CORROSION - DESCRIPTION AND OPERATION

1. General

A. Corrosion is a natural phenomenon which destroys metal by chemical or electrochemical action and converts it to a metallic compound such as an oxide, hydroxide, or sulfate. All metals used in airplane construction are subject to corrosion. Attack may take place over an entire metal surface or it may be penetrating in nature, forming deep pits. It may follow grain boundaries or it may penetrate a surface at random. Corrosion may be accentuated by stress from external loads or from lack of homogeneity in the metallic structure or from improper heat treatment. It is promoted by contact between dissimilar metals or with materials which absorb moisture, such as rubber, felt, dirt, salt, etc..

B. Corrosion can take many different forms, and the corrosion resistance of materials used in the airplane can drastically change with only small environmental changes. Corrosion is often thought of as a slow process; however, some forms of corrosion can occur very quickly, in days or even hours. Airplanes exposed to salt air, heavy atmospheric industrial pollution, warm humid environments and/or over water operations will require more stringent corrosion prevention and control programs than airplanes operated in dry environments.

C. Maintenance of the airplane primary coatings as specified in Chapter 20, Standard Practices - Airframe, combined with a constant cycle of cleaning, inspection, preservation and lubrication appropriate to the operational environment, must be incorporated by the operator to prevent corrosion. The basics of a corrosion prevention and control program consists of the following:

(1) Personnel trained in the conditions, detection, identification, cleaning, treatment, and preservation for corrosion.

(2) Adequate inspection intervals for detecting corrosion appropriate to the environment.

(3) Airplane washing with clean water on regularly scheduled intervals.

(4) Keeping drain holes and passages clear and open.

(5) Prompt maintenance and repair of the primary coatings as specified in Chapter 20, Standard Practices - Airframe.

(6) Prompt corrosion treatment after detection.

(7) Inspection and replication of corrosion inhibitive compounds on a scheduled basis.

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

NOTE: For additional general information on corrosion, treatment, repair, damage limits, and corrosion control, refer to FAA Advisory Circular No. 43-4A. For specific information, refer to the 208 Series Structural Repair Manual.

2. Types of Corrosion

A. Electrochemical Corrosion

(1) Refer to Figure 1 for an illustration of electrochemical corrosion. The following conditions must exist for electrochemical corrosion to occur.

(a) There must be a metal that corrodes and acts as the anode.

(b) There must be a less corrodible metal that acts as the cathode.

(c) There must be a continuous liquid path between the two metals which acts as the electrolyte, usually condensation and salt or other contaminations.

(d) There must be a conductor to carry the flow of electrons from the cathode to the anode. This conductor is usually in the form of a metal-to-metal contact (rivets, bolts, welds, etc.).

(2) The elimination of any one of the four conditions described above will stop the corrosion reaction process.

(3) One of the best ways to eliminate one of the four described conditions is to apply an organic film (such as paint, grease, plastic, etc.) to the surface of the metal affected. This will prevent the electrolyte from connecting the cathode to the anode, and current cannot flow, therefore, preventing corrosion reaction.

(4) At normal atmospheric temperatures, metals do not corrode appreciably without moisture, but the moisture in the air is usually enough to start corrosive action.

(5) The initial rate of corrosion is usually much greater than the rate after a short period of time. This slowing down occurs because of the oxide film that forms on the metals surface. This film tends to protect the metal underneath.

(6) When components and systems constructed of many different types of metals must perform under various climatic conditions, corrosion becomes a complex problem. Salt on metal surfaces (from sea coast operation) greatly increases the electrical conductivity of any moisture present and accelerates corrosion.

(7) Other environmental conditions which contribute to corrosion are:

(a) Moisture collecting on dirt particles.

(b) Moisture collecting in crevices between lap joints, around rivets, bolts and screws.

B. Direct Surface Attack - The most common type of general surface corrosion results from direct reaction of a metal surface with oxygen in the atmosphere. Unless properly protected, steel will rust and aluminum and magnesium will form oxides. The attack may be accelerated by salt spray or salt bearing air, industrial pollutants or engine exhaust.

C. Pitting - While pitting can occur in any metal, it is particularly characteristic of passive materials, such as the alloys of aluminum, nickel and chromium. It is first noticeable as a white or gray powdery deposit similar to dust, which blotches the surface. When the deposits are cleaned away, tiny pits can be seen in the surface.

