CHAPTER 3. EFFECTS OF CORROSION

300. GENERAL. Most metals are subject to corrosion, but corrosion can be minimized by use of corrosion resistant metals and finishes. The principal material used in airframe structures is high-strength aluminum alloy sheet coated (clad) with a pure aluminum coating (alclad) which is highly resistant to corrosive attack. However, with an accumulation of airborne salts and/or industrial pollutants, along with an electrolyte (moisture), pitting of the alclad will occur. Once the alclad surface is broken, rapid deterioration of the high strength aluminum alloy below occurs. Other metals commonly used in airframe structure, such as nonclad high-strength aluminum alloys, steel, and magnesium alloys, require special preventive measures to guard against corrosion.

a. Aluminum alloys, for example, are usually anodized (a chemical coating), or in some later generation aircraft an aluminum applied plating (ion vapor disposition (IVD)), then primed and possibly topcoated with paint.

b. Steel (except most stainless steels) and other metals, such as brass and bronze, require cadmium plating, zinc plating, IVD aluminum coating and/or conversion coating.

c. Magnesium alloys are highly susceptible to corrosion attack, especially where airborne salts and/or industrial pollutants are present, and require special chemical and electrochemical treatments and paint finishes.

301. EFFECTS OF CORROSION ON METALS. The characteristics of corrosion in commonly used aircraft metals (summarized in Table 3-1) are:

a. Magnesium. Magnesium is the most chemically active metal used in airplane construction and is highly susceptible to and difficult to protect from corrosion. Therefore, when a failure in the protective coating does occur, the prompt and complete correction of the coating failure is imperative if serious structural damage is to be avoided. Corrosion of magnesium is possibly the easiest type of corrosion to detect, since even in its early stages the corrosion products occupy several times the volume of the original magnesium metal. The beginning attack shows as a lifting of the paint film and as white spots on the surface, which rapidly develop into snow-like mounds or whiskers. Correction of damage involves the complete removal of corrosion and application of a chemical conversion coat and protective finish. Magnesium always requires protective coatings. Some magnesium parts in current aircraft have been originally protected by proprietary electrolytic processes, such as HAE and DOW 17 coatings. The HAE process can be identified by the brown to mottled gray appearance of the unpainted surface. DOW 17 coatings have a green to grayish-green color. Coatings of the electrolytic type are thicker than those applied by immersion or brushing. Electrolytic finishes cannot be restored in the field. When failure occurs, corrosion products should be removed, the bare magnesium should be touched up with chemical treatment solution, and the part repainted. Care should be taken to minimize removal of, and ensure repair of, these coatings.

b. Steel. Corrosion of steel is easily recognized because the corrosion product is red rust. When iron-base alloys corrode, dark corrosion products usually form first on the surface of the metal. These products are protective. However, if moisture is present, this ferrous oxide coating is converted to hydrated ferric oxide, which is red rust. This material will promote further attack by absorbing moisture from the air. The most practical means of controlling corrosion of steel is complete removal of corrosion products by mechanical means and by maintaining the protective coating system (usually a plating, often combined with a paint system).

c. Aluminum. Aluminum and its alloys exhibit a wide range of corrosive attack including: uniform surface, galvanic, pitting, intergranular, exfoliation, crevice, stress, and fretting corrosion (see Chapter 2, paragraphs 204. and 205.). Both bare and clad aluminum alloys resist corrosion in nonmarine areas. Where airborne salts and/or industrial pollutants are present, all aluminum alloys require protection. The corrosion product of aluminum is a white-to-gray powdery material which can be removed by mechanical polishing or brushing with materials softer than the metal. General surface attack of aluminum penetrates slowly but is accentuated in the presence of dissolved salts in an electrolyte. Considerable attack can usually take place before serious loss of structural strength develops. However, at least three forms of attack on aluminum alloys are particularly serious:

(1) Penetrating pit-type corrosion through walls of aluminum tubing.

(2) Stress-corrosion cracking of materials under sustained stress and corrosive environment.

(3) Intergranular attack characteristic of certain alloys where clearly defined grain boundaries differ chemically from the metal within the grain.

d. Anodized Aluminum. Some aluminum parts are protected with an anodized coating. Aluminum oxide film on aluminum is naturally protective, and anodizing merely increases the thickness of the oxide film. When this coating is damaged in service, it can be only partially restored by chemical surface treatment. Therefore, when performing any processing of anodized surfaces, unnecessary destruction of the anodized surface should be avoided.

e. Titanium. Although titanium is strongly corrosion resistant, electrical insulation between titanium and other metals is necessary to prevent galvanic corrosion of the other metal. Frequent inspection of such areas is required to ensure that insulation failure has not allowed corrosion to begin. Under certain conditions, chlorides and some chlorinated solvents may induce stress-corrosion cracking of certain titanium alloys.

f. Cadmium and Zinc. Cadmium is used as a coating to protect steel parts and to provide a compatible surface when a part is in contact with other materials. Attack on cadmium is evidenced by white-to-brown-to-black mottling of the surface. Zinc forms voluminous white corrosion products. When cadmium and zinc plate show mottling and isolated voids or cracks in the coating, the plating is still performing its protective function. The cadmium plate on iron or steel is still protecting until such time as actual iron rust appears.

NOTE: Any mechanical removal of corrosion products should be limited to metal surfaces from which the cadmium has been depleted.

g. Stainless Steels. Stainless steels are iron-base alloys containing 12 percent or more of chromium (as well as other elements). They consist of two types, magnetic and nonmagnetic. The magnetic steels are identified by numbers in the American Iron and Steel Institute (AISI) 400-series, such as 410, 430, etc. These steels are not as corrosion resistant as the nonmagnetic, which are identified by numbers in the AISI 300-series, such as 304, 316, etc. The AISI 300-series steels have nickel contents ranging from 6 to 22 percent, while the 400-series steels have nickel contents of only 2 percent. The corrosion resistance of these steels is due to their ability to form a protective oxide film on the surface. This "passive" film can be reinforced by treatment in certain chemical solutions. However, such steels will pit when exposed to harsh corrosive environments such as airborne salts and industrial pollutants. Particularly susceptible are crevices and other areas in which foreign materials collect. Corrosion can be prevented by keeping stainless steel clean.

h. Nickel and Chromium. Nickel and chromium are used as protective coatings and as alloying elements with iron in stainless steels. Chromium plating is also used to provide a smooth, wear resistant surface and to reclaim worn parts. Where corrosion resistance in a marine environment is required, nickel undercoat is used. The degree of protection is dependent upon plating thickness. Both of these metals form continuous oxide coatings that can be polished to a higher luster and still protect not only themselves but any underlying metal. Chromium coatings contain cracks, and corrosion originates at these separations.

i. Copper and Copper Alloys. Copper and its alloys are generally corrosion resistant. However, the effects of minor amounts of corrosion on copper electric components can appreciably degrade the performance of the components. The product of corrosion on copper is generally a bluish-green coating on the surface of the material. When coupled with most metals used in aircraft construction, copper is the less active metal and greatly accelerates corrosion of the other metals.

j. Silver, Platinum, and Gold. These metals do not corrode in the ordinary sense, although silver tarnishes in the presence of sulfur. The tarnish is a brown-to-black film. Gold tarnish is very thin and shows up as a darkening of reflecting surfaces.

(1) When silver is plated over copper there can be an accelerated corrosion of the copper, through galvanic action, at pinholes or breaks in the silver plating. This corrosion is known as "red plague" and is identifiable by the presence of a brown-red powder deposit on the exposed copper.

(2) "Purple plague" is a brittle gold-aluminum compound formed when bonding gold to aluminum. The growth of such a compound can cause failure in microelectronic interconnection bonds.

k. Tin. Tin is common on R-F shields, filters, crystal covers, and automatic switching devices. Tin has the best combination of solderability and corrosion resistance of any metallic coating. The problem with tin is its tendency to grow "whiskers" on tin-plated wire and other plating applications.

TABLE 3-1. CORROSION OF METALS

ALLOY	TYPE OF ATTACK TO WHICH ALLOY IS SUSCEPTIBLE	APPEARANCE OF CORROSION PRODUCT
Magnesium	Highly susceptible to pitting	White, powdery, snowlike mounds and white spots on surface
Low Alloy Steel (4000-8000 series)	Surface oxidation and pitting, surface, and intergranular	Reddish-brown oxide (rust)
Aluminum	Surface pitting, intergranular, exfoliation stress-corrosion and fatigue cracking, and fretting	White-to-grey powder
Titanium	Highly corrosion resistant; extended or repeated contact with chlorinated solvents may result in degradation of the metal's structural properties at high temperature	No visible corrosion products at low temperature. Colored surface oxides develop above 700 °F (370 °C)
Cadmium	Uniform surface corrosion; used as sacrificial plating to protect steel	From white powdery deposit to brown or black mottling of the surface
Stainless Steels (300-400 series)	Crevice corrosion; some pitting in marine environments; corrosion cracking; intergranular corrosion (300 series); surface corrosion (400 series)	Rough surface; sometimes a uniform red, brown, stain

Table 3-1. CORROSION OF METALS (CONTINUED)

Nickel-base (Inconel, Monel)	Generally has good corrosion resistant qualities; susceptible to pitting in sea water	Green powdery deposit
Copper-base Brass, Bronze	Surface and intergranular corrosion	Blue or blue-green powdery deposit
Chromium (Plate)	Pitting (promotes rusting of steel where pits occur in plating)	No visible corrosion products; blistering of plating due to rusting and lifting
Silver	Will tarnish in the presence of sulfur	Brown-to-black film
Gold	Highly corrosion resistant	Deposits cause darkening of reflective surfaces
Tin	Subject to whisker growth	Whisker-like deposit

302.-399. RESERVED.

CHAPTER 4. CORROSION PRONE AREAS AND PREVENTATIVE MAINTENANCE

400. GENERAL. This chapter lists corrosion problem areas that are common to most aircraft. Corrosion prone areas should be cleaned, inspected, and treated more frequently than less corrosion prone areas. The list is not necessarily complete for any specific aircraft, but could be used to set up a maintenance inspection program. Also included in this chapter are factors in corrosion control and preventative maintenance.

401. EXHAUST TRAIL AREAS. Both jet and reciprocating engine exhaust gas deposits are very corrosive. Inspection and maintenance of exhaust trail areas should include attention to the areas indicated in Figure 4-1. Inspection should also include the removal of fairings and access plates located in the exhaust gas path.

a. Gaps, seams, hinges, and fairings are some of the exhaust trail areas where deposits may be trapped and not reached by normal cleaning methods.

b. Exhaust deposit buildup on the upper and lower wing, aft fuselage, and in the horizontal tail surfaces will be considerably slower and sometimes completely absent from certain aircraft models.

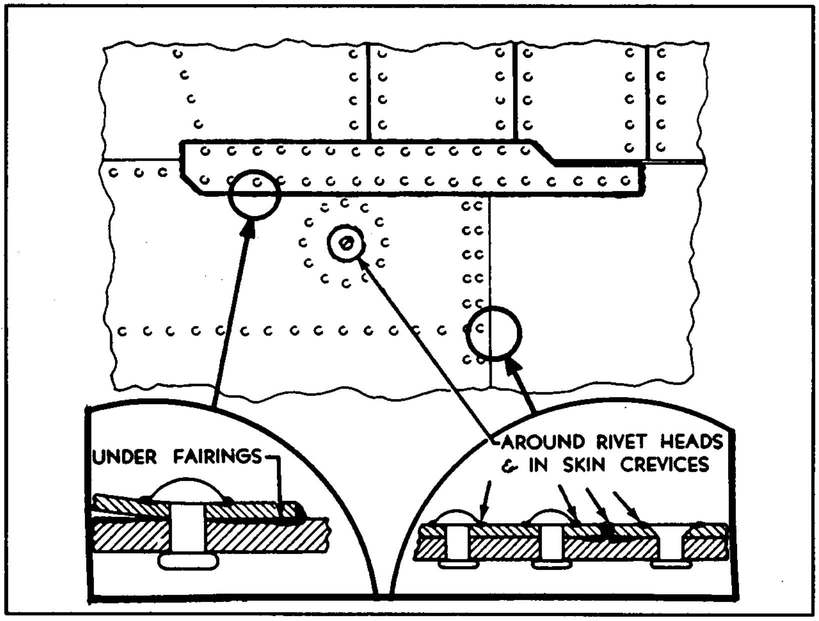

FIGURE 4-1. EXHAUST TRAIL AREA CORROSION CONTROL POINTS

402. BATTERY COMPARTMENTS AND BATTERY VENT OPENINGS. In spite of protective paint systems and extensive sealing and venting provisions, battery compartments continue to be corrosion problem areas. Fumes from overheated battery electrolyte are difficult to contain and will spread to internal structure. Unprotected surfaces will be subjected to corrosive attack. For lead-acid

batteries, frequent cleaning and neutralization of acid deposits with sodium bicarbonate solution will minimize corrosion. If the battery installation includes external vent openings on the aircraft skin, these areas should be included in the inspection and maintenance procedure. If aircraft batteries with electrolytes of either sulfuric acid or potassium hydroxide are in use, their leakage will cause corrosion. Consult the applicable maintenance manuals for the particular aircraft to determine which type battery was installed and the recommended maintenance practices for each. Cleaning of nickel cadmium compartments should be done with ammonia or boric acid solution, allowed to dry thoroughly, and then painted with an alkali-resistant varnish.

