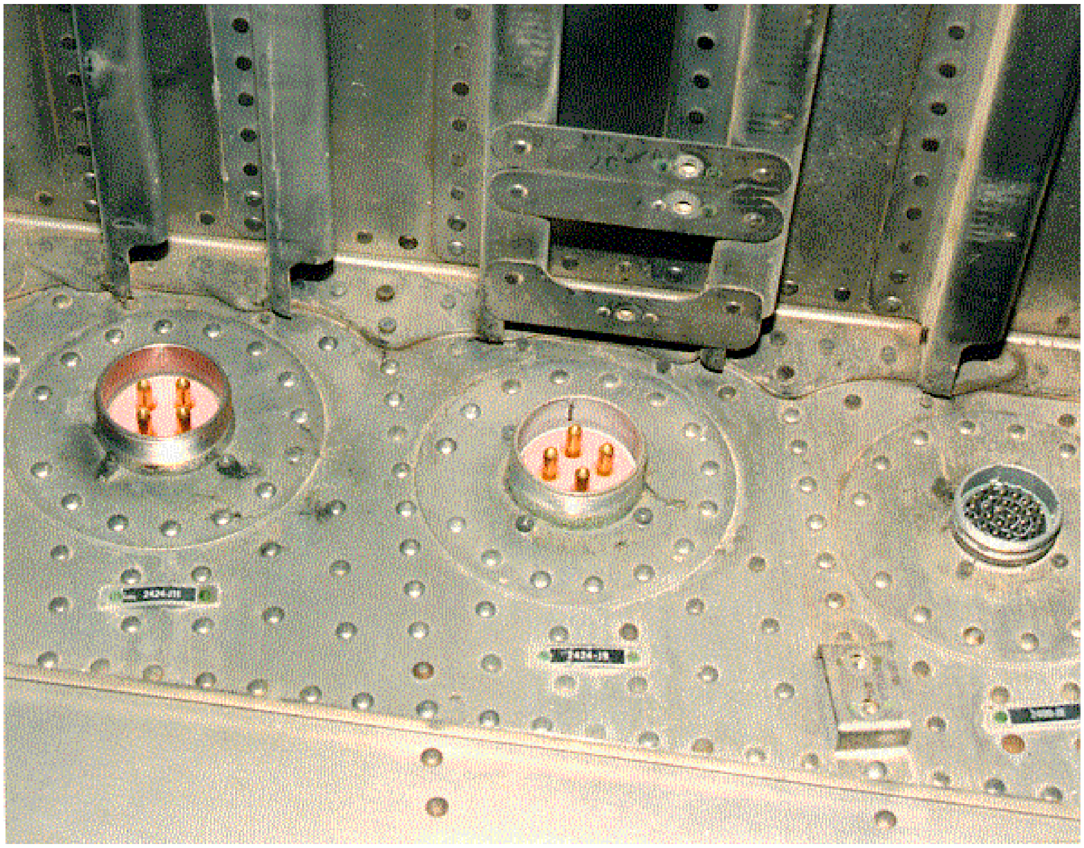

FIGURE 4-2. ENGINE COMPARTMENT ELECTRICAL CONNECTORS

m. Surface Preparation. The true cleanliness of bare metal surfaces after a cleaning process is very critical to adhesion of any subsequent coating material. Examples of subsequent coatings include: chemical conversion coating (pre-paint), paint system, sealant, dry film lubrication, etc. The method generally used to identify a surface that is clean enough for adhesion of any of the subsequent coatings is called the Water Break Test. Figure 4-4 illustrates a water-break surface. Perform a water break test as follows:

(1) Feather edges of any existing paint finish (if applicable) to ensure a smooth overlapping transition between the old and new paint coating. Feathering can be accomplished using 240 or 320 grit aluminum oxide abrasive cloth or a fine or medium grade abrasive mat.

(2) Clean (lightly scrub) the area with very fine or fine abrasive mat saturated with water. Rinse surface with fresh water. Particular attention should be given to fasteners and other areas where residues may become entrapped.

(3) Visually inspect the part after the last rinse; the surface should be water-break free (See figure 4-4). A surface showing water breaks (water beading or incomplete wetting) is contaminated, usually with grease or oil (fingerprints, etc.). The contaminated surface will not allow proper adhesion with any subsequent protective coating system (conversion coating, primer, topcoat).

(4) If the surface is not water-break free, clean area with a solution of 1 part aircraft cleaning compound, MIL-C-85570, Type II, to 9 parts distilled water. Lightly scrub the area with very fine or fine abrasive mat saturated with cleaning solution. Rinse surface with distilled water. Visually inspect the part after the last rinse. The surface should be water-break free.

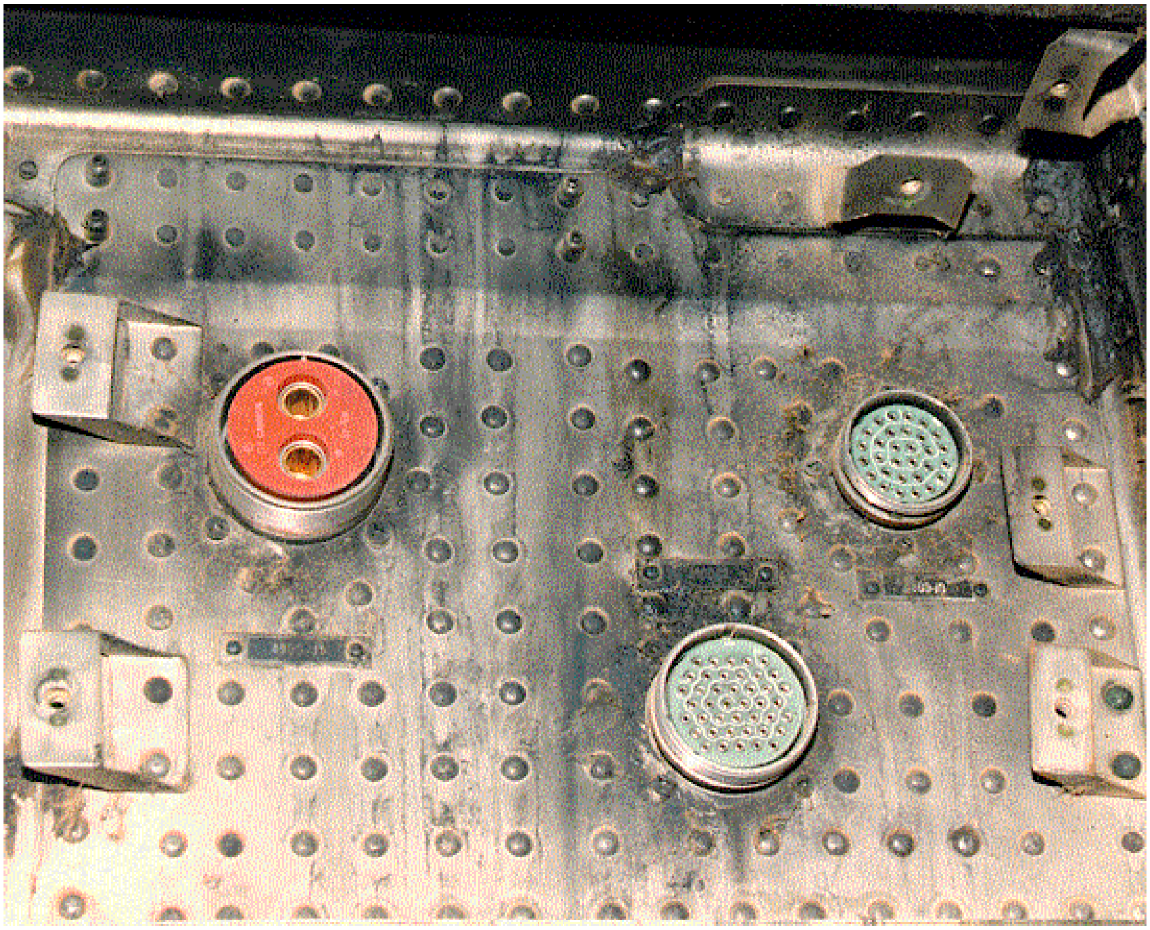

FIGURE 4-3. ENGINE COMPARTMENT ELECTRICAL CONNECTORS

n. Special Considerations. Dust, fingerprints, surface oxides, and other contaminants can undo the protection provided by subsequent protective coatings. Specific avionics equipment and components should be cleaned by procedures addressed for the specific equipment in chapter 5.

o. Post-cleaning Procedures.

(1) After completion of the cleaning steps, inspect the affected area for signs of residue, surface film, or water.

(2) If inspection reveals the area is not clean, (residue, surface film), repeat the appropriate cleaning procedures. Water-displacement, preservation, and lubrication should follow the cleaning and drying steps for completing the preventive maintenance.

406. DRYING EQUIPMENT AND PROCEDURES.

a. General. Drying time depends on the complexity of the equipment/component being dried. The more complex the individual component, the longer the drying time. Another consideration in drying time is the humidity or moisture content of the air where the drying oven is operated. The higher the moisture content of the ambient air, the longer the drying time.

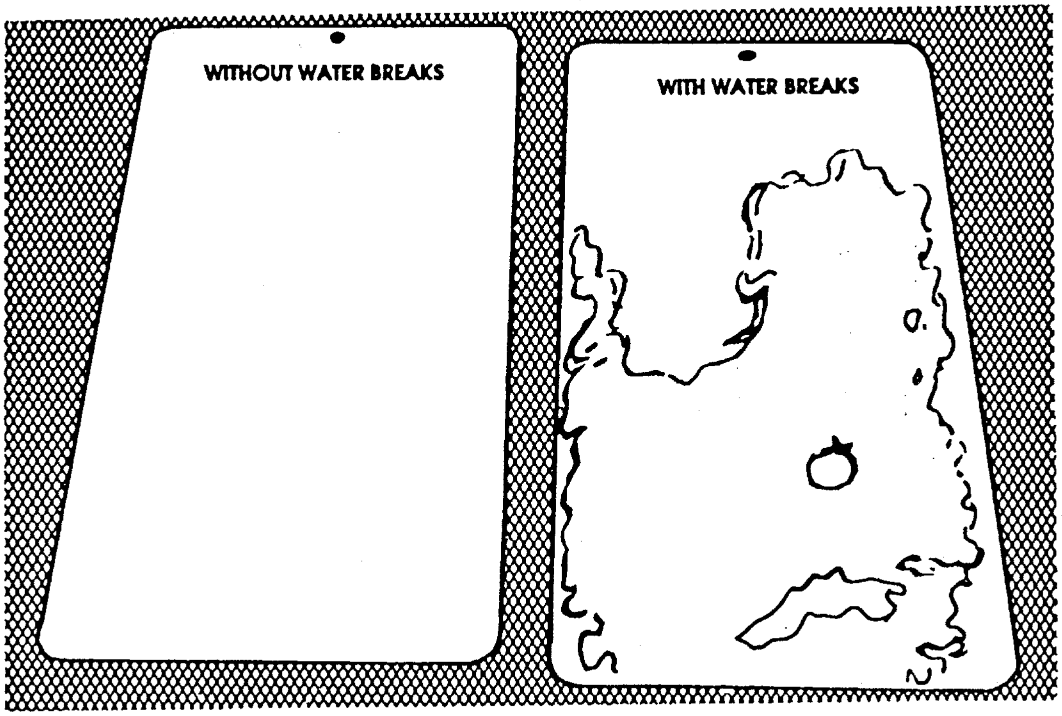

FIGURE 4-4. A WATER-BREAK FREE SURFACE COMPARED WITH ONE WITH BREAKS

CAUTION: Portable air blowers, hot air blowers, hair dryers, and similar drying devices may cause fires when used in or around aircraft. Use only authorized (spark proof) hot air guns in and around aircraft. The motion of air from an aerosol spray, compressed air, and air from dryers can generate static charges that can degrade or destroy Electrostatic Discharge (ESD) sensitive devices. Care must be exercised during handling, cleaning, and repair of these items. Refer to chapter 9 for recommended shop practices.

b. Drying Preparation. Prior to placing a component in a drying oven, remove all covers, lids, etc. Ensure any pressure sensitive tape and protective plastic bags used during the cleaning cycle have been removed.

c. Air Drying. Air drying is usually adequate for housings, covers, and some hardware. This method is not considered adequate for more complex equipment or components that may contain cavities or moisture traps.

d. Drying with Hot Air Blower. Procedures for the use of hot air blowers are as follows:

(1) Blow off excess water with dry air or dry nitrogen at not more than 10 psi pressure. Deflect air off interior back and sides of enclosure to diffuse air jet.

