CHANGE

AC NO: 43-4 CHG 2

DATE: 10/8/74

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: CORROSION CONTROL FOR AIRCRAFT

PURPOSE. This change to the advisory circular clarifies the discussion on the removal of corrosion and treatment of the corroded areas. Reports that have been received indicate that some operators have misinterpreted the procedure for removing corrosion.

PAGE CONTROL CHART

Remove Pages	dated	Insert Pages	dated
47 and 48	5/15/73	47 and 48	10/8/74

R. P. SKULLY
Acting Director, Flight Standards Service

Initiated by: AFS-302

CHAPTER 9. CORROSION DAMAGE AND REWORK LIMITS

71. DISCUSSION. Corrosion evaluation will be required after initial inspection and cleaning to determine nature and extent of repair or rework. The first requirement for evaluation is good and sound maintenance judgement. Evaluate corrosion as follows:

a. Light corrosion - Characterized by discoloration or pitting to a depth of approximately 0.001 inch maximum. This type of damage is normally removed by light hand sanding or a minimum of chemical treatment.

b. Moderate corrosion - Appears similar to light corrosion except there may be some blisters or evidence of scaling and flaking. Pitting depths may be as deep as 0.010 inch. This type of damage is normally removed by extensive hand sanding or mechanical sanding.

c. Severe corrosion. General appearance may be similar to moderate corrosion with severe blistering exfoliation and scaling or flaking. Pitting depths will be deeper than 0.010 inch. This type of damage is normally removed by extensive mechanical sanding or grinding.

72. TREATMENT OF CORRODED AREAS. There are two basic methods of corrosion removal - mechanical and chemical. The method used depends upon the type of structure, its location, the type and severity of corrosion, and the availability of maintenance equipment. Mechanical means are generally used on moderate to heavy corrosion, particularly if the part involved has a relatively heavy cross section or is skin of heavy gage. Lighter corrosion is removed by chemical means. Mechanical methods are recommended for heavily corroded areas on all nonclad aluminum alloys and on magnesium alloys.

* *

73. DETERMINING DEGREE OF CORROSION DAMAGE. Determine degree of corrosion damage (light, moderate or severe) with a depth dial gage if accessibility permits. Before measurements are made, visually determine if corrosion is in an area which has previously been reworked. If corrosion is in the recess of a faired or blended area, measure damage to include the material which has previously been removed. The following method outlines the process for taking measurements with the depth gage.

a. Remove loose corrosion products if present.

b. Position depth gage as illustrated in Figure 9-1 and determine the measurement reading.

NOTE: The base of the depth gage must be flat against the undamaged surface on each side of the corrosion. When taking measurements on concave or convex surfaces, place the base perpendicular to the radius of the surface as shown in Figure 9-1.

c. Take several additional depth readings.

d. Select deepest reading as being depth of the corrosion damage.

74. DETERMINING REWORK LIMITS. The maximum allowable amount of material removed from any damaged surface may be determined from criteria contained in the allowable damage limit chart in the manufacturer's repair manual. If no criteria is given, contact the aircraft manufacturer for cleanup limits.

75. DETERMINING MATERIAL THICKNESS REDUCTION AFTER CORROSION CLEANUP. The amount of material which may be removed from a part or panel during corrosion cleanup is usually available in the manufacturer's allowable damage limit charts. To ensure that the allowable limits are not exceeded, an accurate measurement must be made of the material removed or material thickness remaining in the reworked area.

a. Measurement of panel thickness after rework can be made using a ultrasonic tester.

b. Measurement of the depth of blended pits (material removed) can be made using a depth dial gage. (See Figure 9-1.) If the area is inaccessible, clay impressions, or any other means which will give accurate results, may be used to determine material removed. In the event that material removal limits have been exceeded, the area or part must be repaired or replaced. If replacement or repair criteria is not contained in the repair manual, contact the manufacturer.

76.-80. RESERVED.

CHANGE

AC NO: 43-4 CHG 1

DATE: 3/1/74

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: CORROSION CONTROL FOR AIRCRAFT

PURPOSE. This change provides additional information regarding identification and treatment of corrosion attack on aircraft structure. A new paragraph added to Chapter 2 discusses sudden decompression due to undetected corrosion damage in the rear pressure bulkhead of a pressurized aircraft. Corrosion control of aircraft used in agricultural crop-dusting operations is presented in a new Chapter 14.