403. LAVATORIES, BUFFETS, AND GALLEYS. These areas, particularly deck areas behind lavatories, sinks, and ranges, where spilled food and waste products may collect if not kept clean, are potential trouble spots. Even if some contaminants are not corrosive in themselves, they will attract and retain moisture and, in turn, cause corrosive attack. Pay attention to bilge areas located under galleys and lavatories. Clean these areas frequently and maintain the protective sealant and paint finishes.

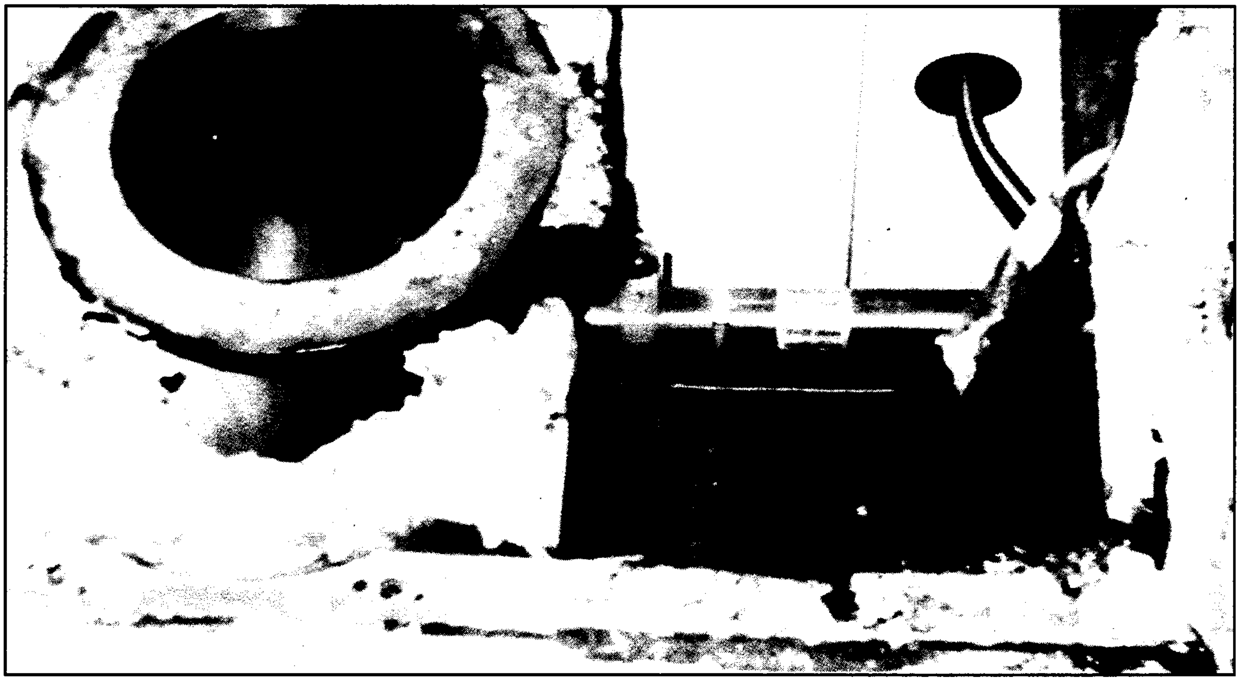

FIGURE 4-2. TYPICAL DAMAGE TO FLOOR AROUND LAVATORIES, BUFFETS, AND GALLEYS

404. BILGE AREAS. On all aircraft, the bilge area is a common trouble spot. The bilge is a natural sump or collection point for waste hydraulic fluids, water, dirt, loose fasteners, drill chips, and other odds and ends of debris. Residual oil quite often masks small quantities of water which settle to the bottom and set up a hidden potential corrosion cell. With the exception of water displacing corrosion preventative compounds, keeping bilge areas free of all extraneous material, including water and oil will insure the best protection against corrosion. A good vacuum cleaner and clean wiping cloths are necessary to clean such areas.

405. WHEEL WELLS AND LANDING GEAR. The wheel well area probably receives more punishment than any other area of the aircraft. It is exposed to mud, water, salt, gravel, and other flying debris from runways during flight operations (see Figure 4-3).

a. Frequent cleaning, lubrication, and paint touch-up are needed on aircraft wheels and on wheel well areas. Because of the many complicated shapes, assemblies, and fittings in the area, complete coverage with a protective paint film is difficult to attain. Thus, preservative coatings tend to mask trouble rather than prevent it. Because of the heat generated from braking, preservative coatings cannot be used on aircraft landing gear wheels.

b. During inspection of this area, particular attention should be given to the following trouble spots:

(1) High strength steel.

(2) Exposed surfaces of struts, oleos, arms, links, and attaching hardware (bolts, pins, etc.).

(3) Axle interiors.

(4) Exposed position indicator switches and other electrical equipment.

(5) Crevices between stiffeners, ribs, and lower skin surfaces which are typical water and debris traps.

(6) Magnesium wheels, particularly around bolt heads, lugs, and wheel web areas.

(7) Exposed rigid tubing, especially at "B" nuts and ferrules under clamps and tubing identification tapes.

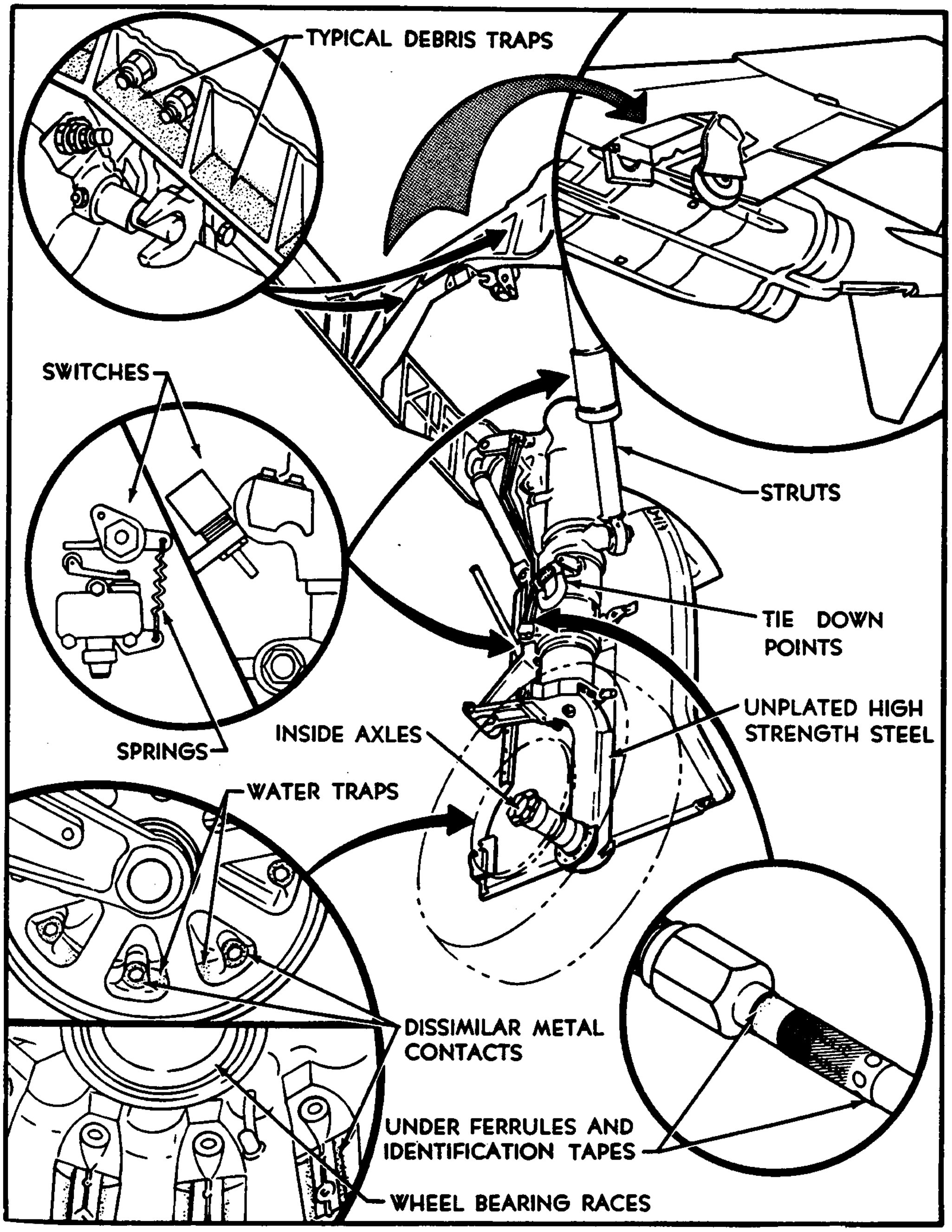

FIGURE 4-3. LANDING GEAR AND WHEEL CORROSION POINTS

406. EXTERNAL SKIN AREAS. External aircraft surfaces are ordinarily covered with protective finishes. In addition, paint coatings may be applied. The affected external aircraft surfaces are readily visible or available for inspection and maintenance. Much emphasis has been given to these areas in the past, and maintenance procedures are well established. Even here, certain types of configurations or combinations of materials become troublesome and require special attention if serious corrosion difficulties are to be avoided. Some of the common trouble areas, other than those attributed to engine exhaust deposits, are grouped as follows:

a. Steel, Titanium, CRES, and Nickel Alloy Fasteners. Fasteners and areas around these fasteners are trouble spots. These areas are subject to high operational loads, moisture intrusion, and dissimilar metal skin corrosion (see Figure 4-4).

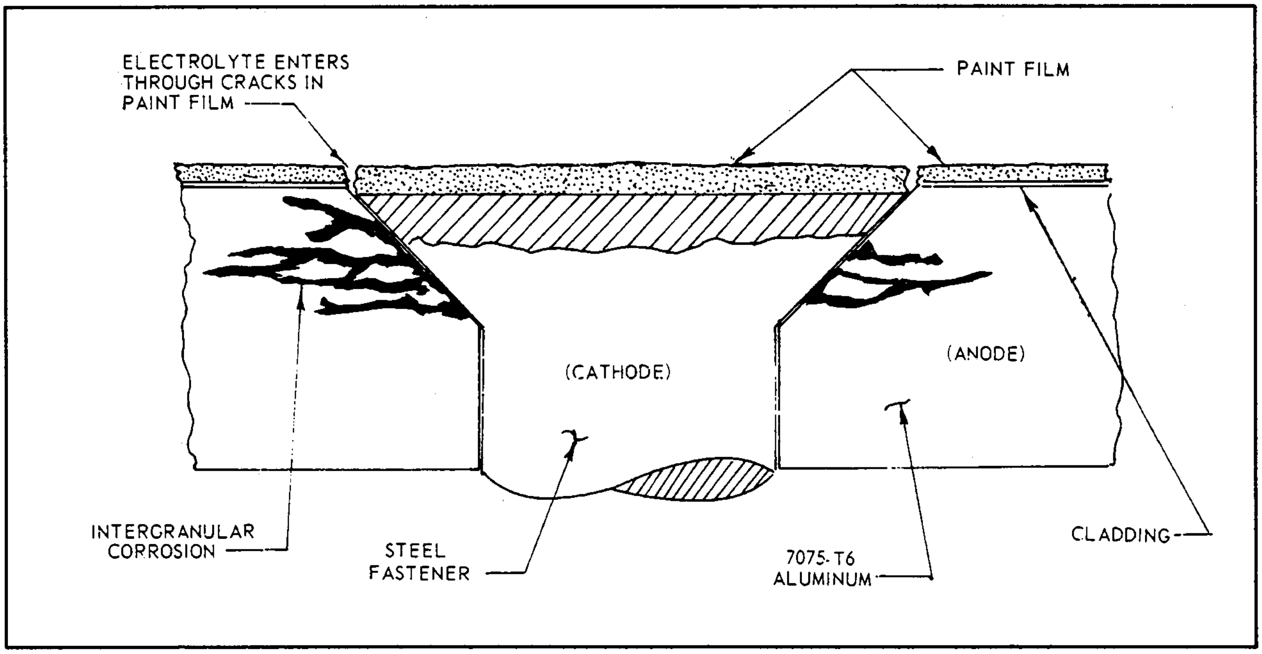

FIGURE 4-4. INTERGRANULAR CORROSION OF 7075-T6 ALUMINUM ADJACENT TO STEEL FASTENER

b. Faying Surfaces and Crevices. Similar to corrosion around fasteners, corrosion in faying surfaces, seams, and joints is caused by the intrusion of moisture and other corrosive agents. The effect of this type of corrosion is usually detectable by bulging of the skin surface.