(2) Dry the equipment with a hot air gun. Surfaces should not be heated with the air gun above 130°F (54°C) when drying the equipment.

e. Drying with Circulating Air Oven. The circulating air drying oven is used to dry small electrical and electronic components, such as non-pressurized instruments, control boxes, PCBs, and similar devices. The circulating air drying oven should not be operated above 130°F (54°C) when drying avionics equipment or components. Damage may result from overheating of discrete electronic circuits components. Procedures for the operation of the circulating air drying ovens are as follows:

(1) Blow off excess water with dry air or dry nitrogen at not more than 10 psi pressure. Deflect air off interior back and sides of enclosure to diffuse air jet;

CAUTION: Older circulating air drying ovens may have uncalibrated dials or controls for setting the oven temperature. These uncalibrated ovens should have the dials calibrated, prior to use, by placing a "red line" on the dial so as not to exceed 130°F (54°C).

(2) Set the temperature control at a maximum of 130°F (54°C);

(3) Place the component(s) in the oven and close the door. If a timer is available, set the time for approximately 3 to 4 hours; and

NOTE: Opening and closing the oven door during the drying cycle will increase the drying time. This is due to the diffusion of hot, dry air in the oven cabinet with cooler, more humid air from the surrounding area.

(4) Upon completion of the drying cycle, remove the component(s).

f. Drying with Forced Air Oven. The forced air drying oven is the most efficient of the drying ovens. This unit can be used to dry all types and sizes of equipment and components. The procedures for the operation of the forced air drying oven are as follows:

(1) Blow off excess water with dry air or dry nitrogen at not more than 10 psi pressure. Deflect air off interior back and sides of enclosure to diffuse air jet;

CAUTION: Check the temperature dial (or control calibration) periodically to ensure the temperature setting is correctly calibrated.

(2) Set the temperature control at a maximum of 130°F (54°C);

(3) Place the component(s) in the oven and close the door. If a timer is available, set the time for approximately 1 to 2 hours. Opening and closing the oven door during the drying cycle will increase the drying time slightly but not appreciably. This is considered one of the advantages of the forced air drying oven over the circulating air type oven; and

(4) Upon completion of the drying cycle, remove the component(s).

g. Drying with Vented Oven (Bulb-type). Vented drying oven procedures are as follows:

(1) Blow off excess water with dry air or dry nitrogen at not more than 10 psi pressure. Deflect air off interior back and sides of enclosure to diffuse air jet;

(2) Place the component(s) in the oven and close the door. Dry the component or equipment at a maximum of 130°F (54°C). If a timer is available, set the time for approximately 3 to 4 hours; and

(3) Upon completion of the drying cycle, remove the component(s).

h. Drying with Vacuum Oven. Vacuum Oven Drying procedures are as follows:

(1) Blow off excess water with dry air or dry nitrogen at not more than 10 psi pressure. Deflect air off interior back and sides of enclosure to diffuse air jet;

(2) Place the component(s) in the oven and close the door. Dry the equipment at approximately 130°F (54°C) and 26 inches of mercury (Hg). If a timer is available, set the time for approximately 1 to 2 hours; and

(3) Upon completion of the drying cycle, remove the component(s).

i. Solvent Vapor Drying. Solvent vapor drying is an additional feature of the solvent ultrasonic cleaner. This method of drying is considered the fastest and most efficient method of drying avionics components. The drying time is usually 15 seconds to 3 minutes. Follow the equipment manufacturer's operating procedure for cleaning and degreasing. The procedures for solvent vapor drying are as follows:

CAUTION: Environmental regulations may prohibit the use of the ozone depleting chlorofluorocarbons (CFC) solvents used in solvent ultrasonic cleaners.

(1) Suspend the component being processed in the solvent vapor cloud for a period of 15 seconds to 3 minutes. Drying time depends on the complexity of the component and the amount of water or solvent present;

(2) Rinse by altering the position of the component in the vapor cloud to drain any trapped water or solvent;

(3) After thorough rinsing, slowly raise (withdraw) the component out of the vapor cloud. This will cause rapid drying of the component; and

(4) Inspect the component for visible signs of water or solvent. If required, repeat the solvent vapor drying process.

407. PRESERVATION.

a. General. Surfaces and components not normally conformal coated or painted need preservation. Cleanliness and elimination of moisture are keys to avoiding corrosion. Preservation of equipment is essential, since it is nearly impossible to guarantee a dry, moisture-free environment. In today's avionics systems, miniaturization has resulted in very small electronic circuits. Even a small amount of corrosion can cause the entire system to fail. Preservation has become an essential part of the repair and maintenance of avionics systems.

b. Why Preserve.

(1) To protect nonmoving parts by filling air spaces, displacing water, and providing coatings;

(2) To protect components such as hinges, control cables, gears, linkages, bearings, etc. from wear by providing lubrication; and

(3) To protect nonoperational or idle equipment.

c. When to Preserve.

(1) After cleaning;

(2) On equipment prior to shipment;

(3) On equipment or components that are not operational, including those awaiting parts and repair;

(4) On parts or components that are normally inaccessible for inspection without disassembly;

(5) Where additional protection is required for other coating systems;

(6) After immersion and exposure to fresh and salt water or fire extinguishing agents; and

(7) When other corrosion protection systems have failed because of in-service use.

d. What to Preserve. Preservatives should be used only where their application and maintenance will not hamper electrical circuits or component operation. Most preservatives form a nonconductive film that acts to insulate mating surfaces from moisture intrusion. The following provides a list of avionics equipment and components that may require preservation and maintenance:

(1) Door latches and hinges;

(2) Electrical connectors (internal and external);

(3) Shock mounts, rigid mounts, and associated attaching hardware and brackets;

(4) Any dissimilar metals not protected by other coating systems;

(5) Antenna mounts, brackets, hardware, and housings;

(6) Fasteners, screws, nuts and bolts not otherwise covered elsewhere;

(7) Equipment lids on interior or exterior of equipment that is susceptible to moisture;

(8) Solder joints not otherwise protected by other coatings;

(9) Any unprotected surface that will not receive a paint coating system or other coating material (plating or conformal coatings);

(10) External and internal surfaces of coaxial connectors;

(11) External surfaces of cooling system joints; and

(12) Ground straps and wires.

e. What Not to Preserve. The following items should not be preserved or come in contact with preservatives:

(1) Laminated circuit boards that are conformal coated;

(2) Nonmetallic surfaces such as acrylic control box face plates;

(3) Tunable capacitors and inductors;

(4) Internal surfaces of wave guides;

(5) Internal surfaces of tuned tanks;

(6) Relay and circuit breaker contacts; and

(7) Fuses.

f. Preservative Materials. Preservatives are materials that can take the place of more permanent coating materials such as paint, but require removal and repeated application on a scheduled basis. Some preservatives may also act as water-displacing compounds. Table 4-4 contains a list of preservatives and water-displacing compounds for use on avionics components. Preservatives 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.

g. How to Preserve. The application of preservatives for specific avionics components is covered in chapter 5. The following are general application procedures that apply in most cases:

(1) Ensure surface to be preserved is free of dirt, grime, other contaminants, standing water, and corrosion products. Remove corrosion products as outlined in chapter 5. Clean and dry the surface as appropriate with a cleaner and dryer as outlined earlier in this chapter;

(2) When necessary, apply pressure-sensitive tape to protect areas and components not to be preserved. Paragraph 407e. refers to areas and components not to be preserved;

(3) Water-displacing preservative compounds that conform to MIL-C-81309, Type III, (Avionics), MIL-C-81309, Type II, and MIL-C-85054 (AMLGUARD) should be applied with an even, thin film to the surface. Ensure complete coverage of dissimilar metal contact areas, crevices, and water entrapments areas. Avoid excessive application. When MIL-C-85054 is used, apply a second coat after 30 minutes;

(4) Non-water displacing preservative compound that conforms to MIL-C-16173, Grade 4 should receive a film of water-displacing preservative compound as described in paragraph 407g(3) to the part or component prior to the application of MIL-C-16173, Grade 4, to remove any moisture. MIL-C-16173, Grade 4, should be applied with a brush or sprayed in a thin, even film to nonmoving external areas. Fasteners may be dipped in MIL-C-16173, Grade 4, prior to installation; and

NOTE: MIL-C-16173, Grade 4, may be thinned for spraying as required with an approved solvent or a general purpose oil.

(5) Remove pressure sensitive tape as required.

TABLE 4-4. PRESERVATIVE COMPOUNDS FOR AVIONICS EQUIPMENT

Description	Characteristics	Application	Restrictions
Corrosion Preventive Compound, Water-Displacing, Ultra-Thin Film, MIL-C-81309, Type III, avionics grade 2.	General preservative for avionics equipment, internal areas of electrical connectors, and solder receptacles and joints. Contains water-displacing properties.	Apply by spraying an even, thin film to the surface. Can be removed with an approved solvent or Dry Cleaning Solvent, P-D-680, Type II.	Not intended for use on exterior of avionics equipment. Deposits a thin film which must be removed for proper function of contacts 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.
Corrosion Preventive 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, busbars, ground straps, and internal/external areas of junction boxes.	Apply by spraying an even, thin film to the surface. Can be removed with an approved solvent or Dry Cleaning Solvent, P-D-680, Type II.	Do not use on interior surfaces of electrical connectors and receptacles. Do not use on interior surfaces of coaxial connectors. Do not use around oxygen, oxygen fittings, or oxygen regulators, since fire or explosion may result.
Corrosion Preventive Compound, Water-Displacing, Clear, MIL-C-85054.	General preservative for external surfaces exposed to elements and moisture, including: chassis, equipment covers, mounting racks, equipment racks, shelving, brackets, radar plumbing, antenna hardware, latches, terminal boards, busbars, ground straps, junction boxes, fasteners, external connectors, coaxial connectors, and receptacles.	Apply by spraying an even thin film or brush onto the surface. Material presents a thin, non-tacky, clear film. Can be removed with an approved solvent or dry cleaning solvent, P-D-680, Type II, Isopropyl Alcohol, TT-I-735, or by applying Corrosion Preventive Water-Displacing Compound, MIL-C-85054, and wiping.	Do not use on interior surfaces of electrical equipment and hardware. Do not use on moving/sliding surfaces. Do not use on interior surfaces of electrical connectors, coaxial connectors, or receptacles. Do not use around oxygen, oxygen fittings, or oxygen regulators, since fire or explosion may result.
Corrosion Preventive Compound, Solvent Cutback, Cold Application, MIL-C-16173, Grade 4.	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, and receptacles.	Apply by brush or spraying an even, thin film to the surface. Material presents a semi-transparent film. Can be removed with an approved solvent or Dry Cleaning Solvent, P-D-680, Type II.	Do not use on interior surfaces of avionics equipment. Do not use on interior of electrical connectors, coaxial connectors, or receptacles. Do not use around oxygen, or oxygen regulators, since fire or explosion may result.