PAGE CONTROL CHART

Remove Pages	dated	Insert Pages	dated
i and ii	5/15/73	i	3/1/74
		ii	5/15/73
v		v	3/1/74
17 (and 18)	5/15/73	17 and 18	3/1/74
		18-1 and 18-2	3/1/74
		101 and 102	3/1/74

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Initiated by: AFS-302

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cleaning and corrosion-removal as necessary. A preservative should then be reapplied. 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.

d. Top coating materials (Buna - N) used in integral fuel cells are impervious to fuel but not completely impervious to water. Since it is impossible to keep fuel completely free of water, moisture does penetrate through the top coating materials and sometimes causes fretting or intergranular corrosion on aircraft structural parts. It has also been found that micro-organisms which live in fuel (particularly JP types) become attached to the top coating materials and sometimes result in deterioration of such materials. Defense against such attacks is well-managed storage facilities and adequate filtration of fuel. (JP is jet propellant, abbreviated).

e. Electrical connectors may have been potted with a compound to provide more reliability of equipment. The compound prevents entrance of water into the area of connectors where the wires are soldered to the pins.

(1) Loss of pressurization in compartments containing bulkhead connectors is also prevented. Rubber "O" rings are also used to seal moisture out of the mating area of pin connections.

(2) Moisture will occasionally get into electrical plugs and cause failure. Therefore, it is necessary that such plugs be disconnected for inspection. Maintenance personnel will have to determine exact inspection requirements on the basis of past trouble.

(3) Trouble has been found in electrical components, and provisions have not always been made to seal water from such equipment.

* f. Severe corrosion damage to the rear pressure bulkhead below the floor level may occur as a result of contamination by fluids. In the event the corrosion is hidden from visual inspection, the use of appropriate nondestructive testing methods is required.

A catastrophic aircraft accident was attributed to sudden cabin pressure loss through the rear pressure bulkhead. Prior inspection had not considered the possibility of serious corrosion occurring between the bulkhead and periphery doubler at the floor level. Following the accident, inspection access holes were incorporated in the bulkhead area and a revised inspection program was established to require more frequent inspections of the rear pressure *

* bulkhead below the floor level at both front and rear faces (see figures 2-8 and 2-9). A detailed examination with fiber optics can now be accomplished through inspection access holes which have improved aft accessibility. The doubler bond is checked from the forward face using dye penetrant for edge separation. The phasemaster NDT examination is used to detect corrosion and/or separation along the edge of the doubler. (The bonded area is not suitable for X-ray examination.) *

21.-25. <u>RESERVED</u>.