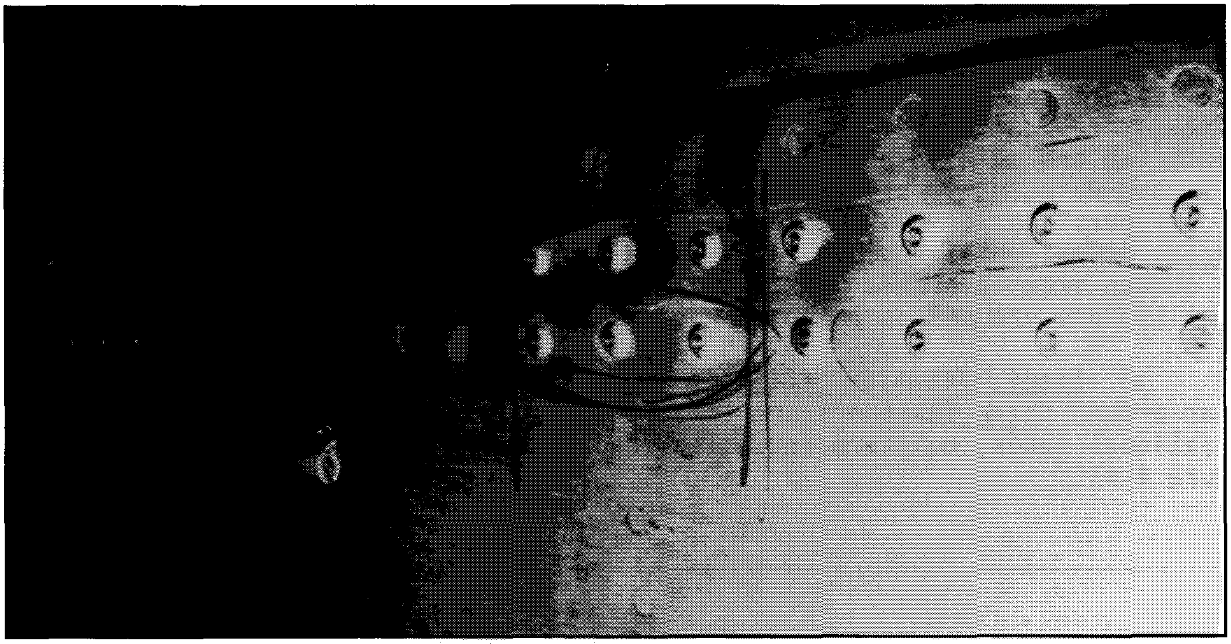

FIGURE 4-5. CRACK AND SKIN BULGING CAUSED BY CORROSION

c. Magnesium Skins. Properly surface treated, insulated, and painted magnesium skin surfaces give relatively little trouble from a corrosion standpoint if the original surface is maintained. However, trimming, drilling, and riveting destroy some of the original surface treatment which may not be completely restored by touch-up procedures.

(1) Some aircraft have steel fasteners installed through magnesium skin with only protective finishes under the fastener heads, and fillet sealant or tape over the surface for insulation. Further, all paint coatings are inherently thin at abrupt changes in contour, such as at trimmed edges. With magnesium's sensitivity to moisture, all of these conditions add up to a potential corrosion problem whenever magnesium is used.

(2) Any inspection for corrosion should include all magnesium skin surfaces, as well as other magnesium fittings or structural components, with special attention to edges, areas around skin edges and fasteners, and cracked, chipped, or missing paint.

d. Spotwelded Skins. Corrosion of this type construction is chiefly the result of the entrance and entrapment of moisture or other corrosive agents between layers of the metal (see Figure 4-6).

(1) Spotwelded assemblies are particularly corrosion prone. Corrosive attack causes skin buckling or spotweld bulging, and eventually spotweld fracture. Some of the corrosion may be caused originally by fabricating processes, but its progress to the point of skin bulging and spotweld fracture is the direct result of moisture or other corrosive agents

working its way through open gaps or seams. The use of weld-through sealing materials is expected to minimize this problem, but many in-service aircraft still have unsealed spotweld skin installed. This type of corrosion is evidenced by corrosion products appearing at the crevices through which the corrosive agents enter.

(2) Corrosion may appear at either external or internal faying surfaces, but it is usually more prevalent on external areas. More advanced corrosive attack causes skin buckling and eventual spotweld fracture. Skin buckling in this early stage may be detected by sighting or feeling along spotwelded seams or by using a straight edge.

(3) To prevent this condition, keep potential moisture entry points including gaps, seams, and holes created by broken welds filled with noncorrosive sealant.

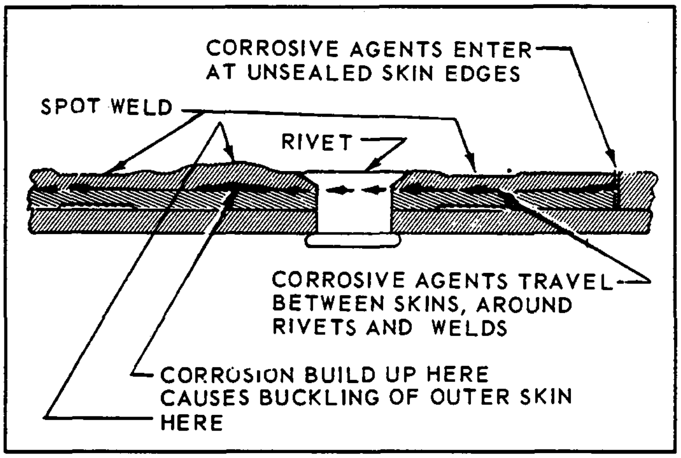

FIGURE 4-6. SPOTWELDED SKIN CORROSION

e. Piano-type Hinges. These are prime spots for corrosion due to dissimilar metal contact between the steel pin and aluminum hinge tangs. They are also natural traps for dirt, salt, and moisture. Where this type of hinge is used on access doors or plates, and actuated only when opened during an inspection, they tend to corrode and freeze in the closed position between inspections. When the hinge is inspected, it should be lubricated and actuated through several cycles to ensure complete penetration of the lubricant (see Figures 4-7 and 4-8).

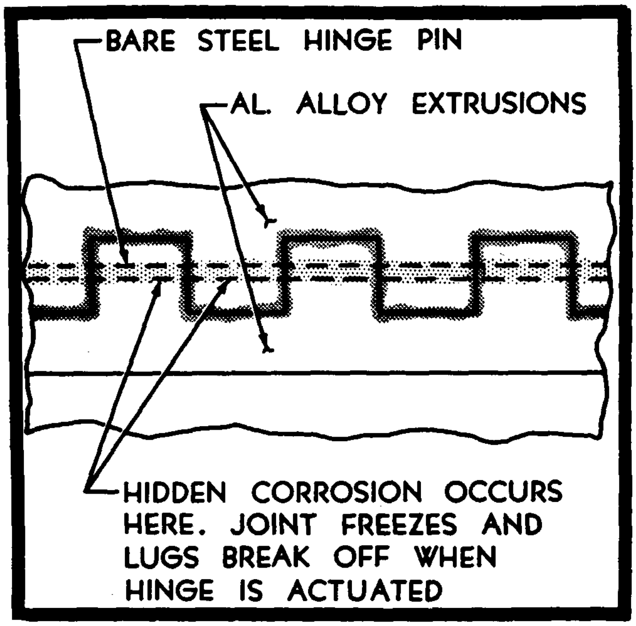

FIGURE 4-7. HINGE CORROSION POINTS

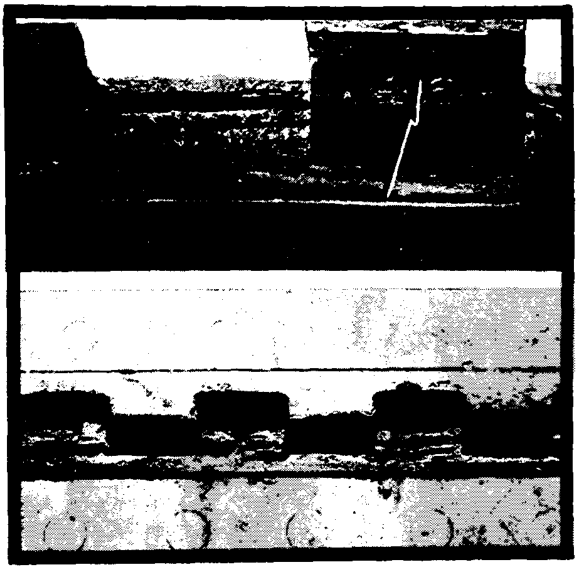

FIGURE 4-8. HINGE FAILURE CAUSED BY CORROSION

f. <u>Heavy or Tapered Aluminum Alloy Skin Surfaces</u>. Heavy or thick sections of most heat-treated aluminum alloys are susceptible to pitting or intergranular corrosion and exfoliation of the metal. When inspecting external skin surfaces, especially around countersunk fastener heads, look for white or grey powder deposits or metal exfoliation. This is usually first evident as small raised areas or bumps under paint film.

(1) Treatment of this corrosive attack includes removal of all corrosion products, i.e., exfoliated metal is blended and polished not to exceed the limits set by the aircraft manufacturer. If corrosion products remain after the limits set by the aircraft manufacture have been reached, contact the aircraft manufacturer or the Federal Aviation Administration (FAA) for authorized limits. The treatment is not complete until the restoration of protective surface finishes is accomplished.

(2) Protect reworked areas with a chemical conversion coating, sealant primer, and top coat if applicable. Reworked areas should be carefully watched for any indications of renewed corrosive activity.

g. <u>Organic Composites.</u> Organic composites used in aircraft can cause different corrosion problems than those normally associated with all metal structure. Composites such as graphite/epoxy act as a very noble (cathodic) material, creating the potential for galvanic corrosion. The galvanic corrosion potential coupled with different methods of attachment (i.e., adhesive bonding, stepped structures, locking mechanical fasteners, etc.) lead to multicomponent galvanic couples with the problem being particularly aggravated by high humidity and salt water environments. Application of aircraft sealants over the dissimilar metal/composite junctions will prevent galvanic corrosion if moisture is completely excluded. However, since complete exclusion of moisture is virtually impossible under extended periods of flight operation, the most effective method of eliminating the voltage potential is to provide a nonconductive layer such as fiberglass/epoxy and/or sealant between the composite and dissimilar metal surfaces.

407. WATER ENTRAPMENT AREAS. Corrosion will result from the entrapment of moisture. With the exception of sandwich structures, design specifications usually require that the aircraft have low point drains installed in all areas where moisture and other fluids can collect. In many cases, these drains are ineffective either due to location or because they are plugged by sealants, extraneous fasteners, dirt, grease, and debris. Potential entrapment areas are not a problem when properly located drains are functioning, and the aircraft is maintained in a normal ground attitude. However, the plugging of a single drain hole or the altering of the level of the aircraft can result in a corrosion problem if water becomes entrapped in one of these "bathtub" areas. Daily inspection of low point drains is a recommended practice.