408. LUBRICANTS.

a. General. Lubrication of equipment performs several important functions: it prevents wear between moving parts, provides a barrier to corrosion, and is a short-term preservative. Particular attention should be given to lubrication points around hinges, latches, etc., for prevention of lubrication breakdown. Lubrication breakdown includes caking of the lubricant, an indicator of contamination.

b. Requirements. Maintenance personnel should refer to the applicable maintenance manual for specific lubrication requirements, materials, and frequency.

409. PACKAGING, HANDLING, AND STORAGE.

a. General. An avionics corrosion control program must include procedures for packaging, handling, and storage of avionics equipment and components. These components will be rendered useless if the packaging, handling, and storage procedures are not followed. Materials used for the packaging, handling, and storage must be compatible with the avionics equipment and the anticipated environment. Figures 4-5 and 4-6 show typical storage and shipping containers. These containers are not intended for storage in the elements.

b. Packaging and Storage Materials Guidelines.

(1) Certain packaging materials containing wood, cotton, foam, and paper are susceptible to mold and fungal attack. (See chapter 3, paragraph 308.) These materials and other items such as shredded newspaper, excelsior, and cardboard may give off sulfurous or acidic vapors that can promote a corrosive attack on electronic components.

(2) Use only metal or preserved wooden shelves for storing avionics equipment and components. Inadequately preserved wood can produce corrosive vapors.

(3) Provide closed-cell polyethylene foam 1/2 inch thick as a cushioning for equipment on shelves, pallets, etc. Do not use an open-cell foam or sponge rubber, horse hair, or similar material that will hold moisture.

(4) Use conductive plastic or metal caps for electrical connector protection.

(5) Use cellular plastic film cushioning material (bubble wrap) for short-term protection during transportation of equipment and to protect against handling and shock damage.

(6) Never place bubble wrap in direct contact with ESD-sensitive devices. The electronic device or component should first be placed in a conductive bag. For equipment requiring ESD protection, refer to chapter 9.

(7) Use plastic bags for short-term protection of noninstalled small components and microminiature PCBs against moisture and contamination.

(8) Use unicellular polypropylene packing foam and water vapor proof packaging material for long-term protection of miniature and micro-miniature circuit components, laminated circuit boards, and critical avionics components against moisture and contamination. Figures 4-5 and 4-6 show typical shipping containers for avionics equipment.

c. Handling. Damage can occur to avionics equipment because of incorrect packaging methods and rough handling between the manufacturer, aircraft, and avionics repair facilities. The best method of avoiding handling damage when transporting equipment is to use the specially designed cushioned shipping container from the original equipment manufacturer. A method that can be used if the original shipping container is not available is to use cellular plastic film cushioning material (bubble wrap). Bubble wrap is primarily used to absorb shock and is not intended as a water vapor proof packaging material. Bubble wrap should be placed around the component to be protected in two layers, with the second layer rotated 90 degrees from the original layer. The corners should be left open to allow the component and packing material to breath and avoid condensation and water entrapment. Secure the alternating layers of bubble wrap using masking tape or other pressure sensitive tape.

d. Package and Storage. Packaging of avionics equipment is normally a function of a supply or receiving and shipping department. In many cases, the packaging of avionics equipment is accomplished by aircraft or avionics maintenance personnel. Packaging methods employed by these personnel are an important consideration for the equipment due to the length of time in storage awaiting repair or transit between aircraft and repair stations.

(1) Proper packaging should include provisions for the length of time the equipment will be in storage. Equipment should be packaged for long-term storage if the length of storage time is not known.

(2) Proper packaging materials, when specifically designed shipping containers are not available, should include: 6 mm thick (minimum) anti-static "zip lock" plastic-type bags. These bags are adequate for short-term storage and protection from moisture and contamination. They should be used during maintenance or repair operations on laminated circuit boards and small electrical/electronic components. They should also be used as part of a longer storage packaging and sealing system. For long-term storage, water vapor proof, heat-sealed barrier material provides excellent protection against moisture and contamination. Cushioning material such as unicellular polypropylene packaging foam should be used in conjunction with the plastic bags and water vapor proof, heat-sealed barrier material when protection from shock and handling is required.

(3) For equipment requiring ESD protection refer to chapter 9.

e. Electrical Connector and Wave Guide Caps. Metal caps and blank off plates, preferably moisture and vapor proof, are the preferred methods of protecting electrical connectors and wave guides from contamination and damage. Conductive plastic caps are another acceptable method of protection. Use only plastic caps which cover by surrounding the connectors or wave guide. Do not use push-in type caps or covers. These type caps or covers can easily be overlooked during assembly or become foreign object debris (FOD). When metal or conductive plastic caps and blank off plates are not available, electrical connectors and wave guides may be capped off with pressure-sensitive tape conforming to MIL-T-22085, Type II. Other type tapes should not be used to seal or cap-off electrical connectors or wave guides.

f. Desiccants. Desiccants are normally packaged with equipment packaged for storage or shipment. The purpose of the desiccant is to absorb moisture and lower the relative humidity. The following describes some of the problems and considerations for using desiccants.

(1) Desiccants may be ineffective for the following reasons:

(a) Moisture may condense as water when the desiccant becomes saturated.

(b) Desiccant is not placed in the proper location.

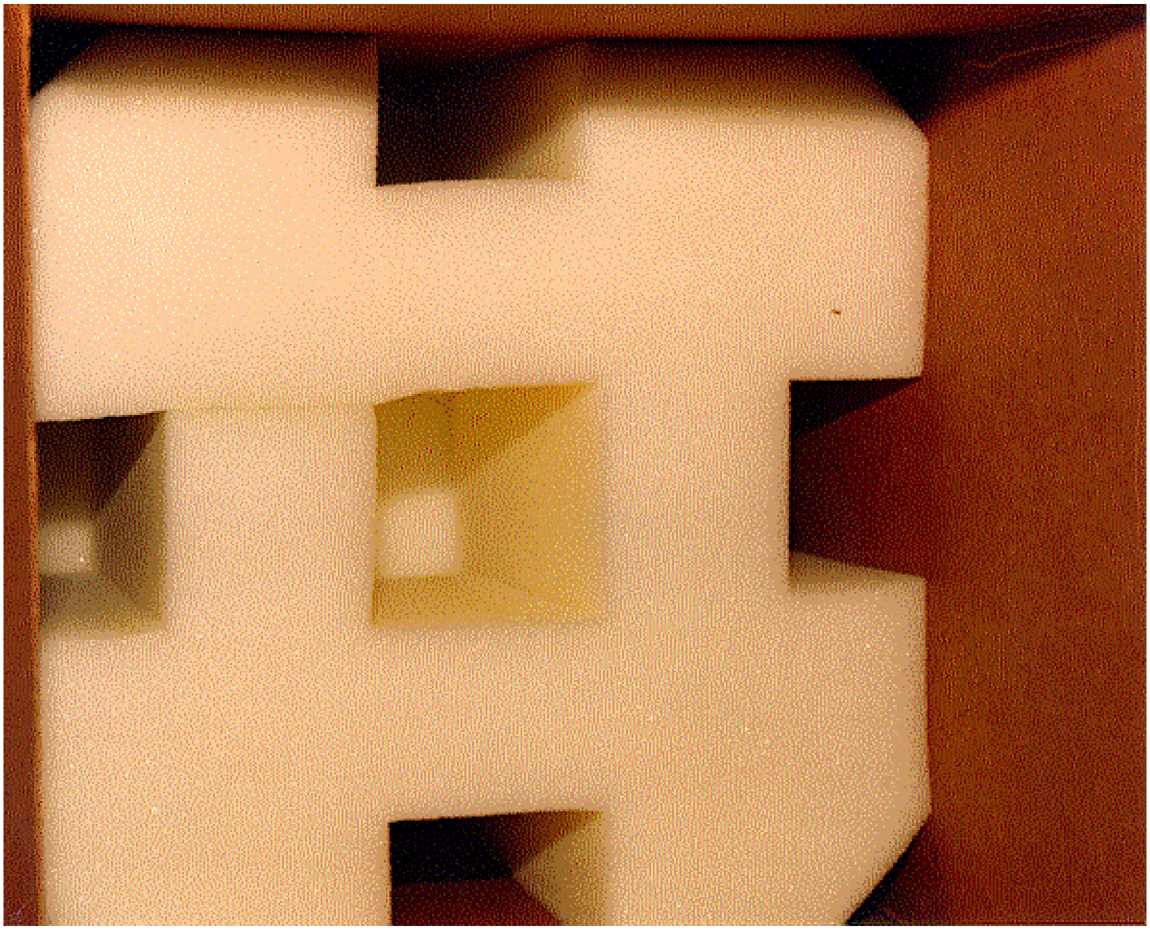

FIGURE 4-5. TYPICAL SHIPPING CONTAINER FOR AVIONICS EQUIPMENT

(c) Rapid changes in ambient temperature may produce precipitation before the desiccants can react.

(d) Not enough desiccant was used for the area to be protected.

(2) The following considerations apply to desiccants:

CAUTION: Do not use loose desiccants in packing of avionics equipment. Loose desiccant may contaminate and cause damage to the packaged equipment.

(a) Desiccant material should be contained in rupture-resistant sturdy bags.

(b) Desiccant bags should be secured to prevent movement.

(c) Desiccant bags should not be placed on or permitted to come in contact with unprotected surfaces.

(d) Desiccants should be reactivated prior to reuse.

(e) Desiccant bags should not be removed from their sealed container until ready for use.

FIGURE 4-6. TYPICAL SHIPPING CONTAINER FOR AVIONICS EQUIPMENT

(3) If a desiccant bag should break open during transit, clean the avionics equipment immediately upon discovery. Do not turn moving parts any more than absolutely necessary until all desiccant particles have been removed. Work out the desiccant particles with a clean acid brush and not more than 10 psi dry air pressure. An alternate method is to use a clean acid brush and a vacuum cleaner. For equipment with ESD protection refer to chapter 9.

g. Humidity Indicators. Humidity indicators should be placed in containers when desiccants are used. A humidity indicator is used to determine if a desiccant is sufficiently active to maintain an acceptable relative humidity within the container.

CAUTION: Do not place humidity indicator in direct contact with metal. Chemicals used in the indicator may cause corrosion.

410. thru 500. RESERVED.

CHAPTER 5. CORROSION REMOVAL, SURFACE TREATMENT, PAINTING, AND SEALING

501. GENERAL. This chapter outlines the materials, equipment, and techniques involved in corrosion control. Maintenance personnel should analyze each corrosion problem and select the correct corrosion removal and preservation materials. Where possible, follow-up actions should be conducted to ensure that all corrosion has been removed and proper protection has been applied. An avionics corrosion control program is an important function in maintaining any aircraft and aircraft component. The program requires knowledge of the science and technology of avionics corrosion control. Preventive maintenance must occur as part of all maintenance functions performed on avionics systems. Whenever equipment is removed from the aircraft for bench check or repair, covers and housings should be inspected and treated for corrosion. Avionics technicians must ensure that corrosion, repair, treatment, and preventive maintenance becomes a normal part of their maintenance and repair procedure.