D. Dissimilar Metal Corrosion - When two dissimilar metals are in contact and are connected by an electrolyte (continuous liquid or gas path), accelerated corrosion of one of the metals occurs. The most easily oxidized surface becomes the anode and corrodes. The less active member of the couple becomes the cathode of the galvanic cell. The degree of attack depends on the relative activity of the two surfaces; the greater the difference in activity, the more severe the corrosion. Relative activity in descending order is as follows:

(1) Magnesium and its alloys.

(2) Aluminum alloys 1100, 3003, 5052, 6061, 220, 355, 356, cadmium and zinc.

(3) Aluminum alloys 2014, 2017, 2024, 7075 and 195.

(4) Iron, lead and their alloys (except stainless steel).

(5) Stainless steels, titanium, chromium, nickel, copper, and their alloys.

(6) Graphite (including dry film lubricants containing graphite).

E. Intergranular Corrosion - Selective attack along the grain boundaries in metal alloys is referred to as intergranular corrosion. It results from lack of uniformity in the alloy structure. It is particularly characteristic of precipitation-hardened alloys of aluminum and some stainless steels. Aluminum extrusions and forgings in general can contain nonuniform areas which, in turn can result in galvanic attack along the grain boundaries. When the attack is well advanced, the metal can blister or delaminate and cause exfoliation.

F. Stress Corrosion - This results from the combined effect of static tensile stresses applied to a surface over a period of time. In general, cracking susceptibility increases with stress, particularly at stresses approaching the yield point; and with increasing temperature, exposure time and concentration of corrosive ingredients in the surrounding environment. Examples of parts which are susceptible to stress corrosion cracking are aluminum alloy bellcranks employing pressed-in taper pins, landing gear shock struts with pipe thread type grease fittings, clevis joints and shrink fits.

G. Corrosion Fatigue - This is a type of stress corrosion resulting from the cyclic stresses on a metal in corrosive surroundings. Corrosion may start at the bottom of a shallow pit in the stressed area. Once attack begins, the continuous flexing prevents repair of protective surface coating or oxide films and additional corrosion takes place in the area of stress.

3. Typical Corrosion Areas

A. This section lists typical areas of the airplane which are susceptible to corrosion. These areas should be carefully inspected at periodic intervals to detect corrosion as early as possible.

(1) Engine Exhaust Trail Areas.

(a) Gaps, seams and fairings on the lower right side of the fuselage, aft of the engine secondary exhaust stack, are typical areas where deposits may be trapped and not reached by normal cleaning methods.

(b) Around rivet heads, skin laps and inspection covers on the airplane lower fuselage, aft of the engine secondary exhaust stack, should be carefully cleaned and inspected.

(2) Battery Box and Battery Vent Opening.

(a) The battery, battery cover, battery box and adjacent areas, especially areas below the battery box where battery electrolyte may have seeped, are particularly subject to corrosive action. If spilled battery electrolyte is neutralized and cleaned up at the same time of spillage, corrosion can be held to a minimum by using a weak boric acid solution to neutralize the battery electrolyte (ni-cad battery) or baking soda solution to neutralize the lead acid type battery electrolyte. If boric acid or baking soda is not available, flood the area with water.

(3) Steel Control Cables (Including Stainless Steel).

(a) Checking for corrosion on control cables is normally accomplished during the preventative maintenance check. During preventative maintenance, broken wire and wear of the control cable is also checked.

(b) If the surface of the cable is corroded, carefully force the cable open by reverse twisting and visually inspect the interior. Corrosion on the interior strands of the cable constitutes failure and the cable must be replaced. If no internal corrosion is detected, remove loose external rust and corrosion with a clean, dry, coarse-weave rag or fiber brush.

NOTE: Do not use metallic wools or solvents to clean installed cables. Use of metallic wool will embed dissimilar metal particles in the cables and create further corrosion. Solvents will remove internal cable lubricant, allowing cable strands to abrade and further corrode.

(c) After thorough cleaning of the exterior cable surface, apply a light coat of lubricant (VV-L-800) to the external cable surface.

(4) Piano-Type Hinges.

(a) The construction of piano-type hinges forms moisture traps as well as dissimilar metal corrosion between the steel hinge pin and the aluminum hinge. Solid film lubricants are often applied to reduce corrosion problems.

(b) Care and replacement of solid film lubricants require special techniques peculiar to the specific solid film being used. Good solid film lubricants conform to Specification MIL-L-23398D.