408. ENGINE FRONTAL AREAS AND COOLING AIR VENTS. Constant abrasion by airborne dirt and dust, bits of gravel from runways, and rain tends to remove the protective surfaces from these areas. Furthermore, cores of radiator coolers, reciprocating engine cylinder fins, etc., due to the requirement for heat dissipation, may not be painted. Engine accessory mounting bases usually have small areas of unpainted magnesium or aluminum on the machined mounting surfaces. With moist and salt or industrial pollutant-laden air constantly flowing over these surfaces, they are prime sources of corrosive attack. Inspection of such areas should include all sections in the cooling air path with special attention to obstructions and crevices where salt deposits may build up during marine operations (see Figures 4-9 and 4-10).

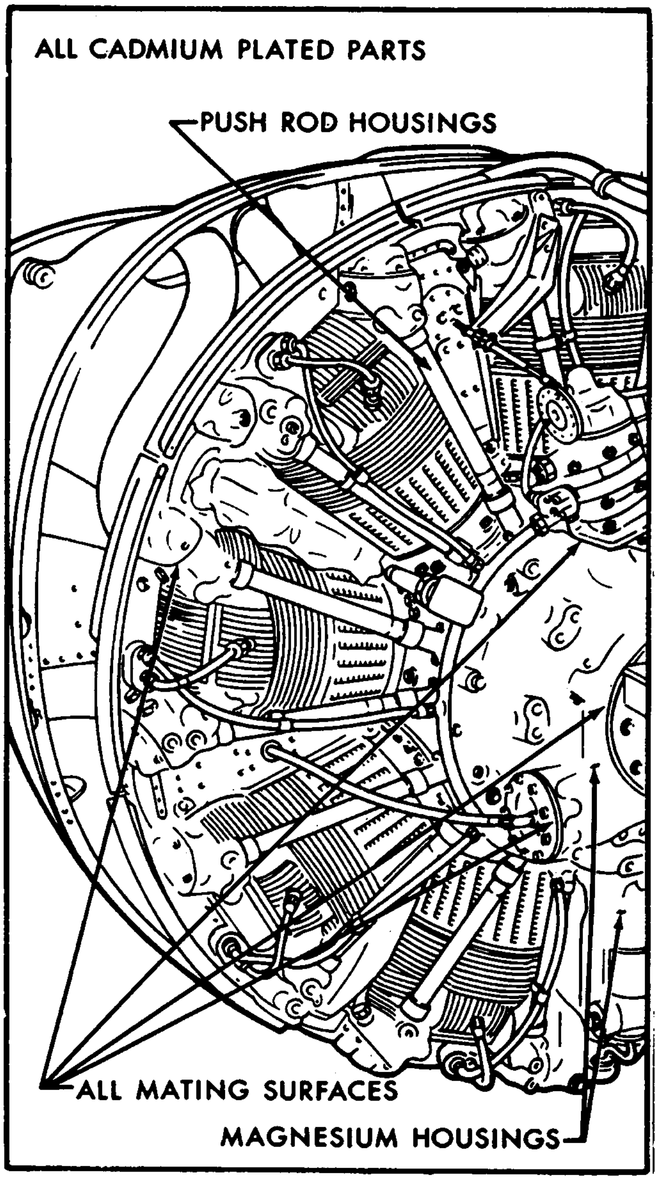

FIGURE 4-9. RECIPROCATING ENGINE FRONTAL AREA CORROSION

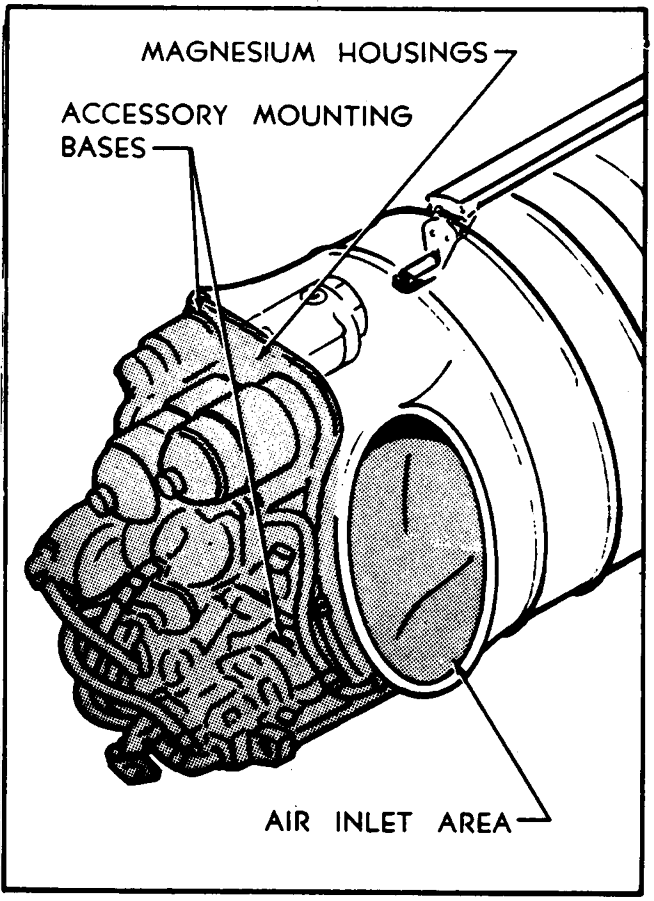

FIGURE 4-10. JET ENGINE FRONTAL AREA CORROSION POINTS

409. ELECTRONIC PACKAGE COMPARTMENTS. Electronic and electrical package compartments cooled by ram air or compressor bleed air are subjected to the same conditions common to engine and accessory cooling vents and engine frontal areas. While the degree of exposure is less because of a lower volume of air passing through and special design features incorporated to prevent water formation in enclosed spaces, this is still a trouble area that requires special attention.

a. Circuit breakers, contact points, and switches are extremely sensitive to moisture and corrosive attack and should be inspected for these conditions as thoroughly as design permits. If design features hinder examination of these items while in the installed condition, inspection should be accomplished after component removal for other reasons.

b. Treatment of corrosion in electrical and electronic components should be done only by, or under the direction of, qualified personnel familiar with the function of the unit involved as conventional corrosion treatment may be detrimental to some units.

c. Most corrosion that occurs on avionic equipment is similar to that which occurs on the basic airframe structure. The difference between avionic and airframe corrosion is that minute amounts of corrosion in avionic equipment can cause serious degradation or complete failure, while it would be unnoticed on larger structures.

d. Smog, smoke, soot, and other airborne contaminants are extremely corrosive to exposed avionic equipment. Many fumes and vapors emitted from factories or industrial complexes are highly acidic and greatly accelerate corrosion. An example is the corrosive effect of ozone, a product of many welding machines and large electrical motors. Complete degradation of rubber seals and damage to delicate components have occurred in equipment stored near ozone-producing equipment. Avionic shops and storage areas should have a filtered air-conditioning system.

e. Another man-made atmosphere is the aircraft environmental control system. These systems induce cooling air to the equipment. They may include a filter system that extracts moisture, and in some cases contaminants, from the air that enters the equipment. Failure to replace and/or clean a filter, or eliminate a leaky environmental seal, may cause a moisture or contaminant buildup that could cause a corrosive atmosphere within the equipment.

f. The control of corrosion in avionic systems is similar to that in airframes, with appropriate modifications. The general differences in construction and procedures between airframe and avionics relative to corrosion control are:

(1) Less durable protection systems;

(2) Small amounts of corrosion can make equipment inoperative;

(3) Dissimilar metals are often in electrical contact;

(4) Stray currents can cause corrosion;

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

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

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

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

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

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

410. MISCELLANEOUS TROUBLE AREAS. A variety of additional trouble spots exists, and some are covered by manufacturers' publications. Most aviation activities can add a favorite to the following list:

a. Examine all flexible hose assemblies for chafing, weather checking, hardening, discoloration, evidence of fungus, and torn weather protective coatings or sleeves. Replace those hoses that are found to be discrepant.

b. Trimmed edges of sandwich panels and drilled holes should have some type of corrosion protection. A brush treatment with an inhibitor solution or the application of a sealant along the edge, or both, is recommended. Any gaps or cavities where moisture, dirt, or other foreign material can be trapped should be filled with a sealant. The adjacent structure (not the sandwich) should have sufficient drainage to prevent moisture accumulation. Damage or punctures in panels should be sealed as soon as possible to prevent additional moisture entry--even if permanent repair has to be delayed.

c. Control cables may present a corrosion problem whether carbon steel or stainless steel is used. The presence of bare spots in the preservative coating is one of the main contributing factors in cable corrosion. Cable condition should be determined by cleaning the cable assembly, inspection for corrosion, and application of an approved preservative if no corrosion is found. If external corrosion is found, relieve tension on the cable and check internal strands for corrosion. Cables with corrosion on internal strands should be replaced. Pay particular attention to sections passing through fairleads, around sheaves, and grooved bellcrank arms. External corrosion should be removed by a clean, dry, coarse rag or fiber brush. After complete corrosion removal, apply a preservative.

d. Topcoating materials (Buna - N, Polyurethane, and Epoxy) used in integral fuel cells are impervious to fuel but not completely impervious to moisture absorption. Since it is impossible to keep fuel completely free of water, moisture can penetrate through the topcoating materials and sometimes causes pitting or intergranular corrosion on aircraft structural parts. It has also been found that micro-organisms which live in the water entrained by fuel, particularly jet propellant types, feed on fuel hydrocarbon and hydrocarbon-type elastomeric coatings materials. These micro-organisms excrete organic acids, and dead micro-organisms act as a gelatinous acidified sponge which can deteriorate integral tank coatings and corrode the aircraft structure. Microbial corrosion can be minimized by preventing as much water contamination of the fuel as possible with well-managed storage facilities, adequate filtration of fuel, and drainage of water contamination from integral fuel cells which keeps the water moving and reduces the chance for the colonies of micro-organisms to develop. Micro-organic activity can be reduced by using a biocide additive such as "Biobor JF" or equivalent. Solution strength and application frequency should be in accordance with the manufacturer's instructions.

e. Electrical connectors/components may be potted with a sealing compound to provide more reliability of equipment. The sealing compound prevents entrance of moisture into the area of connectors where the wires are attached to the pins.

(1) Rubber O-rings may also be used to seal moisture out of the mating area of pin connections and to prevent loss of pressurization in compartments containing bulkhead connectors.

(2) Moisture intrusion into electrical connectors can cause corrosion and an electrical failure. Suspected plugs should be disconnected, dissembled, solvent cleaned, and inspected for corrosion.

(3) When sealing provisions are not designed into the electrical component, these components can have moisture intrusion and internal corrosion.

f. Severe corrosion damage to the rear pressure bulkhead below the floor may occur as a result of contamination by fluids. Inspection for rear bulkhead corrosion may require extensive disassembly of components and fixtures to allow a thorough visual inspection. When inspection access holes are available, inspection by fiber optics is useful. Other nondestructive inspection (NDI) methods (x-ray, ultrasonic, and eddy current) are also available. However, these inspection techniques require specially trained personnel, NDI comparison standards, and suitable access. A regular inspection of the rear pressure bulkhead (both front and rear faces) below the floor level should be accomplished to prevent serious corrosion from occurring between the bulkhead and periphery doubler at the floor level. Such corrosion could weaken the bulkhead skin and cause sudden cabin pressure loss.

g. Some older aircraft have developed delaminations in cold bonded joints. Corrosion between the delaminated surfaces is caused by moisture intrusion along the edge of the mating parts or around fasteners securing the mating parts together. Localized bulging of the skin or internal structural component, usually around the fasteners, is the first indication of a corrosion problem (see Figure 4-11). Skin cracks or dished or missing fastener heads may also indicate severe corrosion in bonded joints. Corrosion which occurs between skins, doublers, and stringers or frames will produce local bulging or pulled rivets (see Figure 4-12). Corrosion that occurs between the skins and doublers or tear straps away from backup structure such as stringer or frame will not produce local bulging. An external low frequency eddy current inspection may be used to determine the extent of corrosion in the skin. Lap joints should be opened with wedges to determine the full extent of corrosion damage (see Figures 4-13 and 4-14). Internal visual inspection should be used to detect delaminated doublers or tear straps. A penetrating water displacement corrosion inhibitor should be applied to faying surfaces after corrosion removal and repair.

h. Flap and slat recesses and equipment installed in these areas, which are normally closed, may corrode unnoticed unless special inspections are performed.