502. CORROSION REMOVAL MATERIALS AND EQUIPMENT.

a. General. Avionics technicians and repair stations should review Appendix 1 of this AC to convert military specification corrosion repair materials and equipment mentioned in these chapters to the commercial equivalent.

b. Corrosion Removal. When corrosion is detected, corrective action is required. When the corrosion is within repairable limits specified in the applicable original equipment manufacturer's (OEM) manual or other directive, corrective action should be initiated. This should consist of paint removal (as required), cleaning, corrosion removal, treatment, and the application of protective coatings and preservation. The mildest method of corrosion removal should always be used. The following paragraphs list approved methods for use on avionics equipment.

WARNING: Prolonged breathing of vapors from organic solvents or materials containing organic solvents is dangerous. Refer to the appropriate Material Safety Data Sheet (MSDS) for warnings and required protective gear. Chemical paint removers are toxic to the skin, eyes, and respiratory tract. Avoid breathing the vapors. Use only with adequate ventilation. Avoid skin and eye contact. Wear gloves and goggles while handling. If eye contact is made, wash immediately with large amounts of water. If skin contact is made, wash immediately with soap and water.

CAUTION: Epoxy paint removers are harmful to rubber and plastic products, including wiring insulation. Exercise care to avoid contact with such surfaces. Mask those adjacent areas which are not to be stripped with pressure sensitive tape.

(1) Chemical Paint Removers. Epoxy paint removers conforming to MIL-R-81294 may be used to chemically remove paint from metal surfaces. This paint remover should be applied by brush. Care must be observed to ensure that the paint remover does not contact any part of the body. Observe all cautions and warnings. Whenever a chemical paint remover has been used, ensure that the surface is washed with a detergent and water mixture and thoroughly rinsed prior to the application of other coatings. Properly dispose of hazardous wastes generated during the stripping process.

(2) Cleaning. Chapter 4, paragraph 405 outlines the materials and procedures for cleaning avionics equipment.

(3) Corrosion Removal Equipment and Methods.

(a) Hand Rubbing/Abrasion. The nature of some surfaces, such as chrome-, nickel-, gold- and silver-plated contacts, restricts the use of highly abrasive methods. Tarnish and light corrosion can be removed from such surfaces by hand rubbing with a pencil eraser, brushes, and nonabrasive pads. Surfaces such as covers, connectors, receptacles, antenna mounts, equipment racks, chassis, etc., may have light to moderate corrosion removed by an abrasive mat or cloth.

(b) Portable Mini-Abrasive Unit. The portable mini-abrasive unit is a hand-held miniature abrasive tool used to remove light corrosion products from small avionics components, such as PCBs, edge connector pins, small avionics structural components, etc. Care should be taken not to remove the thin plating from these surfaces. Mono-basic sodium phosphate conforming to MIL-S-13727 is generally the specified abrasive material used in portable mini-abrasive units. Refer to the manufacturer's manual for other possible material choices. The portable mini-abrasive unit should only be operated in a blast cleaning booth or other similar structure. Contamination of other equipment or components by mono-basic sodium phosphate can occur if it is allowed to blow freely into the surrounding shop area.

(c) Hand-Held Abrasive Tools. The hand-held abrasive tool is used to remove corrosion products from larger components such as avionics equipment structures and housings. Glass beads conforming to MIL-G-9954 are generally the specified abrasive material used in hand-held abrasive tools. Refer to the manufacturer's manual for other possible approved abrasive material choices. This unit should also be operated only in a blast cleaning booth or other similar structure. Contamination of other equipment or components by glass beads can occur if they are allowed to blow freely into the surrounding shop area.

503. SURFACE TREATMENT.

a. Chemical Conversion Material Procedures. Chemical conversion is an extremely important part of the corrosion control process. Properly applied, chemical treatments impart considerable corrosion resistance to the basic metal and greatly improve the adhesion of subsequently applied paints.

WARNING: Chemical film materials are strong oxidizers and a fire hazard when in contact with organic materials such as paint thinners. Do not store or mix surface treatment materials in containers previously containing flammable products. Rags contaminated with chemical film materials should be treated as hazardous materials and disposed of accordingly.

(1) Treatment Application Particulars. The material for the treatment of aluminum alloys conforms to MIL-C-81706, Chemical Conversion Material. Class 1A chemical conversion material provides superior corrosion protection. Class 3 chemical conversion material provides less corrosion protection and is used where low electrical resistance is required, such as mounting areas for antennas. The material for the treatment of magnesium alloys conforms to MIL-C-3171, Type VI, Chemical Conversion Material. These chemical conversion materials may be in the form of dry crystals or pre-mixed. When dry crystals are provided, they must be mixed with an appropriate amount of distilled water. When the chemical conversion material is pre-mixed, no additional distilled water need be added.

(2) Distinguishing Between Magnesium and Aluminum. The methods to distinguish between magnesium and aluminum are as follows:

(a) Magnesium may be distinguished from aluminum by spot testing with a silver nitrate solution. When silver nitrate crystals are provided, dissolve a few crystals (approximately 1/4 teaspoon) of silver nitrate conforming to O-C-265 in approximately one ounce of distilled water. When a pre-mix is provided, that solution is ready for use.

WARNING: Silver nitrate, O-C-265, is corrosive and toxic to the eyes, skin, and respiratory tract. Skin and eye protection is required. Use only in a well ventilated area.

(b) Select or make a clean, bare spot on the metal. Place one drop of solution on the spot. If that area turns black, the material is magnesium. Aluminum and its alloys will not show any reaction to silver nitrate solution.

b. Aluminum Surface Treatment. When an aluminum alloy needs to be surface treated, clean the surface to obtain a water break-free surface as described in chapter 4, paragraph 405m. Apply chemical conversion coating on the aluminum surface as follows:

NOTE: Metal portions of brushes should be wrapped with masking tape prior to use when applying conversion coating material in order to protect against contamination from the metal wrapping of the brush.

NOTE: Chemical conversion material conforming to MIL-C-81706 is the only chemical conversion treatment for aluminum used on avionics equipment.

WARNING: Chemical conversion material is flammable and toxic to the eyes, skin, and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well ventilated areas. Keep away from open flames or other sources of ignition.

CAUTION: Chemical conversion solutions can become contaminated if brought in contact with glass containers, ferrous metals (other than 300-series stainless steels), or copper alloys. Stainless steel, polyethylene, and polypropylene containers should be used. Discard all contaminated solutions.

(1) Wet the surface with water.

(2) While the surface is still wet, apply the chemical conversion material using an artist's brush. Continue to apply the chemical conversion material until an iridescent golden color is obtained. This usually takes 2 to 4 minutes.

(3) Once the iridescent golden color is obtained, immediately rinse the chemical from the surface with fresh water. Rinsing thoroughly is important to stop the chemical action and minimize solution entrapment. Failure to adequately rinse may accelerate corrosion and reduce paint adhesion.

(4) Remove all excessive chemical conversion material that may be trapped in pools within the aircraft or component.

(5) After thorough rinsing, allow the coated surface to air dry for a minimum of 30 minutes undisturbed. Do not wipe the area with a cloth or brush until dry, since premature wiping would remove the soft coating. The coating is soft until dry.

NOTE: As a chemical conversion solution approaches its shelf life, or at temperatures below 50°F, more time may be required to form good films. This is indicated by the proper golden color.

(6) Any difficulties in properly obtaining the iridescent golden color can usually be attributed to insufficiently cleaned metal surfaces, or to depleted or contaminated solution. Chemical conversion materials generally have a shelf life of one year. Contaminated or over-aged chemical conversion material may not form good films. Suspected overage chemical conversion material may still be used if the iridescent golden color can be obtained on the aluminum in under 4 minutes.

c. Magnesium Surface Treatment. When a magnesium alloy needs to be surface treated, clean the surface to obtain a water break-free surface as described in chapter 4, paragraph 405m. Apply chemical conversion coating on the magnesium alloy surface as follows:

WARNING: Chemical conversion material is flammable and toxic to the eyes, skin, and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well ventilated areas. Keep away from open flames or other sources of ignition.

CAUTION: Chemical conversion solutions can become contaminated if in contact with glass containers, ferrous metals (other than 300-series stainless steels), or copper alloys. Stainless steel, polyethylene, and polypropylene containers should be used. Discard all contaminated solutions.

NOTE: Chemical conversion material conforming to MIL-M-3171 is the only chemical conversion treatment for magnesium used in avionics.

(1) Wet the surface with water.

(2) While the surface is still wet, apply the chemical conversion material using an artist's brush. Continue to apply the chemical conversion material until a greenish-brown or brass yellow color is obtained. This usually takes 1 to 5 minutes.

(3) Once the greenish-brown or brass yellow color is obtained, immediately rinse the chemical from the surface with fresh water. Rinsing thoroughly is important to stop the chemical action and minimize solution entrapment. Failure to adequately rinse may accelerate corrosion and reduce paint adhesion.

(4) Remove all excessive chemical conversion material that may be trapped in pools within the aircraft or component.

(5) After thorough rinsing, allow the coated surface to air dry for a minimum of 30 minutes undisturbed. Do not wipe the area with a cloth or brush until dry, since premature wiping would remove the soft coating. The coating is soft until dry.

NOTE: As a chemical conversion solution approaches its shelf life, or at temperatures below 50°F, more time may be required to form good films. This is indicated by the proper greenish-brown or brass yellow.

(6) Any difficulties in properly applying chemical conversion materials can usually be attributed to insufficiently cleaned metal surfaces, or to depleted or contaminated solution. Contaminated or over-aged chemical conversion material may not form good films. Suspected overage chemical conversion material may still be used if the greenish-brown or brass yellow color can be obtained on the magnesium in under 30 minutes.

d. Treatment of Other Metals. The treatment of other metals is limited to corrosion removal and cleaning.

e. Post-Treatment of Conversion Coated Surfaces. Before painting or applying sealant, allow chemical conversion coating to dry (usually 1 hour). The coating is soft until dry. Do not wipe the area with a cloth or brush until dry, since wiping will remove the soft coating.

504. PROTECTIVE COATINGS.

a. General. Protective coatings (generally paint) are susceptible to damage by handling, accidental scratching, and corrosion. The function of boxes, chassis, housings, and frames are to enclose, protect, and secure the vital internal components of the avionics unit. Therefore, with proper maintenance of the protective coating, the structural integrity and protection of the avionics unit can be maintained.

(1) Painted Surfaces. Painted surfaces on avionics equipment will withstand a normal amount of abrasion from handling and hand tools. When the painted surface becomes chipped, scratched, or scuffed, the loss of the protective coating allows the base metal to become more susceptible to corrosion. Maintenance personnel should pay particular attention to the use of tools around, and handling of, avionics equipment. When protective coatings are properly applied, they will prolong the useful life of the base material by protecting it from corrosion and harmful agents. The application of a paint system involves three basic steps:

(a) Surface preparation;

(b) Application of primer or undercoat; and

(c) Application of one or more finish coats.