1 Solid film lubricants prevent galvanic coupling on close tolerance fittings and reduce fretting corrosion. Surface preparation is extremely important to the service/wear life of solid film lubricants.

2 Solid film lubricants are usually applied over surfaces precoated with other films such as anodize and phosphate. They have been successfully applied over organic coatings such as epoxy primers.

CAUTION: Solid film lubricants that contain graphite, either alone or in mixture with any other lubricants, may not be used since graphite is cathodic to most metals and will cause dissimilar corrosion in the presence of electrolytes.

(5) Steel Components.

(a) The red oxide (rust) will not protect the underlying base metal unlike some other metal oxides. The presence of rust actually promotes additional attack by attracting moisture from the air and acting as a catalyst in causing additional corrosion to take place. Light red rust on bolt heads, hold-down nuts, and other nonstructural hardware is generally not dangerous. However, it is indicative of a general lack of maintenance and possible attack in more critical areas, such as highly stressed landing gear components and flight surface actuating components. When paint failures occur or mechanical damage exposes highly stressed steel surfaces to the atmosphere, even small amounts of rusting are potentially dangerous and must be removed.

NOTE: If rust is detected on non highly stressed steel surfaces, refer to Chapter 20Interior and Exterior Finish - Cleaning/Painting, and Chapters 51, Damage Investigation and Classification and Corrosion of the 208 Series Structural Repair Manual for removal and treatment procedures.

NOTE: The main landing gear legs, center tube, and nose gear drag link spring are highly stressed components with shot peened surfaces. Refer to Chapter 32, Main Landing Gear - Cleaning and Painting, for instructions on rust removal and treatment of these components.

(6) Internal Fuel Tanks.

(a) The internal fuel tanks have the same primary coatings as the other aluminum skins used on the airplane. If fuel contamination is detected or suspected, the internal fuel bays should be inspected for damage to the primary coatings. Repair the coatings in accordance with Chapter 28, Fuel Tanks - Maintenance Practices.

4. Corrosion Detection

A. The primary means of corrosion detection is visual, but in situations where visual inspection is not feasible, other techniques must be used. The use of liquid dye penetrant, magnetic particle, X-ray and ultrasonic devices can be used, but most of these sophisticated techniques are intended for the detection of physical flaws within metal objects rather than the detection of corrosion.

(1) Visual Inspection. A visual check of the metal surface can reveal the signs of corrosive attack, the most obvious of which is a corrosive deposit. Corrosion deposits of aluminum or magnesium are generally a white or grayish white powder, while the color of ferrous compounds varies from red to dark reddish brown.

(a) The indications of corrosive attack are small, localized discolorations of the metal surface. Surfaces protected by paint or plating may only exhibit indications of more advanced corrosive attack by the presence of blisters or bulges in the protective film. Bulges in lap joints are indications of corrosive buildup which is well advanced.

(b) In many cases the inspection area is obscured by structural members, equipment installations or, for other reasons, are and is awkward to check visually. In such cases, mirrors, borescope or similar devices can be used to inspect the obscured areas. Any means which allows a thorough inspection can be used. Magnifying glasses are valuable aids for determining whether or not all corrosion products have been removed during cleanup operations.