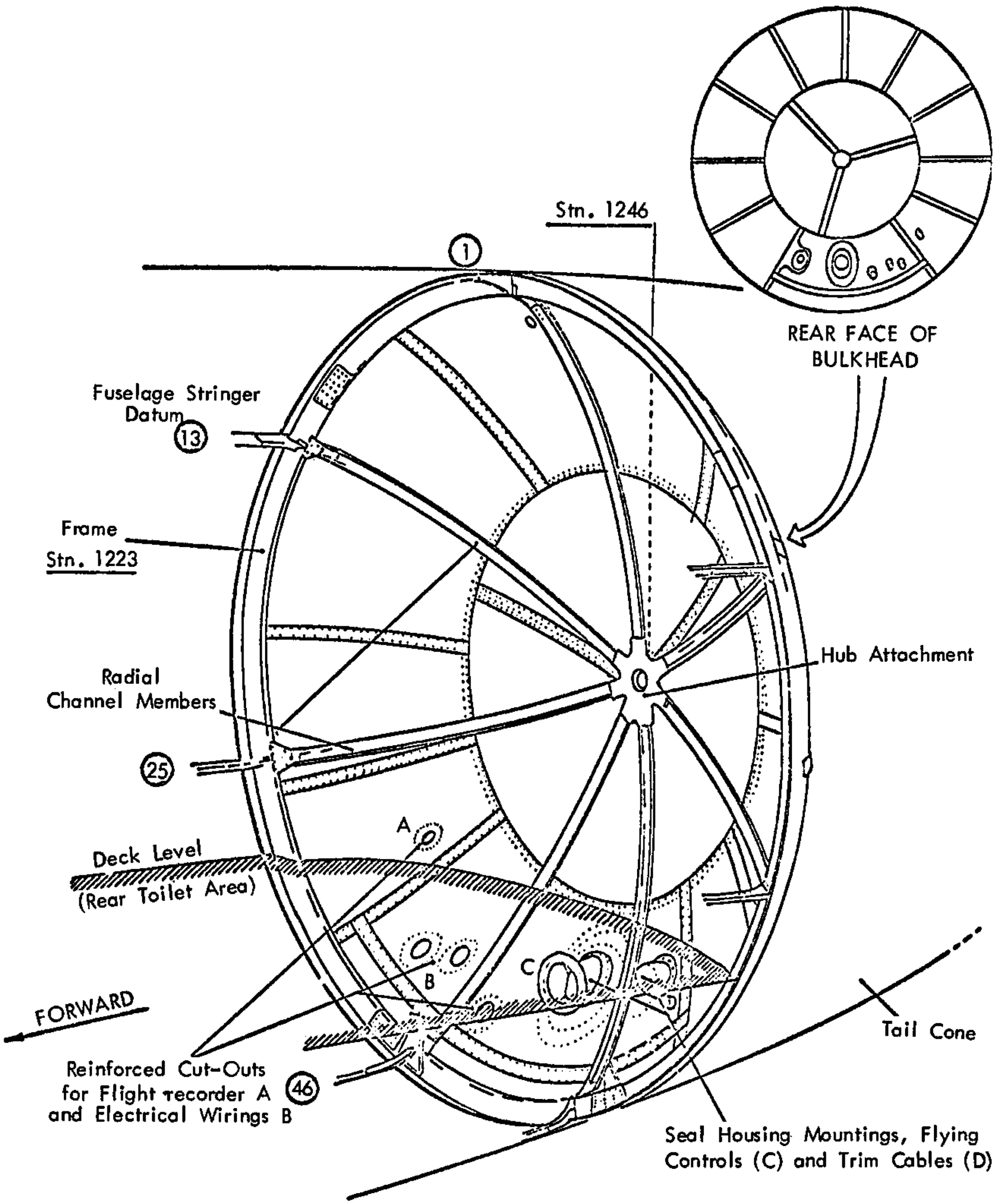

FIGURE 2-8 TYPICAL BASE OF BULKHEAD

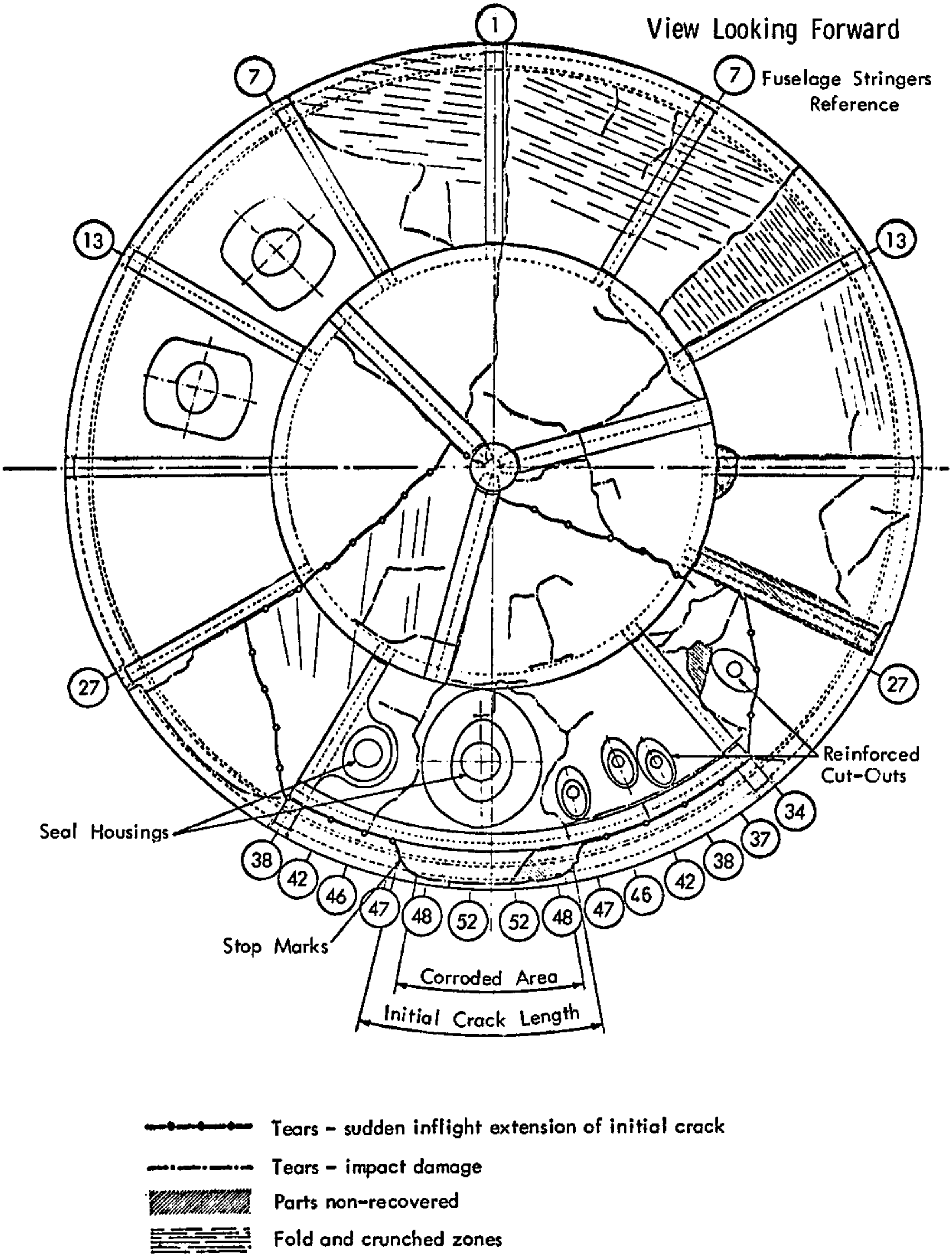

FIGURE 2-9 TEARS IN REAR PRESSURE BULKHEAD

CHAPTER 14. CORROSION PROTECTION FOR AGRICULTURAL AIRCRAFT

151. GENERAL. Practically all chemicals used in dusting and spraying operations are corrosive by nature and hasten deterioration of fabric, metal, and wood. It is essential to safe operation that precautions be taken to prevent corrosion and deterioration of wood, metal, and fabric. Cleanliness of the airplane is one of the most important precautions of all. If it were practicable and feasible to clean the airplane thoroughly, that is, give it a thorough dry washing inside and out after each day's work, probably no special corrosive preventative measures would be necessary..

152. PRECAUTIONS. Since thorough daily cleaning is not practicable, the following precautions should be taken:

a. All fittings and metal structures should be covered with two coats of zinc-chromate primer, paralketone, or similar materials. This coating should be applied to items such as wing-root fittings, wing-strut fittings, control-surface hinges, horns, mating edges of fittings and attach bolts, etc.

b. Nonstainless steel control cables should be coated with paralketone or other similar protective coating, or should be replaced with corrosion-resistant cables.

c. Periodic inspection of all critical portions of the aircraft structure should be made. Structural parts showing corrosion should be cleaned and refinished if the corrosion attack is superficial. If the part is severely corroded, it should be replaced with a corrosion proof part.

d. Experience has shown that additional access openings to permit ready inspection of lower and rearward portions of the fuselage are particularly desirable.

e. Provide additional drainage and ventilation for all interiors to prevent collection of moisture.

f. At the time of recovering, both metal and wood airplane structural members should be coated with zinc-chromate primer (two coats), followed by dopeproof paint or wrapping with cellophane tape.

g. Spray interiors of metal-covered wings and fuselages with an adherent corrosion inhibitor.

h. Wash exterior surfaces with clear fresh water at least once a week. Interior surfaces should also be washed, taking care to prevent damage to electrical circuits or other items subject to malfunctioning due to moisture.

i. Openings in the wings, fuselage, and control-surface members, such as tail-wheel wells, openings for control cables, etc., should be sealed as completely as possible to prevent entry of dust or spray.