(2) Minor Paint Damage. Minor paint film damage generally occurs when maintenance personnel use hand and power tools on and around avionics equipment. Damage can also occur from equipment handling. The result of this damage is a protective finish that is chipped, scratched, or abraded. Short-term protection includes the application of a water-displacing corrosion preventive compound. Chapter 4 describes several water-displacing, corrosion preventive compounds that provide short and moderate term preservation. Long-term repair of a damaged protective coating is accomplished by touching up the paint system.

(3) Extensive Paint Damage. Extensive paint damage requires stripping of the old paint, evaluation for corrosion, cleaning, conversion coating for aluminum and magnesium, priming, and the application of one or two finish coats.

b. Cleaning and Surface Preparation. When the surface to be painted is contaminated, the paint system will not properly adhere. Almost all paint system adhesion failures such as peeling, flaking, etc., are the result of an improperly prepared (contaminated) surface. Contaminants include oil, grease, dirt, moisture, or defective paint systems (loose or cracked paint). Proper cleaning and surface preparation includes removal of corrosion products and other contaminants. Chapter 4, paragraphs 403, 404, and 405, and this chapter, paragraph 502b, describe the equipment and procedures for cleaning and corrosion removal. Surface preparation (conversion coating) for aluminum and magnesium surfaces are described in this chapter, paragraph 503. Surfaces that are not to be painted should be masked with pressure-sensitive tape.

c. Painting Equipment and Materials. Painting equipment and accessory materials available for the application of protective paint coatings are listed in the following paragraphs.

(1) Painting Equipment.

(a) Spot Touch-up Spray Gun;

(b) Artist's Air Brush;

(c) Paint Brush;

(d) Artist's Paint Brush;

(e) Air Regulator and Metering Valve; and

(f) Paint Spray Booth.

(2) Painting Materials.

(a) Water-Reducible Epoxy Primer, Chemical and Solvent Resistant, conforming to MIL-P-85582. A low Volatile Organic Compound ((VOC) of not more than 340 g/1), environmentally-compliant primer used to improve topcoat adhesion and provide a corrosion-inhibiting undercoating. This two-part primer kit should be mixed per the paint manufacturer's instructions and applied over a properly prepared surface as described in chapter 4, paragraphs 403, 404, and 405, and this chapter, paragraphs 502b and 503a.

NOTE: Local air pollution regulations may restrict the use of many primers, paint coatings, and thinners. Comply with all local air pollution regulations. Most aircraft primers and topcoats are issued as two-part kits. Mix only the materials from the same two-part kit. The brand and batch numbers should be the same. Follow all mixing instructions provided by the paint manufacturer.

(b) Primer coating, Epoxy-polyamide, Chemical and Solvent Resistant, conforming to MIL-P-23377. A solvent-based primer used to improve topcoat adhesion and provide a corrosion-inhibiting undercoating. This two-part primer kit should be mixed per the paint manufacturer's instructions and applied over a properly prepared surface described in chapter 4, paragraphs 403, 404, and 405, and this chapter, paragraphs 502b and 503a.

(c) Epoxy-polyamide, conforming to MIL-C-22750, and aliphatic polyurethane, conforming to MIL-C-83286. Several topcoats are available for the final or finish coat. The epoxy-polyamide and aliphatic polyurethane are solvent-based topcoats used to provide long-term protection to avionics equipment. An available environmentally-compliant topcoat is Coating, Polyurethane, High Solids (VOC of 420 g/l), conforming to MIL-C-85285, Type 1. This topcoat is a water-reduced paint that provides long-term protection to avionics equipment. These topcoats are supplied as two-part kits and should be mixed per the paint manufacturer's instructions. Selection of a topcoat color is normally based on the equipment's location. Unless otherwise directed, refer to the OEM specification. The topcoat should be applied over a primed surface within 24 hours of the primer application. Applicable markings should be applied, using a stencil, with Lacquer, Acrylic Nitrocellulose, Lusterless, conforming to MIL-L-19538 in an appropriate color.

WARNING: Topcoats, Epoxy-Polyamide, MIL-C-22750; Polyurethane, Aliphatic, MIL-C-83286; and Coating, Polyurethane High Solids, MIL-C-85285, Type 1, are toxic to the eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated or prolonged contact. Use only in well ventilated areas. Keep away from open flames or other sources of ignition.

WARNING: Prolonged breathing of vapors from organic solvents or materials containing organic solvents is dangerous. Refer to the MSDS for warnings and required protective gear. Polyurethane, Aliphatic Thinner, MIL-T-81772 is flammable and toxic to the eyes, skin, and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well-ventilated areas. Keep away from open flames or other sources of ignition.

(d) Thinners are volatile solutions used to thin or reduce the paint topcoat to a desired consistency. The type of thinner that may be used, and the recommended quantity, are determined by the paint manufacturer and displayed on the paint container.

(3) Paint Problems. Certain discrepancies may appear on finish coatings due to faulty application methods or contamination of the surface to which the coating was applied. Table 5-1 lists the most common defects, probable causes, and prevention methods.

d. Application of Coatings. The methods used to paint, touch-up, or apply preservatives depends on the extent of the job, material, tools, facilities, and time available. Spraying is faster than other methods and results in a smoother surface finish. However, the time and labor required to set up spray equipment may not be justified by the amount of work to be done, or if extensive masking is required. Brushes are used where the use of spray guns is impractical, unsuitable, or not allowed.

(1) Paint Spray Booth. The paint spray booth should be used to conduct paint spray operations. The paint spray booth should, at a minimum, be equipped with an exhaust fan and filtration system capable of evacuating paint fumes and entrapping spray particles.

(2) The paint spray booth should comply with all applicable air pollution control requirements.

e. Application of Primer. Primers identified in paragraph 504c are to be applied on avionics equipment as follows:

(1) The surface to be primed should be thoroughly cleaned and pre-treated per instructions in Chapters 4, paragraphs 403, 404, and 405, and this chapter, paragraph 502b, which describe the equipment and procedures for cleaning and corrosion removal. Surface preparation (conversion coating) for aluminum and magnesium surfaces is described in this chapter, paragraph 503.

(2) Mask all openings and areas not to be painted with pressure sensitive tape and Kraft paper or other suitable barrier materials.

(3) Mix primer per manufacturer's instructions. Thin (reduce) with applicable thinner as required.

TABLE 5-1. CAUSE AND PREVENTION OF PAINT DEFECTS

Paint Application Defects	Cause	Prevention
Webbing	• Insufficient thinning • Wrong thinning mixture	• Ensure sufficient mixing and thinning
Dry Spots or Dulling - flattening out of the gloss in selective areas	• First coat applied too thin, especially in hot weather • Poorly cleaned surface • Wrong thinning mixture	• Ensure proper application • Ensure proper preparation of the surface • Ensure sufficient mixing and thinning
Orange Peel - orange skin appearance	• Spraying at high viscosities • Air pressure too high • Poor spray technique, such as spraying too far from surface	• Ensure proper thinning • Reduce air pressure • Move closer to surface
Blistering - looks like a bubble or swelled area in the paint film	• Trapped solvents • Corrosion under the paint film • Moisture in air supply line • Prolonged exposure to high humidity	• Ensure sufficient drying time between coats • Ensure proper surface preparation • Ensure air supply line is free of water • Avoid use of overly fast drying thinners when temperature is high
Blushing - appears like milky gray cloud on paint film	• Occurs on humid days during or shortly after application • Caused by condensation of moisture on the freshly-painted surface when it is cooled to a temperature below the dew point. The cooling can be caused by: a. Evaporation of fast drying solvents b. Air from the spray gun c. Movement of item to area where the ambient temperature is below the dew point	• Apply paint only when paint area is warm enough to prevent cooling to dew point • Do not subject item to ambient temperatures that are below the dew point until a minimum of 2 hours has elapsed after painting
Fish-Eyed - appears like small crater-like openings just after spraying	• Oil or silicone materials in the air lines • Dirty surfaces	• Ensure all equipment and surfaces to be painted are free of oil or silicones • To remove fish-eyed paint, clean area with an approved solvent. Blot dry using clean absorbent cloth. Repeat as necessary and repaint.

TABLE 5-1. Continued

Paint Application Defects	Cause	Prevention
Grit	• Settling of particulate debris onto freshly painted surfaces, usually within two hours of application	• Clean surface prior to application • Filter paint before mixing • Keep freshly painted surfaces protected from blowing or falling dust and debris
Alligatoring - characterized by irregular separations and wide cracks in the paint film	• Softened undercoat • Uncured layer	• Remove affected paint and refinish • Allow adequate drying time between coats
Bleeding - discoloration of the paint film	• Pigment absorption from underlying coat • Insufficient topcoat thickness	• Apply additional topcoat. If problem remains, remove paint coatings and refinish area with specified paint system
Chalking - dull, powdery film	• Loss of gloss to oxidation of the topcoat	• Polishing or light sanding of area. If problem persists, refinish affected area
Checked - thin lines criss-crossing each other	• Softened undercoat • Uncured layer • Condition increases with aging	• Ensure sufficient mixing and thinning • Allow adequate drying time between coats
Cracking - irregular lines in the paint film	• Inadequate curing of paint • Inadequate mixing • Change in temperature during application	• Allow adequate drying time between coats • Ensure sufficient mixing and thinning
Crowfooting - lines branching in all directions and crossing each other	• Application before undercoat has dried • Too rapid evaporation of thinner • Coating too thick	• Allow adequate drying time between coats • Ensure sufficient mixing and thinning • Ensure proper application of paint
Peeling - separation and lifting of paint	• Separation of topcoat from primer or primer from metal surface due to: a. Lack of or improper chemical conversion coating b. Contaminated (dirty) surface c. Wet surface	• Ensure proper surface preparation • Ensure surface is properly cleaned and dried
Runs and Sags	• Application of too much paint • Paint contains too much solvent	• Properly apply paint • Ensure sufficient mixing and thinning
Scratches and Chips	• Gouging with sharp tool • Sharp blows by tools or stones	• Handle tools properly

(4) Primer coat should be applied per specifications of the OEM by spraying or brushing in an even, uniform thickness. When specifications are not provided, use the following dry primer thickness limits: 1 coat, 0.0004 to 0.0010 inch thickness, for avionics equipment exposed to harsh environments apply 2 coats, 0.0008 to 0.0014 inch thickness.

(5) Ensure as much as possible that the primed item or material is kept in a dry, dust-free location until the primer coating is dry (cured) and hardened. Primer coats are normally tack-free in approximately 30 minutes and can be handled, if required, in approximately 1 hour. The primer will be sufficiently dry (cured) to enable topcoat application in approximately 2 hours. The topcoat should be applied within 24 hours of primer application. Primer coats cured beyond the 24 hour time will require cleaning and a light coating of primer prior to topcoat application.

f. Application of Topcoat. The topcoat is the final or finish coat applied over the primer. The type of topcoat paint and the selection of the color will depend upon the equipment's intended location and the OEM specification. Epoxy-polyamide conforming to MIL-C-22750, aliphatic polyurethane conforming to MIL-C-46168, and aliphatic urethane conforming to MIL-C-83286 are topcoats that may be used. The topcoat should be applied on avionics equipment as follows:

(1) In preparation for application of a topcoat the surface should already be cleaned, pre-treated, masked, and primed per chapter 4, paragraphs 403, 404, and 405. Surface preparation (conversion coating) for aluminum and magnesium surfaces, masking, and priming are described in this chapter, paragraphs 503 and 504e.

(2) The topcoat should be applied by brush or spray to the component within 24 hours of primer application. Application method depends on the type of finish required, materials used, and the surface to be finished. Care should taken to keep the area free of dust and other foreign matter when applying the topcoat.