FIGURE 4-11. SPAR CHORD LIFTING CAUSED BY CORROSION PRODUCTS

FIGURE 4-12. SKIN BULGING AROUND FASTENERS

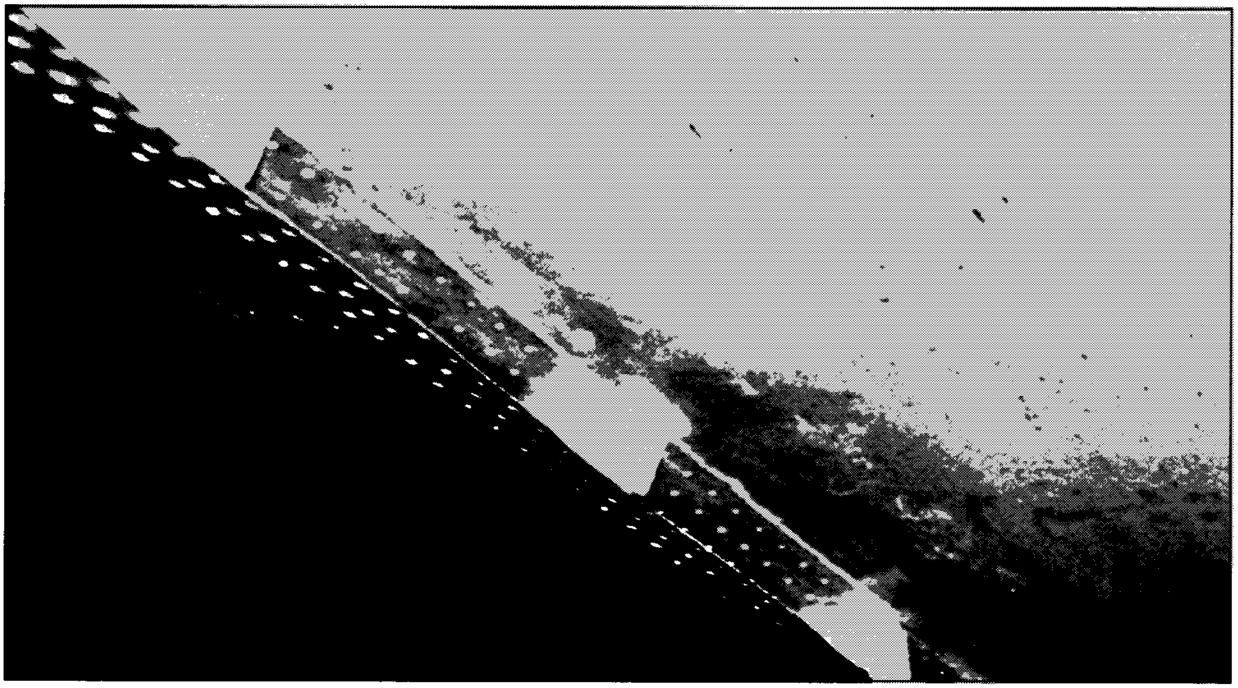

FIGURE 4-13. OPENING OF A CORRODED LAP JOINT FOR REPAIR

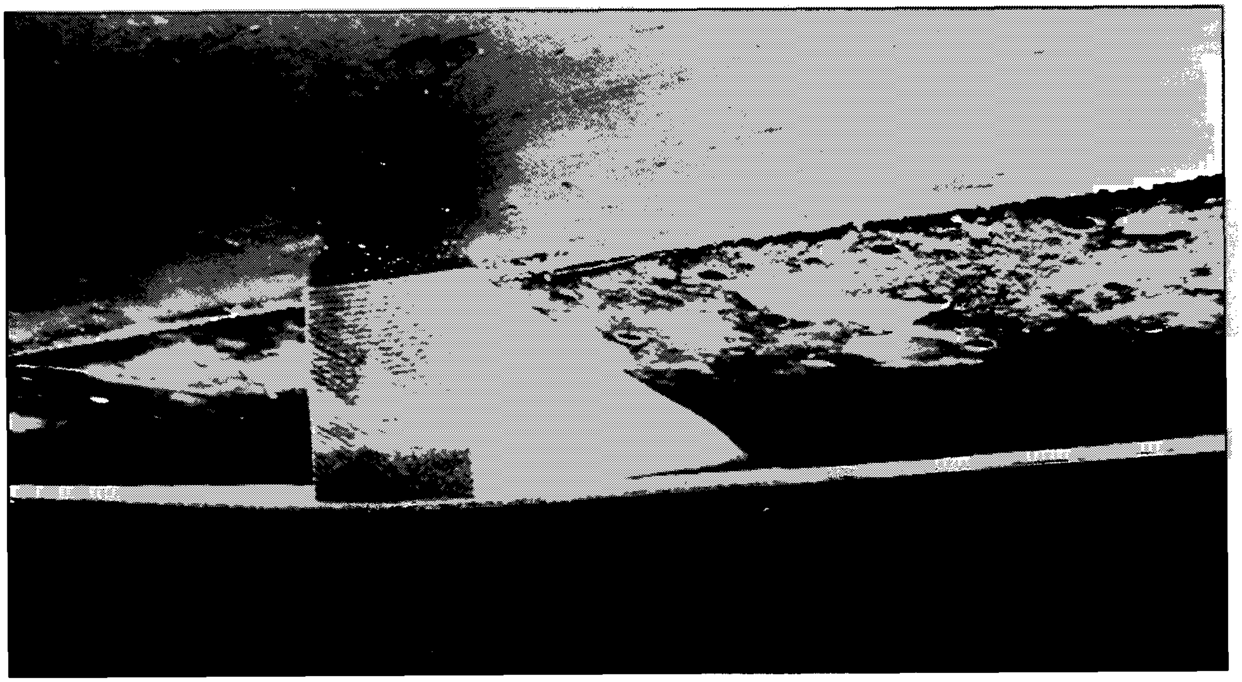

FIGURE 4-14. CLOSEUP VIEW OF A CORRODED LAP JOINT

411. FACTORS IN CORROSION CONTROL.

a. Corrosion Factors. The degree of severity, the cause, and the type of corrosion depend on many factors, including the size or thickness of the part, the material, heat treatment of the material, protective finishes, environmental conditions, preventative measures, and design.

(1) Thick structural sections are generally more susceptible to corrosive attack because of variations in their composition, particularly if the sections are heat-treated during fabrication. When large sections are machined or chem-milled after heat treatment, the corrosion characteristics of thinner sections may be different from those of thicker areas. Section size is based on structural requirements and cannot be changed for the purpose of controlling corrosion. From a maintenance standpoint, the correct approach is one of recognizing the need to ensure the integrity and strength of major structural parts and maintaining permanent protection over such areas at all times.

(2) In-service stresses and field repairs may affect the rates and types of corrosion. Aircraft structure under high cyclic stresses, such as helicopter main rotors, are particularly subject to stress-corrosion cracking. Also areas adjacent to weld repaired items often have corrosion due to insufficient removal of the weld flux, or, for some steels, buildup of a magnetic field. Areas such as these should be closely inspected for signs of corrosion and, when found, proper treatment accomplished.

b. Corrosion Control in Design. Since corrosion is the deterioration of metals resulting from reactions between metals and their environment, some corrosion control or means to minimize corrosion when the aircraft enters operational service should be introduced during the design phase. The corrosion issues discussed in this AC provide information to reduce the rate of corrosive attack by corrosion control measures introduced early in design.

(1) The nature of the material is a fundamental factor in corrosion. High-strength, heat-treatable aluminum and magnesium alloys are very susceptible to corrosion, while titanium and some stainless steel alloys are less susceptible in atmospheric environment. The aircraft manufacturer selects material for the aircraft based on material strength, weight, and cost, while corrosion resistance is often a secondary consideration. However, corrosion control should be considered as early as possible during the preliminary design phase.

(2) The use of more corrosion resistant materials in any design normally involves additional weight to achieve required strength. Since weight consideration is a major factor in the construction of airframes, the primary means of preventing corrosion is by use of protective coatings and proper maintenance procedures.

(3) The use of corrosion resistant alloys is not a cure-all for corrosion prevention. A common mistake is to replace a corroded part with a corrosion resistant alloy only to find that the corrosion has now shifted to another part and increased in severity.

(4) The problem of protection against corrosion is minimized if the material to be protected is intrinsically resistant to corrosion. Aluminum copper alloys are known to have better stress-corrosion resistance and better fatigue strength properties than aluminum zinc alloys; therefore, they are often used as the primary structural materials.

(5) Galvanic corrosion is created by dissimilar metals being in contact with each other. The galvanic series of metals and alloys (Table 4-1) is a factor that should be considered in the repair of aircraft. The further apart the metals listed in Table 4-1 are, the greater the tendency will be for galvanic corrosion. The metals grouped together in Table 4-2 have little differences in electrical potential; thus they are relatively safe to use in contact with one another. However, the coupling of metals from different groups will result in corrosion of the group having a lower number.

TABLE 4-1. GALVANIC SERIES OF METALS AND ALLOYS

Electrode Potential of Various Metals and Alloys (a)

Metal or Alloy (b)	Potential, volts 0.1 N calomel scale (c)
Magnesium	-1.73
Zinc	-1.10
7072, Alclad 3003, Alclad 6061, Alclad 7075	-0.96
5056, 7079-T6, 5456, 5083, 214, 218	-0.87
5052, 5652, 5086, 1099	-0.85
3004, B214, 1185, 1060, 1260, 5050	-0.84
1100, 3003, 615, 6053, 6061-T6, 6062-T6, 6063, 6363, Alclad 2014, Alclad 2024	-0.83
Cadmium	-0.82
7075-T6, 356-T6, 360	-0.81
2024-T81, 6061-T4, 6062-T4	-0.80
355-T6	-0.79
2014-T6, 113, 750-T5	-0.78
2014-T4, 2017-T4, 2024-T3, and T4	-0.68 to -0.70 (d)
Mild steel	-0.58
Lead	-0.55
Tin	-0.49
Copper	-0.20
Bismuth	-0.18
Stainless steel (series 300, type 430)	-0.09
Silver	-0.08
Nickel	-0.07
Chromium	-0.49 to +0.018

(a) Data from Alcoa Research Laboratories.
(b) The potential of all tempers is the same unless temper is designated.
(c) Measured in an aqueous solution of 53g of sodium chloride + 3g hydrogen peroxide per liter at 25 degree C.
(d) The potential varies with quenching rate.

TABLE 4-2. GROUPING OF METALS AND ALLOYS

GROUP I	Magnesium and Magnesium Alloys.
GROUP II	Aluminum, Aluminum Alloys, Zinc, Cadium and Cadium-Titanium Plate.
Group III	Iron, Steels - Except Stainless Steels; Lead, Tin and their Alloys.
GROUP IV	Copper, Brass, Bronze, Copper-Berylium, Copper-Nickel Chromium, Nickel, Nickel Base Alloys, Cobalt Base Alloys, Carbon Graphite, Stainless Steels, Titanium and Titanium Alloys.

NOTE: 1. Metals listed in the same group are considered similar to one another.

2. Metals listed in different groups are considered dissimilar to one another.

c. Protective Finishes. Protective finishes provide protection for the base material from corrosion and other forms of deterioration. Protective finishes are divided into 2 separate categories, sacrificial and non-sacrificial. Sacrificial coatings include cadmium, zinc, and aluminum. Non-sacrificial coatings include hard plating (chromium and nickel), chemical conversion coatings, sealant, primers, and top coat.

d. Geographical Location and Environment. This factor concerns systems exposed to marine atmospheres, moisture, acid rain, tropical temperature conditions, industrial chemicals, and soils and dust in the atmosphere. Limit, whenever possible, the requirement for operation of aircraft in adverse environments.

(1) Moisture is present in the air as a gas (water vapor) or as finely divided droplets of liquid (mist or fog) and often contains contaminants such as chlorides, sulfates, and nitrates, which increase its corrosive effects. Condensed moisture which evaporates will leave its contaminants behind. Condensed moisture and its contaminants can also be trapped in close fitting, wettable joints, such as faying surfaces and be drawn along poor bond lines by capillary action.

(2) Salt particles, when dissolved in water, form strong electrolytes. Normal sea winds carry dissolved salt which makes coastal environments highly corrosive.