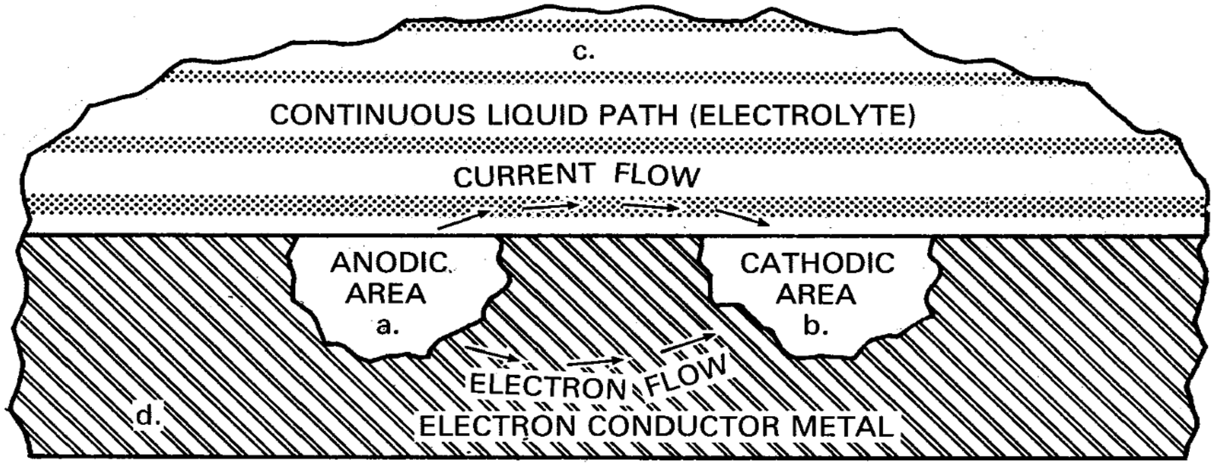
(2) Liquid Dye Penetrant Inspection. Inspection for large stress-corrosion or corrosion fatigue cracks on nonporous or nonferrous metals may be accomplished using dye penetrant processes. The dye applied to a clean metallic surface will enter small openings or cracks by capillary action. After the dye has an opportunity to be absorbed by any surface discontinuity, the excess dye is removed and a developer is applied to the surface. The developer acts like a blotter and draws the dye from cracks or fissures back to the surface, giving visible indication of any fault that is present on the surface. The magnitude of the fault is indicated by the quantity of dye brought back to the surface by the developer.

5. Corrosion Repair

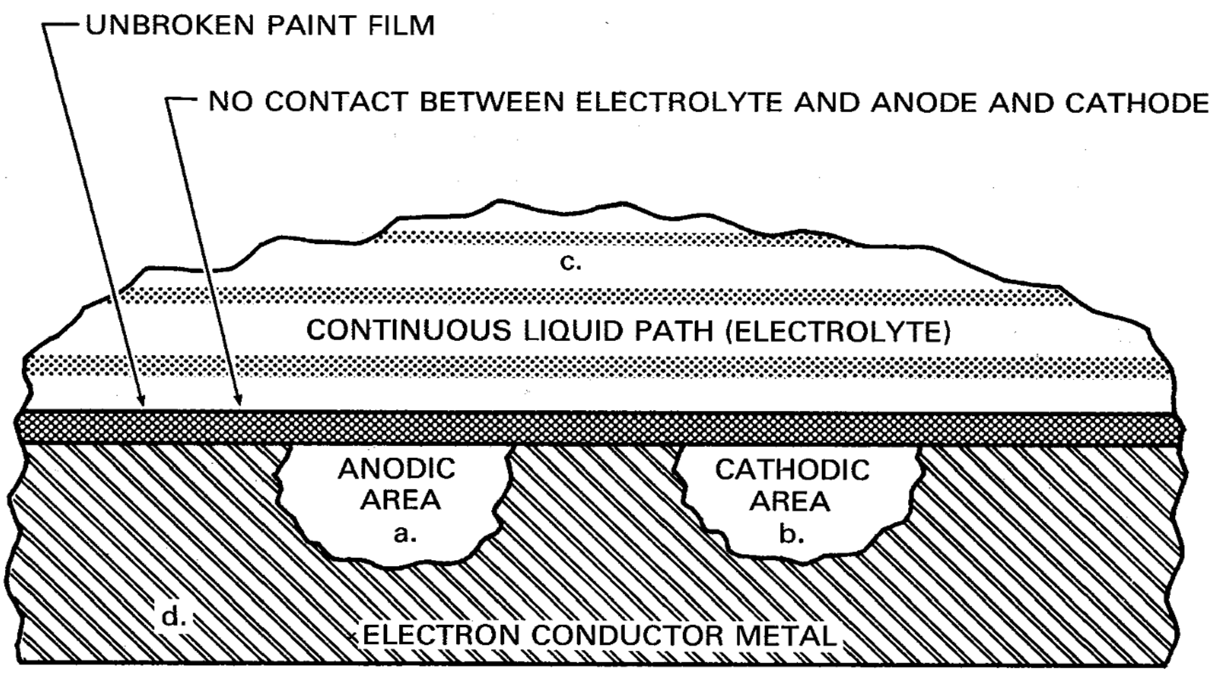
NOTE: When corrosion is detected, refer to the 208 Series Structural Repair Manual for damage limits, repair, treatment, and preservation information.

Figure 1 : Sheet 1 : Corrosion Identification

A22264



SIMPLIFIED CORROSION CELL



CORROSION ELIMINATION BY APPLICATION OF ORGANIC FILM

26821017