(3) When a single coat does not adequately cover the primer and when protection against extreme exposure is necessary, two or more coats may be required.

(4) Remove all masking material as soon as possible.

505. ENCAPSULATES.

a. General. Encapsulates are materials used to cover a component or assembly in a continuous organic resin. Encapsulates provide electrical insulation resistance to corrosion, moisture, and fungus, and mechanically support the components. In avionics equipment, encapsulates are classified as follows:

(1) Potting Compounds. Potting compounds are used to seal electrical connectors, plugs, and receptacles.

(2) Fungus Proof Coatings. Fungus proof coatings, usually varnishes, are used to encapsulate certain avionics circuit components in a thin protective film that is impervious to fungal attack. Varnishes were used in older microelectronics and electrical components.

(3) Conformal Coatings. Conformal coatings are used to encapsulate PCBs and modules.

b. Potting Compounds. Potting compounds are used for their moisture-proof and reinforcement properties. They are used on electrical connectors to protect against fatigue failures caused by vibration and lateral pressure at the point of wire contact with the pin. Potting compounds also protect electrical connectors from corrosion contamination and arcing by excluding moisture, stray particles, and aircraft liquids (hydraulic fluid, fuel, oil, etc.).

(1) Materials. The following materials should be used for sealing (potting) electrical connectors, plugs, and receptacles.

WARNING: Potting compounds are toxic to the eyes, skin, and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well-ventilated areas. Keep away from open flames or other sources of ignition.

(a) Sealing Compound, Synthetic Rubber, Accelerated Cure, conforming to MIL-S-8516 is a two-part polysulfide synthetic rubber compound kit. The kit consists of a base and an accelerator (curing agent). This sealing compound is used for sealing low-voltage electrical connectors, wiring, and other electrical apparatus where the temperature does not exceed 200°F (93°C). This sealing compound should not be used in engine bays, aircraft keel areas, or adjacent to bleed (hot) air ducts.

NOTE: A sealing compound that has reverted changes (reverts) from the cured compound back into a liquid compound.

(b) Sealing Compound, Silicone Rubber, Room Temperature Vulcanizing (RTV), conforming to MIL-S-23586, Type II, Class 2, Grade B-1 is a reversion-resistant silicone rubber compound consisting of a base and an accelerator (curing agent) in a kit. This sealing compound is used for sealing electrical connectors and components where the sustained equipment operating temperature exceeds 200°F (93°C). This sealant has a maximum temperature of 450°F (232°C). This sealant may be used in a closed space.

(c) Sealing Compound, Silicone Rubber, RTV, conforming to MIL-S-23586, Type II, Class 2, Grade A is a reversion-resistant silicone rubber compound consisting of a base and an accelerator (curing agent) in a kit. This sealant is used for sealing small electrical connectors that are not in a closed space and where the sustained equipment operating temperature exceeds 200°F (93°C). This sealant has a maximum temperature of 450°F (232°C). If electrical connectors are potted with this compound and allowed to cure in a closed space, or if they normally exist in a closed space after curing, this sealing compound will be susceptible to reversion.

(d) Sealing Compound, Silicone Rubber, (RTV), conforming to MIL-A-46146, Type II is used for sealing electrical connectors. This compound is a less viscous (flows easily), single-component (one-part) compound. The different types of this compound are defined in paragraph 505d, Sealants.

(e) Sealing Compound, Fuel Resistant, conforming to MIL-S-8802 is used to prevent entry of corrosive elements, and where fuel and oil may be present. This polysulfide sealing compound consists of a base and an accelerator (curing agent) in a kit. This sealing compound has a maximum temperature of 275°F (135°C). The different types of this compound are defined in paragraph 505d, Sealants.

(f) Sealing Compound, Corrosion-Inhibiting, conforming to MIL-S-81733 is used to prevent entry of corrosive elements, and where fuel and oils may be present. This polysulfide sealing compound contains corrosion inhibitors, and consists of a base and an accelerator (curing agent) in a kit. This sealant has a maximum temperature of 250°F (121°C). The different types of this compound are defined in paragraph 505d, Sealants.

(g) Sealing Compound conforming to MIL-M-24041 is used for sealing and reinforcing electrical connectors, wiring, and components in a seawater environment. This sealing compound is a two-component polyether polyurethane system consisting of a prepolymer and a curing agent. This sealing compound has good cold-flow properties and will adhere to metal, rubber, and polyvinyl chloride (PVC). The temperature range of this material is -80°F to +300°F.

(2) Reverting Potting Compounds. Some potting compounds have a past history of reverting to a liquid after a year or two. This reversion is highly dependent on the environment of the potting compound. Compounds that revert exhibit a sticky, viscous, oozing consistency that flows out of the connector back shell. In some cases the reverted potting compounds flow around and through pins and receptacles, insulating the connection where continuity is required.

(3) Precautions. When using potting compounds, the following precautions should be followed:

(a) Thoroughly clean the area to be potted using an approved solvent.

(b) Follow manufacturer's instructions when mixing the base compound and accelerator. Substitutions, partial mixing, or incorrect proportions of the base compound and accelerator may produce a sealant with inferior properties.

(c) Do not mix base compounds and accelerator components of different batch numbers because substantial electrical properties may result.

(d) Potting compounds may contain small quantities of flammable solvents, and/or may release by-products on curing. Observe all warnings and cautions, and use personal protective gear identified in the MSDS and by the potting compound manufacturer.

(e) Potting compounds that have exceeded their listed shelf life should not to be used unless tested and certified by an approved laboratory.

(f) Avoid contamination of the potting compound. Do not use masking tape and fiberboard molds around the connector during the potting compound cure. If potting molds are not furnished with the connector or are not available, a plastic sleeve should be constructed. The plastic sleeve will aid in forming the potting compound around the connector during the cure.

(g) Allow potting compounds to cure until firm prior to installing connector or components in equipment.

(h) Frozen pre-mixed potting compounds should be used as soon as possible after their removal from the freezer or a significant (up to 50 %) reduction in working life can be experienced.

(i) Remove reverting or reverted potting as soon as possible.

c. Fungus-Proof Coatings. Fungus-proof coatings should not be applied indiscriminately to all electrical components. Treat only those components that have a specific need or are designated in the applicable manufacturer's service directives. Fungus-proof coatings can, in some instances, be detrimental to the function and maintenance of equipment. For example, fungus-proof coatings deteriorate wire insulation, and their removal for maintenance action is labor-intensive. A repair activity should re-coat an entire area only when a touch-up of the previously coated component will not provide the required protection. Many hours of repair time will be required if the fungus-proof coating is not maintained.

(1) Fungus-Proof Varnish. The authorized fungus-proof coating is a varnish conforming to MIL-V-173. These varnishes should be thinned, if necessary, with an approved solvent per the manufacturer's instructions or with a thinner conforming to TT-T-306.

(2) Items That Should Not Receive Fungus-Proof Varnish. Varnish should not be applied to any surface where its application will interfere with the operation or performance of the equipment. Those surfaces should be protected during application of fungus-proof varnish with pressure sensitive tape. The following items should be protected from varnish application:

(a) Components and Materials.

i. Cable, wire, braids, and jackets that are flexed during operation of the equipment.

ii. Cables where treatment would reduce the insulation resistance below, or increase the loss factor above, the acceptable service limits provided by the OEM.

iii. Variable capacitors (air, ceramic, or mica dielectric).

iv. High wattage and wire wound resistors.

v. Ceramic insulators that are subject to an operating voltage over 600 volts and in danger of flashover.

vi. Painted, lacquered, or varnished surfaces, unless otherwise specified by the OEM.

vii. Rotating parts such as dynamotors, generators, motors, etc. Electrical components that are associated with the rotating component may be treated in accordance with the procedures outlined in this AC.

viii. Wave guides (mating surfaces).

ix. Electron tubes.

x. Tube clamps.

xi. Miniature tube shields.

xii. Plug-in relays.

xiii. Pressure-contact grounds.

xiv. Coaxial test points or receptacles.

xv. Windows, lenses, etc.

xvi. Transparent plastic parts.

xvii. Plastic materials such as polyethylene, polystyrene, polyamide, acrylic, silicone, epoxy (other than printed wiring boards), melamine, fiberglass, fluorocarbon, vinyl, and alkyds.

xviii. Materials used for their specific arc-resistance properties and classified as such.

(b) Electrical contacts, contact portions, or mating surfaces of binding posts. Also connectors, fuses, jacks, keys, plugs, and relay sockets (including tube sockets, switches, and test points).

(c) Mechanical Parts.

i. Bearing surfaces (including bearing surfaces of gaskets and sliding surfaces).

ii. Gear teeth and gear trains or assemblies.

iii. Pivots and pivot portions of hinges, locks, etc.

iv. Screw threads and screw adjustments (those moved in the process of operation or adjustment).

v. Springs, except at base of pile-up.

(d) Surfaces which rub together for electrical or magnetic contact, such as bearings, contact fingers, potentiometers, shafts, shields, and variable auto-transformers.

(e) Surfaces whose operational temperatures exceed 266°F (130°C), or whose operating temperature will cause carbonization or smoking.

(f) The exterior or visible outside portion of indicating instruments (do not open or treat inside), control boxes, or other equipment mounted in the cockpits of aircraft.

(3) Methods of Application. The varnish coating may be applied by spraying, brushing, dipping, or any combination of these processes. The dried film should have a clear, smooth finish (free from bubbles, wrinkles, filaments, or spray dust). Runs, puddles, or gathering of the film into drops should be avoided. The dry film thickness should be at least 0.002 inch unless otherwise directed in the manufacturer's service directives.

NOTE: All surfaces to be coated should be free of dirt, grease, and other foreign matter. Components that cannot be cleaned satisfactorily or that show evidence of corrosion should be cleaned and treated per the instructions in this AC or replaced by acceptable components. Local air pollution regulations may restrict the use of fungus-proof varnish. Comply with all local air pollution regulations.

CAUTION: Avoid varnish adhesion failures. Apply only on clean, dry surfaces with a temperature of less than 100°F (38°C).

(a) Spraying. For larger equipment, a pressure-pot spray gun system with the tip regulated to give a wet spray is recommended. For small, compact equipment, a pencil spray tip, regulated to give a narrow, wet spray, is recommended. The varnish should be applied in a continuous wet coat over all parts to prevent the formation of fuzz or filaments. Incomplete wetting of the component surface with varnish will produce a "dry spray." The dry spray texture appears as dust on the surface of the component. Dry spray is an unacceptable finish. The equipment or individual assembly should be sprayed from as many angles as necessary to ensure complete coverage with a wet coat. If more than one coat of varnish is necessary or required by the manufacturer's service directives, allow sufficient drying time between coats. Refer to the varnish manufacturer's time/temperature instructions.

(b) Brushing. All parts which cannot be reached by spray may be coated with a brush. A brush may also be used to cover small areas not covered during the spraying process. On components that require extensive masking, brush application may prove more efficient than spray application.

(c) Dipping. Subassemblies or components may be coated by dipping, provided all requirements of paragraphs 505c(2) and 505c(5) are met.

WARNING: Components that are to be enclosed in airtight cases (hermetically sealed) should be allowed to air-dry for at least an additional 24 hours after the varnish dries. Fumes (outgassing) may accumulate to dangerous levels within the case and may be ignited by an ignition source.