(3) Industrial pollutants (such as carbon, nitrates, ozone, sulfur dioxide, and sulfates) contribute to the deterioration of nonmetallic materials and can cause severe corrosion of metals.

(4) Warm, moist air, normally found in tropical climates accelerates corrosion while cold, dry air normally found in arctic climates reduces corrosion.

e. Heat Treatment. Proper heat treatment of materials is a vital factor in maximizing resistance to corrosion.

412. PREVENTATIVE MAINTENANCE.

a. Prevention. Corrosion prevention of aircraft structure depends on a comprehensive corrosion prevention and control plan, implemented from the start of operation of an aircraft, which includes:

(1) Adequately trained personnel in:

(i) Recognition of corrosion inducing conditions;

(ii) Corrosion identification techniques;

(iii) Corrosion detection, cleaning, and treating; and

(iv) Lubrication and preservation of aircraft structure and components.

(2) Inspection for corrosion on a scheduled basis.

(3) Thorough cleaning, inspection, lubrication, and preservation at prescribed intervals. Suggested intervals based on operating environment (see Figures 4-15 through 4-20) are:

(i) Mild zones -- Every 90 days;

(ii) Moderate zones -- Every 45 days; and

(iii) Severe zones -- Every 15 days.

(4) Prompt corrosion treatment after detection.

(5) Accurate record keeping and reporting of material or design deficiencies to the manufacturer and the FAA.

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

(7) Maintenance of the basic finish systems.

(8) Keeping drain holes and passages open and functional. Sealants, leveling compounds, miscellaneous debris, or corrosion inhibitors should not block drain paths (see Figure 4-21).

(9) Replacing deteriorated or damaged gaskets and sealants (using noncorrosive type sealants) to avoid water intrusion and entrapment which leads to corrosion.

(10) Minimizing the exposure of aircraft to adverse environments, such as hangaring away from salt spray.