(4) Drying of Coated Equipment. Equipment coated with varnish should be dried by heating to 130°F (54°C). Heating should be gradual to prevent shrinking, cracking, warping, or other deterioration of the parts or materials. The drying temperature should be maintained for at least 1/2 hour but no longer than 3 hours. The drying process may be done in a vented oven, vacuum oven, or with a hot air gun.

(5) Special Precautions. When varnish is to be applied on certain types of equipment, special precautions are required. The following paragraphs list equipment and parts requiring special precautions.

(a) Radio Receivers and Transmitters. The application of varnish will cause changes in some of the circuit constants. These changes may be discernible only by electrical tests and measurements. A change in alignment may be noted immediately after application of the varnish. As the varnish dries and ages, further changes in circuit constants may take place. The greatest change ordinarily will occur within 72 hours after treatment. The set should be completely realigned at the end of that period.

(b) Coil Shields. When coil shields are removed and replaced, they can be damaged and alter the tuning adjustments. If there is significant damage, proper alignment may be impossible. Extreme care should be exercised in removing and installing coil shields.

(c) Trimmer Capacitors. Avoid spraying or brushing varnish on the plates of trimmer capacitors. To minimize damage, all trimmer capacitors should be masked completely during varnish application. If the variable capacitor fails to operate satisfactorily after treatment, make a thorough inspection for varnish deposits.

(d) Tuning Slugs. If varnish is accidentally applied to a tuning slug, the tuning slug will normally require replacement. Extreme care should be taken in removing and replacing tuning slugs.

(e) Discriminator Circuits. Careful adjustment of discriminator circuits after applying varnish is essential, especially in the case of frequency-modulated receivers. Discriminator circuits are more susceptible to varnish-induced changes in circuit constants than any other component.

(f) Tuned Circuits. Be especially careful during masking to ensure the wires associated with the tuned circuit are not moved. Movement of such wires may change the circuit value.

(g) Relays. Deposits of varnish on the armature, pivot, or similar components will cause the relays to bind. Mask the entire relay carefully prior to general component varnish application. After the masking has been removed, brush-apply varnish as required to coils and leads. Relays with palladium-tipped contacts should be removed before application of varnish.

(h) Meters. Since meters are easily damaged by the varnish spray treatment, all meters should be checked for accuracy before treatment. Some meters may be affected by the heat of the drying process. In other instances, meter magnets may be affected by magnetic fields that exist around drying equipment. Refer to the OEM applicable service instructions for varnish treatment. If guidance is not available, do not apply varnish.

d. Sealants. Sealants are another type of protective film used in avionics equipment. Sealants are usually provided in the uncured form as a liquid or paste which solidifies (cures) after application. Sealants can be applied by hand methods, such as brush or spatula, or by air or mechanically powered filleting/injection guns. Sealants form a flexible seal in gaps and depressions, preventing moisture intrusion at mechanical joints, spot welds, and threaded closures. In addition, they prevent entry of corrosive environments into faying surfaces, fastener areas, exposed landing gear switches, and other metal-encased avionics equipment. They function principally as waterproof barriers. Therefore, when an inspection notes damaged sealant, it should be removed, the area inspected for damage, and new sealant applied. The following describes various types of sealant available.

(1) Sealing Compound, Polysulfide, conforming to MIL-S-81733. A two-part, dichromate cured, polysulfide sealant with added soluble chromates which inhibit corrosion. This sealant is intended for use at faying surfaces subject to galvanic action and temperatures up to 250°F (121°C). This sealant has excellent resistance to shrinkage, aircraft fuels, and lubricating oils. It also resists deterioration from saturation with ester-type hydraulic fluids. The mixed sealant may be applied by brush or spatula. The sealant is provided in four types which allow long assembly times.

(2) Sealing Compound, Polysulfide, Low Temperature Curing, conforming to MIL-S-83318. A two-part polysulfide sealant characterized by an excellent cure rate at low temperature. This sealant is intended for quick field repairs to other sealants. Apply with brush.

(3) Sealing Compound, Polysulfide, conforming to MIL-S-8802, Type A. A brush-applied, room-temperature cured sealing compound that is used for sealing gaps, seams, and faying surfaces. This sealant has excellent adhesion to most aircraft materials; excellent resistance to water, aircraft fuels (aviation gas and jet fuel), and petroleum based oils; good resistance to deterioration from saturation with diphosphate ester-type hydraulic fluids; and can withstand temperatures up to 250°F (121°C). Four different sealants are available with application life and cure times from 1/2 to 4 hours. Type B sealants are spatula-applied compounds with the same characteristics as Type A.

(4) Adhesive Sealant, Silicone, RTV. Noncorrosive, conforming to MIL-A-46146, Type III. This one-part adhesive sealant is used for encapsulating and sealing electrical and electronic components where the avionics equipment will operate at temperatures between 250°F (121°C) and 350°F (177°C).

(5) Adhesive Sealant, Silicone, RTV, conforming to MIL-A-46146, Type I. This general purpose, one-part adhesive sealant is used for encapsulating and sealing electrical and electronic components. This material has good resistance to oxidation, weathering, and water.

CAUTION: A large number of RTV silicone sealants contain an acetic acid curing agent. These sealants, in contact with metal, result in rapid corrosion. RTV sealants that contain acetic acid are not authorized for use on electronic or electrical circuits. They may be identified in most cases by a vinegar odor from the dispenser tube or while curing.

(6) Sealants Containing Acetic Acid. Table 5-2 lists some of the RTV silicone sealants that are considered corrosive and should not be used in avionics equipment.

(7) Adhesion Promoters. Some sealing compounds may require the application of a special primer or adhesion promoter prior to the sealant application, in order to develop a good adhesive bond with the surface. Use only those primers or adhesion promoters recommended by the manufacturer for their product.

(8) Sealant Application Procedures.

(a) Cleaning. Pre-clean the surface where sealant is to be applied per chapter 4, paragraph 405 to remove dirt, grime, etc. Perform a final wipe of the area with an approved solvent, recommended by the sealant manufacturer, using a clean cheesecloth. While the surface is still wet with solvent, wipe dry with a clean, dry piece of cheesecloth.

(b) Masking. To prevent sealant from contacting adjacent areas during application and to aid in post-application smooth out, mask the area to be sealed with pressure sensitive tape.

(c) Primers or Adhesion Promoters. Apply sealant primer or adhesion promoter when recommended by, and in accordance with, the sealant manufacturer's instructions. Allow the surface to air dry undisturbed for 30 minutes to one hour prior to sealant application.

(d) Sealant Mixing. The proper mixing of the base and accelerator sealant components is essential for proper curing and adhesion of the sealant. Mixing should be accomplished in a clean environment per the manufacturer's instructions. The accelerator and base components should be added together after the proper amounts are determined by weight or volume, then mixed until a uniform color is obtained. Two-part sealants are chemically cured and do not depend on solvent evaporation for curing.

TABLE 5-2. CORROSIVE SILICONE SEALANTS, ADHESIVES, AND COATINGS

RTV 102	RTV 192	RTV 999	RTV 92-055
RTV 103	RTV 198	RTV 1890	RTV 94-002
RTV 106	RTV 236	* RTV 3144	RTV 94-003
RTV 108	RTV 730	* RTV 20-046	* RTV 94-009
RTV 109	* RTV 731	* RTV 20-078	* RTV 94-034
RTV 112	RTV 732	RTV 30-079	* RTV 96-005
RTV 116	* RTV 733	* RTV 30-121	* RTV 96-080
RTV 118	RTV 734	* RTV 4-2817	RTV 96-081
* RTV 140	RTV 736	* RTV 90-092	RTV Q3-6069
* RTV 142	* RTV 780	* RTV 92-005	RTV Q3-6090
RTV 154	* RTV 781	RTV 92-007	RTV Q4-2817
RTV 156	RTV 784	RTV 92-009	RTV 92-010
RTV 157	* RTV 785	* RTV 92-018	SCS 100
RTV 158	RTV 786	* RTV 92-024	
RTV 159	* RTV 891	* RTV 92-048	

* Products discontinued by the manufacturer, but may still be available from approved sources.

NOTE: RTV 730 is a high temperature (550°F to 600°F) corrosive sealant that may be required to seal engine compartment electrical connectors. RTV 730 should be used only when specified by the OEM or authorized engineering authority.

(e) Application Life. Once mixed, two-part sealants have an application life. The application life of a sealant is the length of time that a mixed sealing compound remains usable in standard conditions of 70°F (24°C) and 50% relative humidity. Generally, the dash number of the sealant manufacturer's part number is the application life.

(9) Sealant Application. Apply sealant within the application life for the sealant being used. Thick sealants may be applied with a nonmetallic spatula or scraper. Avoid entrapment of air. Work sealant into recesses by sliding the edge of the spatula or scraper firmly back over the recesses. Smoothing of the sealant surface will be easier if the spatula or scraper is first dipped in water. Sealant applied with a brush is applied and smoothed by the brush until the desired thickness is reached. Sealant applied with an air or mechanically powered filleting/injection gun, depending on the application, may not require masking and is especially suited to filling seams, fay sealing, and creating form-in-place door seals. When applying a fay seal, ensure there is adequate sealant squeeze-out between the mating parts.

e. Conformal Coatings. Conformal coatings are generally two-part coatings that are applied in a thin coat to and over PCBs and other components. Conformal coatings protect PCBs and components from moisture, fungus, and thermal shock. They also protect the components from fatigue failure by their encapsulating properties. The coatings are flexible, flame resistant, and are suitable for application to PCBs by dipping, brushing, spraying, or vacuum deposition. The following types of conformal coatings are available: Acrylic resin (AR), Epoxy resin (ER), Silicone resin (SR), Polyurethane resin (UR), and Paraxylylene (XY). Coating thickness is dependent upon the type of coating system. For AR, ER, and UR coatings, the proper thickness is 0.002 plus or minus 0.001 inch; for SR coatings, 0.005 plus or minus 0.003 inch; and for XY coatings, 0.0006 plus or minus 0.0001 inch.

(1) Conformal Coating Removal. Conformal coatings must be removed prior to component removal from the PCB. The following describes the degree of recommended coating removal and various removal methods:

(a) Removal Area. Remove only as much coating as is necessary to facilitate removal of the discrepant component. Remove the coating from all solder connection areas to allow for desoldering. Figure 5-1 shows a typical step-by-step process for the removal of a component from a conformal-coated PCB.

NOTE: Do not attempt to remove all the coating down to the laminate surface. A thin residual layer will not interfere with component removal.

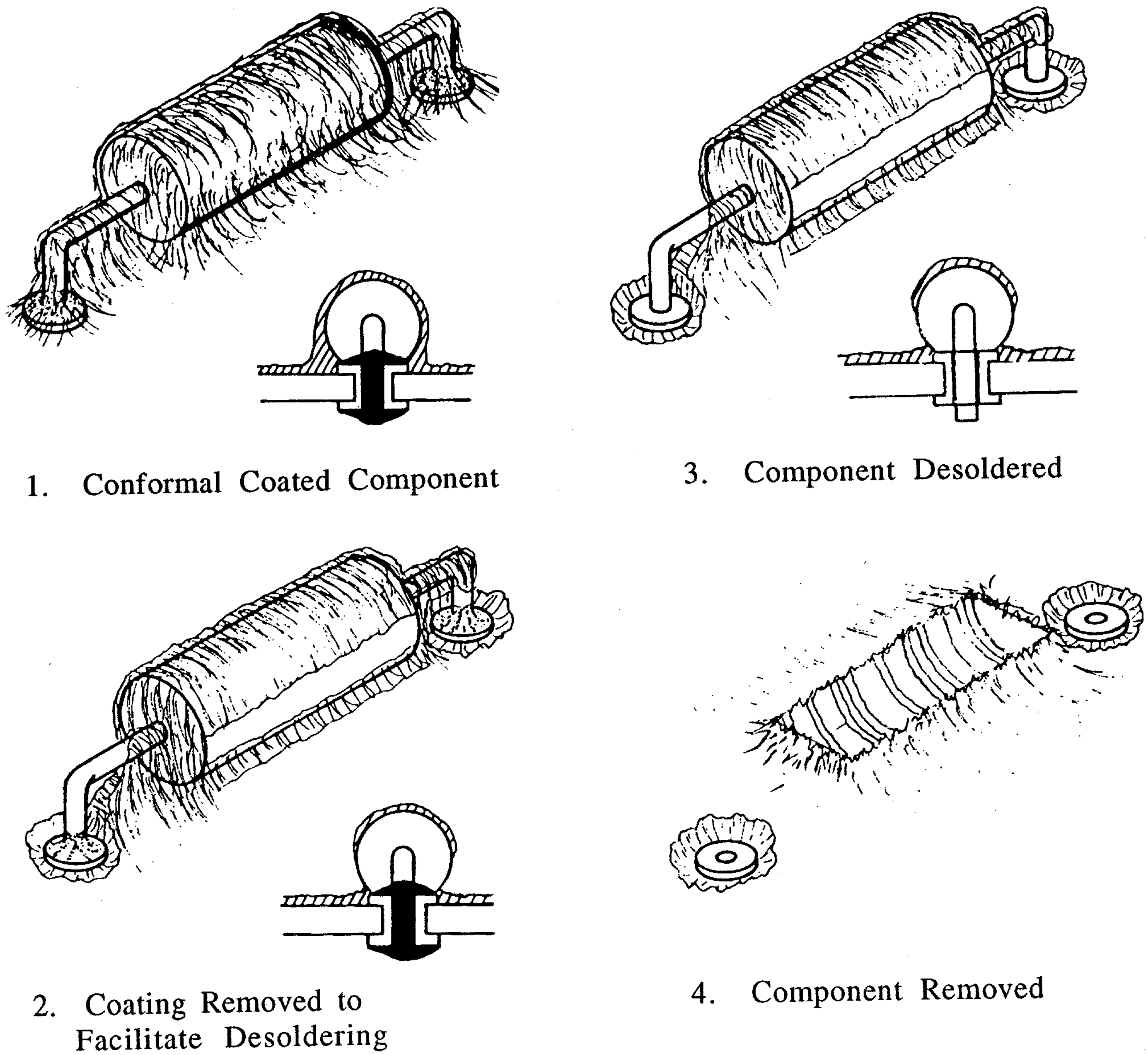

FIGURE 5-1. CONFORMAL COATING REMOVAL

CAUTION: Do not attempt component removal until the component leads are completely free of solder, as damage to the PCB could occur.

i. Prior to desoldering, remove the coating from along all sides of the affected component, below the widest profile of the component.

ii. To debond the component, heat the component body to release it from any residual coating or bonding compound.

iii. Remove any residual remaining coating that may interfere with the replacement component positioning, soldering, or post-soldering cleaning.

TABLE 5-3. REMOVAL METHOD PREFERENCE ON SPECIFIC COATINGS REMOVAL METHODS

Virgin Coating Type	Chemical	Controlled Heat Thermal Parting	Controlled Heat Hot Air	Abrasive Dental Burrs	Abrasive Disc & Bullets	Abrasive Rotary Brushes	Abrasive Dental Tools
Acrylic (AR)	1*		2		5#	4#	3
Epoxy (ER)		2#	1*	3		5#	4
Urethane (UR)		2#	1*			3	4#
Silicone (SR)	3					2	
Paraxylylene (XY)		2	1		5	4	3

* Denotes method that best identifies generic type of conformal coating.
\# For thin coating only.

(b) Removal Methods. There are three basic methods to remove conformal coatings. There is no preferred method or combination of methods. The method(s) employed will depend upon coating thickness, circuit density, and coating transparency. Table 5-3 lists the suggested removal methods for the various type of conformal coatings.

i. Chemical. This method is effective on AR coatings (lacquers and varnishes) which may be dissolved by either an approved solvent recommended by the coating manufacturer; 1, 1, 1 Trichloroethane, MIL-T-81533; or Isopropyl Alcohol, TT-I-735. These solvents are also effective on some SRs. They may dissolve or swell the silicone resins, allowing removal. They should be applied with a solvent-saturated cotton swab or acid brush. Gently rub the affected area and blot the solvent residue with a clean cotton swab. Repeat as required until the coating is removed. The final step is to neutralize the area with distilled or deionized water and blot dry with disposable tissue.

NOTE: Local air pollution regulations may restrict the use of these solvents. Comply with all local air pollution regulations.

WARNING: Solvents are flammable and toxic to the eyes, skin, and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well-ventilated areas. Keep away from open flames or other sources of ignition.

ii. Controlled Heat. Heat is effective on all resin coatings which will soften or revert (over cure) when exposed to a controlled, localized, low temperature (300°F to 400°F) heat source. The heat source method may also be effective for the release of components from the conformal coating or adhesive bonding of compounds beneath component bodies. This method is recommended on thicker coatings (0.025 inch or greater) because thin coatings offer little thermal protection to the PCB laminate. The use of either low pressure hot air or thermal parting is recommended. The area that is heated should be held to a minimum. After the coating has softened, gently push the residue aside with a plastic scraper or thermal parting tip. Scraping and peeling in conjunction with applied heat is effective on all resin coatings except silicone RTVs.

CAUTION: Excessive heat can cause damage to components and PCBs. Use only the minimum temperature which will assist in the removal of the component.

iii. Abrasion. Abrasive removal is effective on all resin coatings. The type of abrasive removal tool and method (motorized or manual) is dependent upon the thickness, hardness, surface contour, and transparency of the coating. Motorized abrasive cutting with dental burrs is effective on transparent, thick, and hard coatings of PR and UR. Abrasive discs are effective on all transparent, thin, hard coatings with flat surfaces. Dental brushes are effective on soft to semi-hard coatings with irregular surfaces. Manual abrasive dental tools, carvers, knives, and chisels, are effective on thin, soft to semi-hard coatings where the removal area is small.

CAUTION: Exercise extreme care when using abrasive methods. Abrasive tools have a high potential for causing damage.

(2) Conformal Coating Replacement. Preparation of the laminate PCB surface is the most important part of the conformal coating application process. Most adhesion failures are the result of improper cleaning and surface preparation.

(a) Cleaning. Prior to the replacement of the conformal coating, all repair actions residues (dirt, grime, soldering flux, etc.) should be removed. Clean the PCB laminate surface or component in accordance with the instructions in chapter 4, paragraph 405.

(b) Drying. Dry the PCB or component in accordance with the instructions in chapter 4, paragraph 406. Set temperature to 130°F (54°C) and dry the PCB or component for 1 hour.

(c) Stabilization. Allow the PCB or component to stabilize at room temperature, 77°F (25°C), for 1 hour. Coatings that are not recommended for accelerated curing above room temperature may be adversely affected by preheated laminates.

(d) Preservation. Cleaned and dried PCBs or components should be stored in a clean, static-free plastic bag if the PCB or component is not conformal coated within 30 minutes after reaching the stabilized room temperature. Seal the bag to prevent moisture from forming on the PCB or component.

(e) Pretreatment. Some conformal coatings require an additional treatment prior to coating application.

i. XY-coated assemblies require a pretreatment adhesion promoter to increase the bond strength of the replacement coating. Follow the coating manufacturer's adhesion promoter and application instructions. Ensure a 0.25 inch (6 cm) overlap of any existing coating.

ii. SR-coated assemblies require a pretreatment primer to increase the bond strength of the replacement coating. Follow the coating manufacturer's application instructions. Ensure a 0.25 inch (6 cm) overlap of any existing coating.

(f) Selection of a Replacement Coating. The selection of a replacement coating is based on the compatibility of the replacement coating with that of the original coating on the PCB or component. Refer to the OEM drawings or repair manual.

(g) Conformal Coating Mixing. Mix the replacement conformal coating per the coating manufacturer's instructions. Ensure the components are mixed in a clean container. Any air bubbles generated during the mixing must be removed. To remove the air bubbles, place the mixture in an anaerobic incubator (vacuum oven) at room temperature and 28 in/Hg for 30 minutes.

NOTE: Some two-part conformal coating resins require measurement by weight and not by volume.

CAUTION: Increasing or decreasing the mixture ratios of the conformal coating components will result in degradation of the coating properties.

(h) Application of Conformal Coating. The selection of a conformal coating will depend upon the area to be coated and any existing coating. The coating should be applied to a uniform thickness, with a 0.25 inch (6 cm) overlap of any existing coating, and no air bubbles.

i. Spraying. Spraying is one of the best methods when more than just a spot touch-up is required. Spraying is particularly useful when the surfaces are uneven or irregular, or there is a high density of components on the PCB.

ii. Brushing. Brushing is one of the best methods for minor patching of existing conformal coating. It is preferable to flow the coating over the area and then brush it out to attain a uniform thickness.

iii. Dipping. Dipping, like spraying, is one of the best methods when more than just a spot touch-up is required. Dipping is generally more suitable to production runs, where more than one PCB or component is involved. Dipping is particularly useful when the surfaces are uneven or irregular, or there is a high density of components on the PCB. Ensure proper coating thickness and avoid puddling of the coating by rotating the PCB or component in all axes during curing of the coating.

(i) Coating Thickness. All conformal coatings, with the exception of silicone RTVs, should have the coating thickness applied to 0.003 inch or less, unless directed otherwise by the OEM directive. Applications greater than 0.003 inch will not allow the solvents in the curing coating to evaporate or outgas, thereby trapping the solvents within the curing coating. These trapped solvents can cause bubbles and pinholes in the coating. Refer to the OEM or maintenance directives for the proper coating thickness. Silicone RTVs may be applied in a thickness up to 0.008 inch. If multiple coats of any of the coatings are required by direction, ensure sufficient time for the solvent to outgas.

(j) Conformal Coating Curing. Although the shortest cure time is desirable to speed the production process, the curing time is generally determined by the chemical characteristics of the coating. The curing temperature is limited by the PCB and its components. There are two main types of curing systems used: moisture reactive and solvent based. Conformal coating curing should always be accomplished in a dust-free environment. Elevated temperature curing should be accomplished in a forced-air drying oven at a temperature of not more than 130°F (54°C).

i. Moisture reactive curing systems use the relative humidity to form a gelatin of the compound and subsequent cure. These types of coating systems usually can be cured at room temperature, 77°F (25°C), but the curing process requires 24 hours.

ii. Solvent based curing systems rely on elevated temperature to accelerate the chemical reaction. The chemical reaction among the ingredients produces a stable one-part solvent that is oxidized by the elevated temperature to cure the coating in as little as 30 minutes.

(k) Coating Inspection and Preservation. The final step in the process of conformal coating replacement is a thorough inspection using an ultraviolet light and a l0X to l5X magnifying lens. Visually inspect the new and original coating for defects such as charring, discoloration, cracking, delaminations, solder flux residue, dry spots, foreign matter, air bubbles, and pinholes. If the inspection is satisfactory, the PCB or component should be placed in a polyethylene bag and taped closed.

506. thru 600. RESERVED.