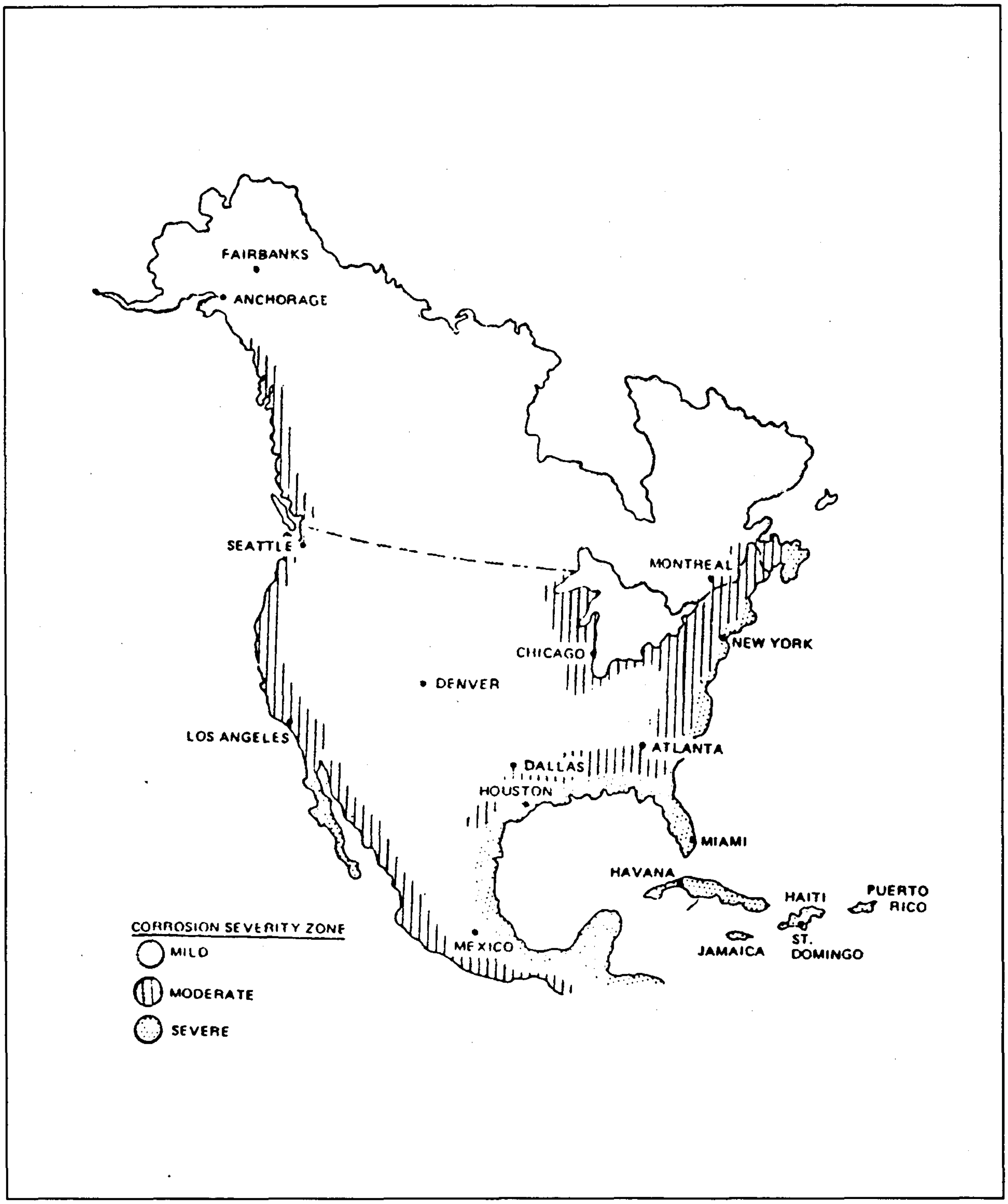

FIGURE 4-15. NORTH AMERICA CORROSION SEVERITY MAP

FIGURE 4-16. SOUTH AMERICA CORROSION SEVERITY MAP

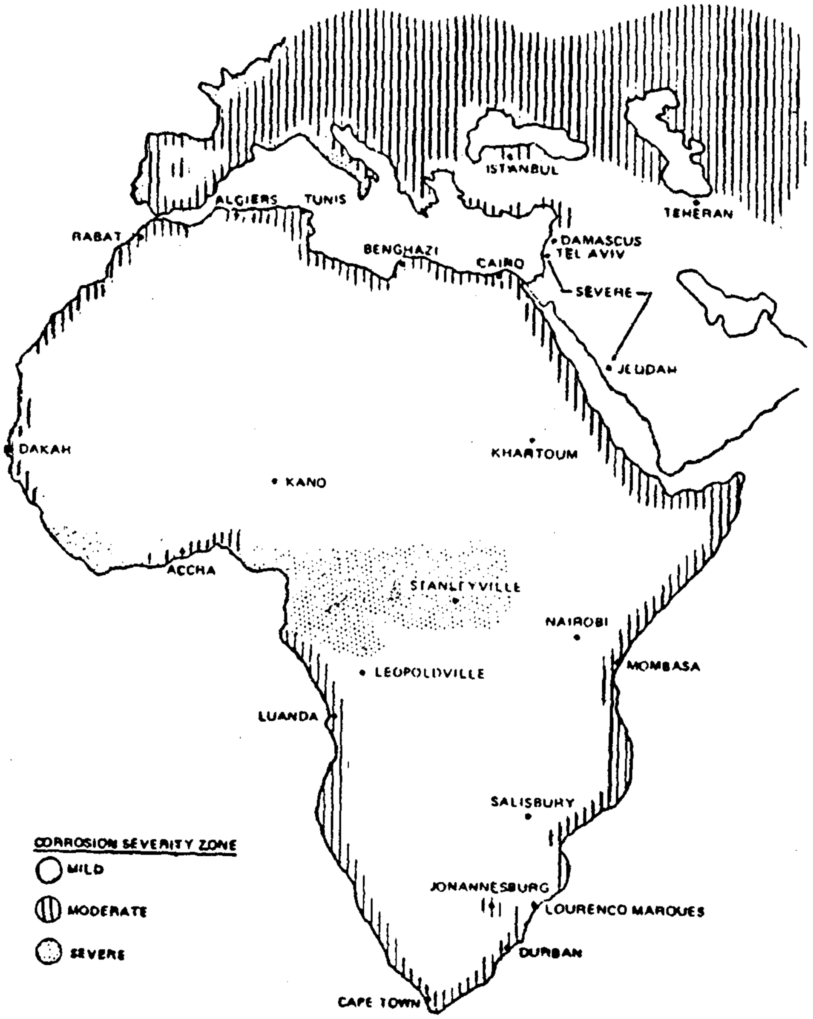

FIGURE 4-17. AFRICA CORROSION SEVERITY MAP

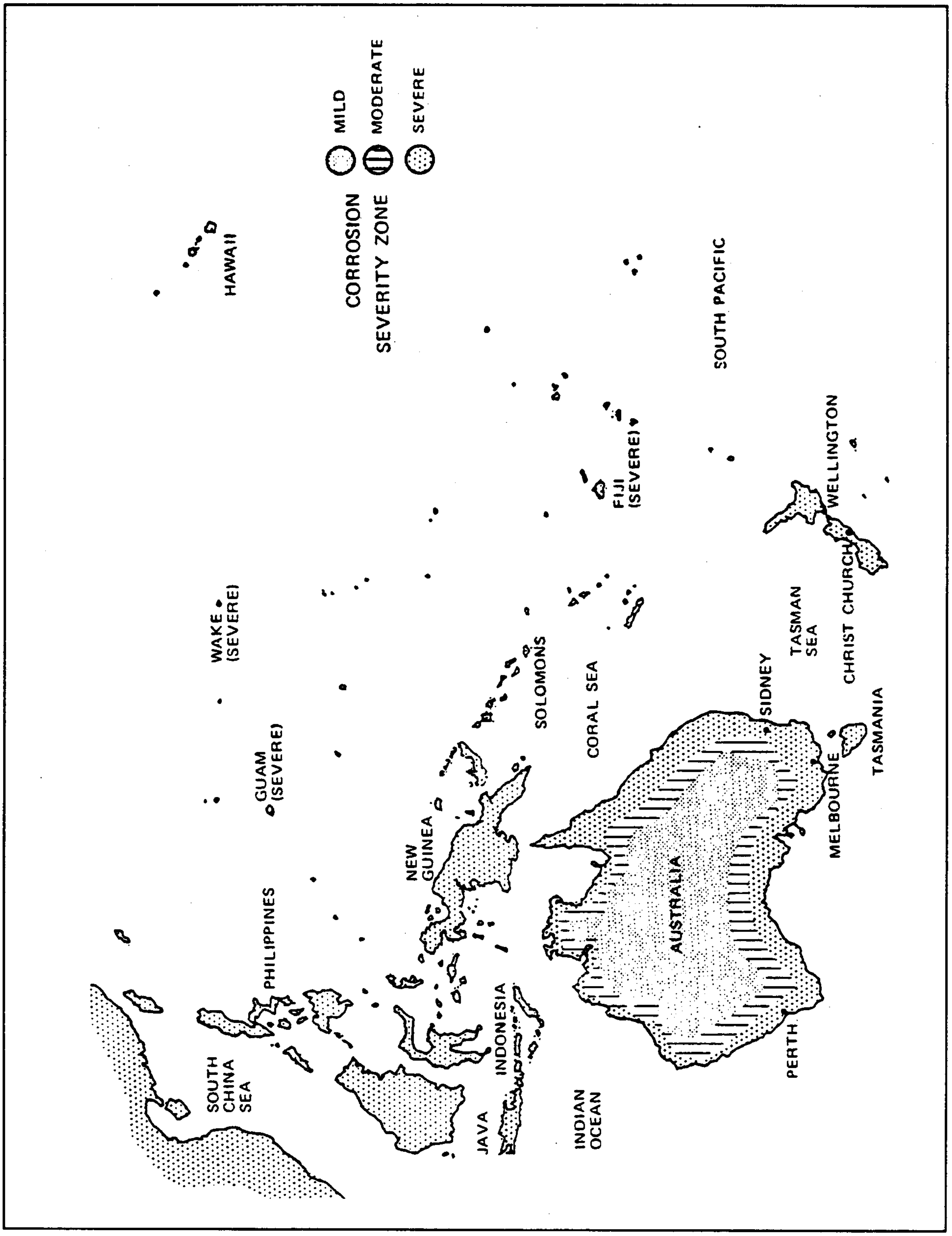

FIGURE 4-18. SOUTH PACIFIC CORROSION SEVERITY MAP

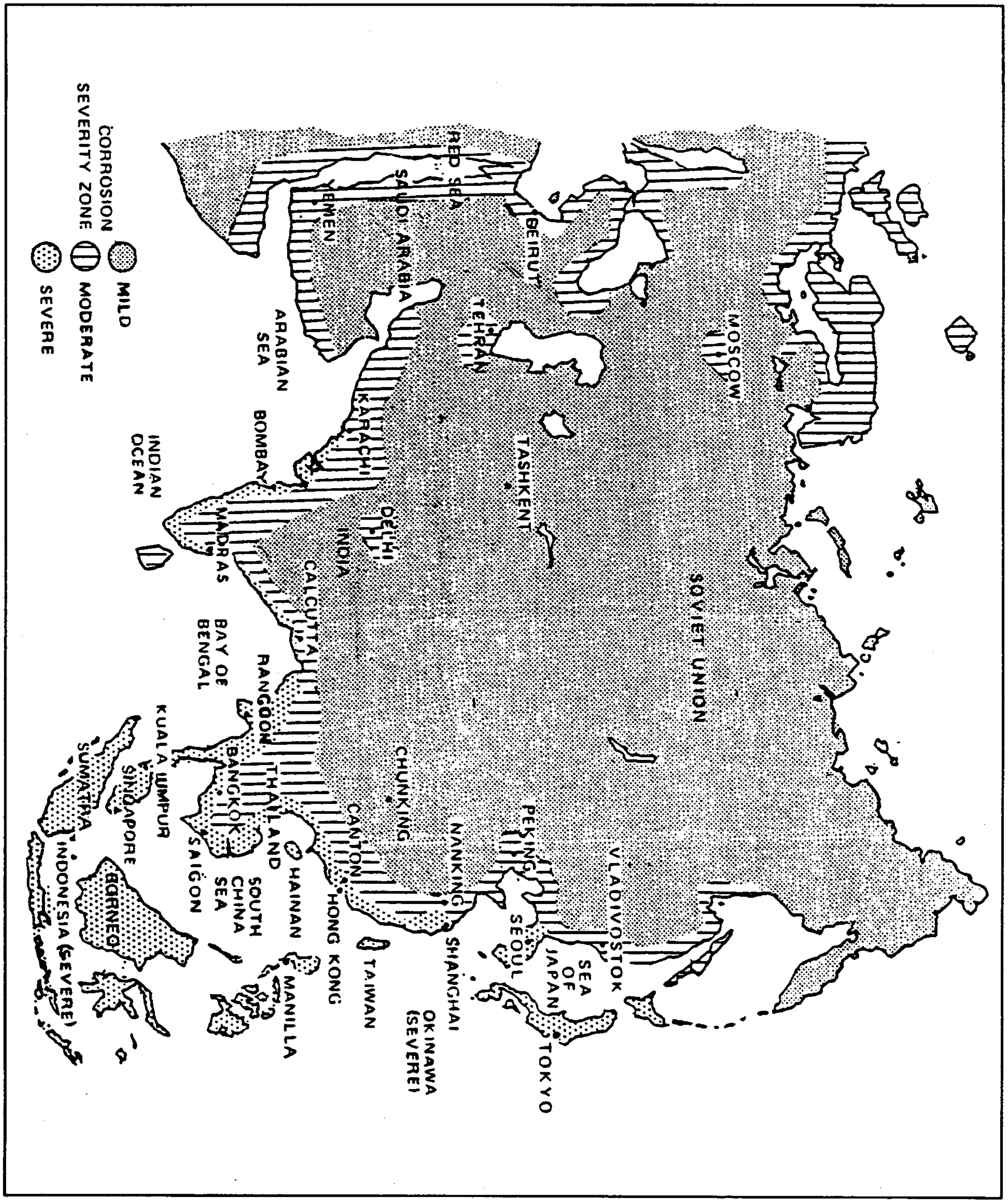

FIGURE 4-19. ASIA CORROSION SEVERITY MAP

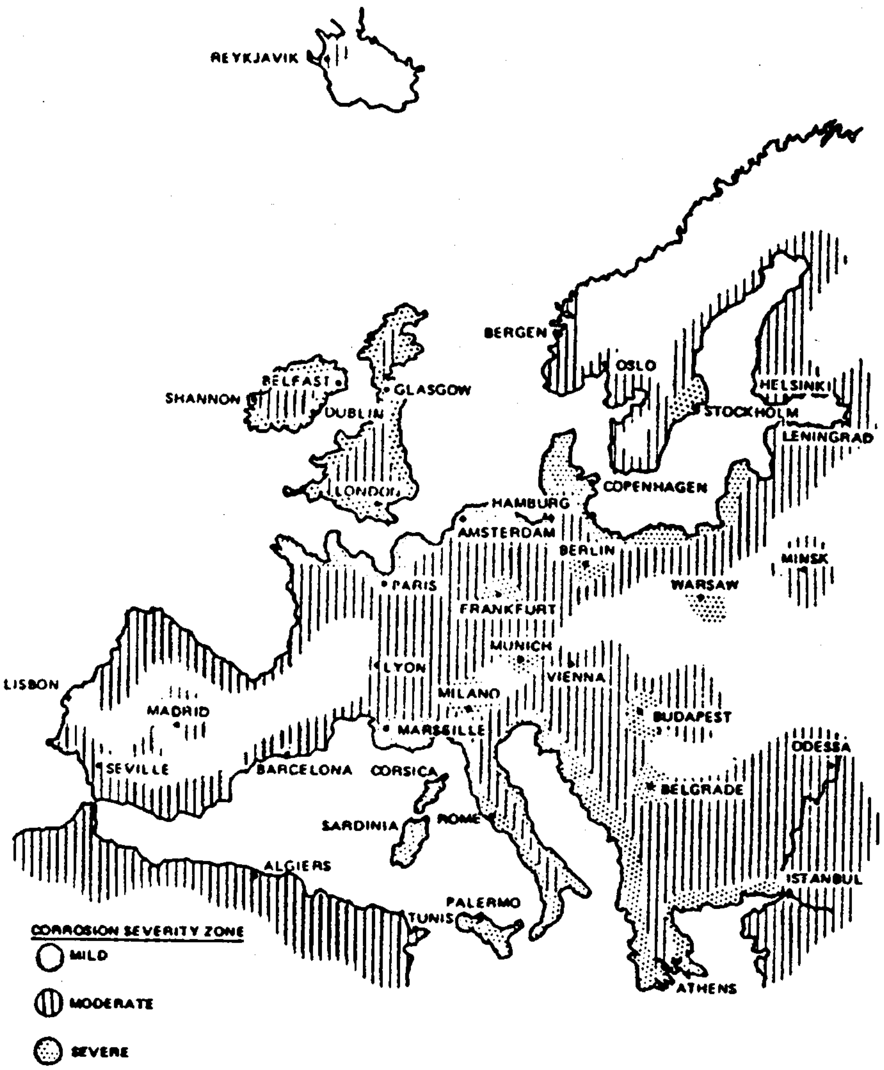

FIGURE 4-20. EUROPE AND ASIA MINOR CORROSION SEVERITY MAP

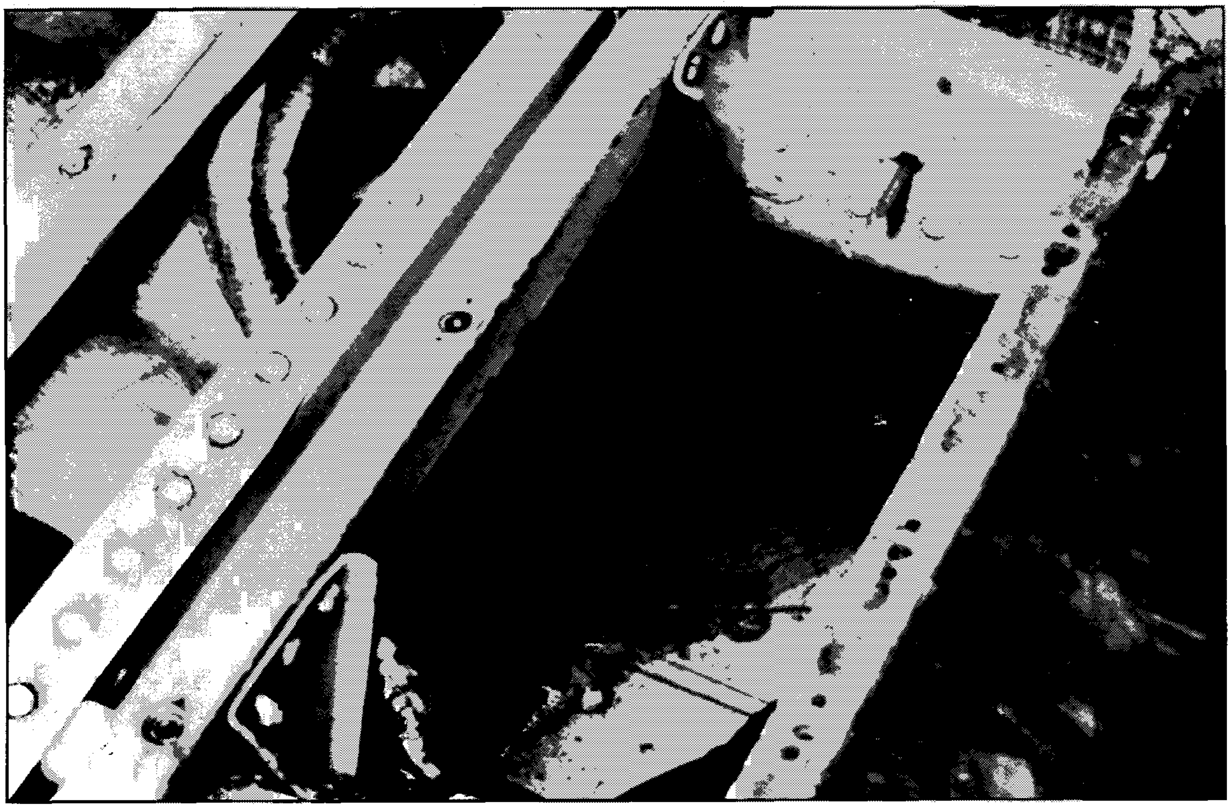

FIGURE 4-21. BLOCKED DRAIN PASSAGES RESULTED IN ACCUMULATION OF CORROSION CONTAMINATES AND MOISTURE

b. Cleaning Compounds.

NOTE: "More is not always better." Mixing more cleaning compound increases the pH of the solution which can do more harm than good. A cleaning compound should always be mixed in accordance with the manufacturer's recommendations.

(1) Cleaning compounds work by dissolving soluble soils, emulsifying oily soils, and suspending solid soils. There are several types of cleaning compounds, each of which cleans a surface using one or more of these mechanisms.

(2) Highly alkaline cleaning compounds (pH greater than 10) are not recommended. Moderately alkaline cleaners (pH between 7.5 and 10) conforming to MIL-C-85570, Types I and II, are recommended. Both types contain detergents, foaming agents, and solvents, and work in the same way as a detergent solution.

(3) High gloss spot cleaner conforming to MIL-C-85570, Type III, is recommended for cleaning exhaust track areas of high gloss paint systems. This material contains solvents, detergents, and suspended abrasive matter to remove soil by wearing away the surface that holds it.

(4) Thixotropic (viscous) cleaner conforming to MIL-C-85570, Type V, is recommended for cleaning wheel wells and replacement of some solvent cleaning where water rinsing can be tolerated. This cleaner contains solvents, detergents and some thickening agents. When applied undiluted to an oily or greasy surface, the cleaner clings long enough to emulsify the soil (about 5 to 15 minutes) and can then be rinsed away with fresh water.

NOTE: The use of solvents for cleaning operations is becoming more and more limited due to environmental regulations. Determine local requirements for waste disposal.

(5) Solvent emulsion cleaners conforming to MIL-C-43616 and MIL-C-85704 become emulsions when diluted. The solvent contained in the cleaner softens oily soils so that they can be emulsified by the detergent and rinsed away.

(6) Detergent solution cleaners conforming to MIL-D-16791 dissolve in water and clean by dissolving soluble salts, emulsifying low viscosity oils, and suspending easily removed dirt and dust. They are not very effective on grease, but are excellent cleaners for interior lightly soiled areas, plastics, and instrument glass covers.

(7) Cleaning solvents dissolve oily and greasy soils so that they can be easily wiped away or absorbed on a cloth. Solvents differ significantly in cleaning ability, toxicity, evaporation rate, effect on paint, and flammability. The use of cleaning solvents is intended for localized spot application only. A dry cleaning solvent conforming to P-D-680, Type II, is the most common cleaning solvent used on aircraft, due to its low toxicity, minimal effect on paint, and relative safety. Other solvents, such as alcohols, ketones, chlorinated solvents, and naphtha, are specialized materials and have restricted use. Refer to the manufacturer's maintenance and cleaning procedures for specific applications.

(8) Miscellaneous cleaning agents include:

(i) Plastic polish which contains mild abrasive matter to polish out scratches in canopy materials;

(ii) Alkaline chemicals used to neutralize specific acidic soils;

(iii) Sodium bicarbonate for electrolyte spills from sulfuric acid batteries; and

(iv) Monobasic sodium phosphate and boric acid for electrolyte spills from nickel-cadmium batteries.

(9) Steam cleaning is not recommended for general use on aircraft. It erodes paint, crazes plastic, debonds adhesives, damages electrical insulation, and drives lubrication out of bearings.

c. Cleaning Procedures.

(1) The following cleaning procedures are recommended:

(i) Remove/disconnect all electrical power;

(ii) Ground aircraft;

(iii) Aircraft wash personnel should wear protective gear (gloves, goggles, aprons, etc.);

(iv) Protect against water/cleaning compound intrusion (close doors, openings, cover vents, pitot static openings, cover wheels, etc.);

(v) Accomplish pre-wash lubrication. Lubricate in accordance with applicable maintenance manual;

(vi) Mix cleaning solution to manufacturer's recommendation;

(vii) Use spray not a stream of water during aircraft wash;

(viii) Do not use abrasive cleaning pads; and

(ix) Rinse aircraft with fresh water to remove all cleaning compounds.

(2) The following postcleaning procedures are recommended:

(i) Remove all covers, plugs and masking materials;

(ii) Inspect and clear all drain holes;

(iii) Inspect open and all known water trap areas for water accumulation and proper drainage;

(iv) Lubricate aircraft in accordance with applicable maintenance manual; and

(v) Apply operational preservation.

d. Preservation. The day-to-day application of corrosion preventive compounds is used to protect metal aircraft parts and components. They function by preventing corrosive materials from contacting and corroding bare metal surfaces. Many of these compounds are also able to displace water and other contaminants from the surfaces to be protected. Some also provide lubrication as well as corrosion protection. Corrosion preventive compounds vary in appearance and consistency from thick, black types to light oils. Some are water displacing and others are not. The thicker compounds provide the best corrosion protection, are longer lasting, and are more difficult to remove. The thinner materials provide some lubrication and do not crack, chip, or peel but must be removed and replaced regularly to provide continuing protection.

e. Surface Treatment.

(1) An important step in the corrosion control process is the surface treatment of the metal with a prescribed chemical to form a protective film. Chemical surface treatments properly applied provide corrosion resistance to the metal and improve the adhesion of subsequently applied paints. These surface treatments, also known as chemical conversion coatings, chromate conversion coatings, chemical films, or pretreatments, are aqueous acid solutions of active inorganic compounds which convert aluminum or magnesium surfaces to a corrosion resistant film.

(i) Aluminum and aluminum alloys chemical conversion materials conform to MIL-C-81706.

(ii) Magnesium alloy chemical conversion materials conform to MIL-M-3171.

(iii) Ferrous metals, stainless steel, and titanium treatment prior to painting are limited to corrosion removal and cleaning.

(2) The surface should be prepared for application of the chemical conversion coatings.

(i) Feather the edges of paint along the edge of areas that have been chemically stripped prior to pretreatment and repainting to ensure a smooth, overlapping transition between the old and new paint surfaces.

(ii) Clean the area with a fine or very fine clean abrasive mat saturated with water.

(iii) Rinse by flushing with fresh water. Particular attention should be given to fasteners and other areas where residues may become entrapped. At this stage in the cleaning, the surface should be water break-free. A surface showing water breaks (water beading or incomplete wetting) is usually contaminated with grease or oil, which will later interfere with conversion coating, sealing, and painting.

(iv) If the surface is not free of water breaks, reclean the area with a solution of aircraft cleaning compound using the abrasive mat. Rinse thoroughly with water.

(3) Chemical conversion coating is applied by brush, sponge stick moistener, or nonatomizing sprayer to achieve a yellow to gold color for aluminum (usually 2 to 4 minutes) or greenish brown, brassy or brownish-yellow for magnesium (30 seconds to 2 minutes).

(4) Immediately rinse the part thoroughly with fresh water. Do not wipe with a rag or cloth.

(5) Allow the chemical conversion coated surface to dry a minimum of 1/2 hour and a maximum of 4 hours before painting.

f. Sealants.

(1) Sealants are one of the most important tools for corrosion prevention and control. They prevent the intrusion of moisture, salt, dust, and aircraft fluids, which can lead to extensive corrosion. For sealants to be effective, it is critical that the correct sealant be chosen for a specific area/situation and that it be applied correctly.

(2) Sealants are used for the following reasons:

(i) Fuel tank sealing;

(ii) Pressure areas;

(iii) Weather sealing;

(iv) Firewalls;

(v) Electrical;

(vi) Acid-resistant areas;

(vii) Windows;

(viii) High temperature applications; and

(ix) Aerodynamic sealing.

(3) There are numerous sealing compounds available with different properties and intended use. Refer to the aircraft manufacturer's manual for specific information concerning selection of the sealing compound and proper application. Observe the warning and cautions of the manufacturer when using sealing compounds. Sealing compounds generally are divided into two major types, those requiring a curing agent and those which cure in air.

(i) Polysulfide, polythioether, and polyurethane sealing compounds consist of the base (prepolymer) and the accelerator (curing agent). When thoroughly mixed, the catalyst cures the base to a rubbery solid. Rates of cure depend on the type of base, catalyst, temperature, and humidity. A full cure may not be achieved for as long as 7 days.

(ii) Silicone sealing compounds generally consist of one component which cures by reaction with moisture in the air. If silicones are applied too thick or in such a way as to prevent moisture from entering the material, they may not cure at all. In addition, many silicone sealing compounds produce acetic acid (vinegar smell) while curing, which can lead to severe corrosion problems. The use of silicone sealing compounds on aircraft should be limited to those non-corrosive products conforming to Specification (MIL-A-46146).

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

(4) Sealant application procedures:

(i) Following the removal of corrosion and application of a chemical surface treatment, prime all surfaces, except internal fuel tank surfaces. If the surfaces have been contaminated following surface treatment, clean the area with cleaning solvent and a clean cloth. Dry the surfaces immediately with a clean cloth. Do not allow solvent to evaporate from the surface.

(ii) Mask off the area being sealed to prevent sealant from contacting adjacent areas during application and postapplication smooth-out operations. Examples of where masking may be beneficial are fillet sealing of exterior surface lap and butt seams.

(iii) When required by the manufacturer, apply a thin coating of an adhesion promoting solution. Allow to dry by evaporation without touching the area for 30 minutes to 1 hour before applying sealant.

(iv) Spatula type sealants may be applied with a non-metallic spatula or scraper. Avoid the entrapment of air. Work sealant into recesses by sliding the edge of the scraper firmly back over the recesses between the tape. Smoothing will be easier if the non-metallic scraper is first dipped in water.

(v) Sealant to be applied with a brush is applied and smoothed until the desired thickness is reached.

(vi) Sealant to be applied with a caulking gun will not usually require masking and is especially adaptable to filling seams or the application of form-in-place gaskets.

(vii) Sealant applied with a spray gun should be applied in a solid, continuous pattern.

(viii) Allow sealant to dry or cure to manufacturer's recommendations.

(ix) When required, prime sealant as soon as it no longer feels tacky, then topcoat as necessary.

(5) Faying surface sealant is applied between the contacting surface of two or more parts, and is the most effective seal that can be produced. It should be used for all assembly and, where possible, reassembly. Where at all possible it should be used in conjunction with fillet sealing. There are two types of faying surface seal installations, removable and permanent.

(i) The removable type is for access doors, removable panels, inspection plates, windows, etc. The sealant is normally applied to the substructure and a parting agent applied on the removable panel during sealant cure.

(ii) The permanent type is for sealing between parts of a structure that is permanently fastened together with a high adhesion sealant.

(6) The fillet, or seam, seal is the most common type found on an aircraft. Fillet seals are used to cover structural joints or seams along stiffeners, skin butts, walls, spars, and longerons, and to seal around fittings and fasteners. It should be used in conjunction with faying surface sealing and in place of it if the assembly sequence restricts the use of faying surface sealing.

(7) Injection sealing is used primarily to fill voids created by structural joggles, gaps, and openings. Use only those sealants recommended by the aircraft/equipment manufacturer. Force sealant into the area using a sealant gun. This method is a means of producing a continuous seal where it becomes impossible to lay down a continuous bead of sealant while fillet sealing. Clean the voids of all dirt, chips, burrs, grease, and oil before injection sealing.

(8) The fastener sealing method depends on the type of fastener. Fasteners are sealed either during assembly or after assembly. To seal a permanent fastener during assembly, apply the sealant to the hole or dip the fastener into the sealant, and install the fastener while sealant is wet. For removable fasteners, start the fastener in the hole and apply sealant to the lower side of the fastener head or countersink. To seal after assembly, apply sealant to the fastener head after installation.

(9) Sealing of fuel cells should be accomplished per the aircraft manufacturer's maintenance manual procedures.

g. Paint Finishes and Touchup Procedures.

(1) The primary objective of any paint system is to protect exposed surfaces against corrosion and other forms of deterioration. Operational uses for particular paint schemes include:

(i) High visibility requirements;

(ii) Identification markings;

(iii) Abrasion protection; and

(iv) Specialty coatings (i.e., walkway coatings).

(2) The paint system on aircraft consists of a primer coat and a topcoat. The primer promotes adhesion and contains corrosion inhibitors. The topcoat provides durability to the paint system, including weather and chemical resistance, along with the coloring necessary for operational requirements.

(3) Some aircraft surfaces (teflon-filled, rain erosion, walkways, etc.) require specialized coatings to satisfy service exposure and operational needs. For these surfaces, refer to the specific manufacturer's maintenance manual for the aircraft in question.

(4) The Environmental Protection Agency, as well as certain local air pollution control districts, has implementated rules which limit the volatile organic content (VOC), or solvent content, of paints applied to aircraft and ground support equipment. It is the responsibility of the user to insure that these rules are understood and obeyed. FAILURE TO COMPLY WITH CURRENT RULES CAN RESULT IN LARGE FINES.

(5) Much of the effectiveness of a paint finish and its adherence depend on careful preparation of the surface prior to touch up and repair.

(i) Aged paint surfaces must be scuff sanded to ensure adhesion of overcoated, freshly applied paint. Sanding requires a complete roughening of the paint surface and can be accomplished by hand sanding or with the use of power tools.

(ii) For final preparation, ensure that surfaces to be painted are free of corrosion, have been prepared and the surrounding paint feathered, have been cleaned, and have been conversion coated. Replace any seam sealants when necessary. Mask areas as required to prevent overspray.

(6) Spray application for touchup, overcoat and total repaint:

(i) Primers should be thinned with the applicable thinner as required and recommended by the paint manufacturer, stirred, and applied in even coats. Primer thickness varies for each type primer but generally the total dry film thickness is 0.6 to 0.9 mils (0.0006 to 0.0009 inch). You should be able to see through this film thickness. Allow primer to air dry prior to topcoat application in accordance with the paint manufacturer's recommendations. Normally topcoat application should occur within 24 hours after primer application.

(ii) Topcoats should be thinned with the applicable thinner as required and recommended by the paint manufacturer, stirred, and applied in even coats. Topcoat thickness varies for each topcoat but generally the total dry film thickness is 1.5 to 2.0 mils (0.0015 to 0.002 inch). Allow the topcoat to air dry in accordance with the paint manufacturer's instructions.

(A) Teflon-filled (antichafe) coatings should be applied over a primer in accordance with the manufacturer's instructions.

(B) Walkway compounds should be applied over a primer in accordance with the manufacturer's instructions.

413.-499. RESERVED.