153.-155. RESERVED.

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ADVISORY CIRCULAR

CORROSION CONTROL FOR AIRCRAFT

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Initiated by: AFS-302

AC NO: 43-4

DATE: 5/15/73

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: CORROSION CONTROL FOR AIRCRAFT

1. PURPOSE. This advisory circular is a summary of current available data regarding identification and treatment of corrosive attack on aircraft structure and engine materials. Corrosion identification, treatment, and frequency of inspection therefor continues to be the responsibility of the specific air carrier and will be in accordance with the carrier's maintenance program.

2. REFERENCES.

   a. Advisory Circular 65-9, Airframe and Powerplant Mechanics, General Handbook.

   b. Advisory Circular 65-12, Airframe and Powerplant Mechanics, Powerplant Handbook.

   c. Advisory Circular 65-15, Airframe and Powerplant Mechanics, Airframe Handbook.

   d. Bureau of Naval Weapons, Navweps 01-1A-509, Corrosion Control For Aircraft.

   e. U.S. Air Force Technical Order 1-1-2, Corrosion Control And Treatment For Aerospace Equipment.

3. BACKGROUND. Corrosion is the deterioration of materials through chemical or electrochemical attack. While new and better materials are continuously being developed, this progress is offset in part by a more agressive operational environment. This problem is compounded by the fact that corrosion is an exceedingly complex phenomenon; it can take many different forms and the resistance of aircraft materials can drastically change with only a small environmental change.

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4. CONCLUSIONS. Corrosion is a natural phenomenon. To speak of "eliminating" corrosion is to indulge in an illusion. However, in most cases the rate of corrosive attack can be reduced to an acceptable level by control. The answer, in part, is to maintain protective films and sealants that keep corrosive agents from contacting metallic surfaces. Cleanliness is of equal importance because for all practical purposes a clean dry surface is not corrosion prone. Frequent inspections are a "must" to ensure that corrosion will be detected and treated at the earliest possible opportunity.

Today's corrosion problems must be combatted with control methods currently available. Improved methods will probably be found in the future as research in the field of corrosion continues and new knowledge becomes available. However, to postpone inspections or corrective action because something new in corrosion control is "just around the corner" is ultimately an expensive proposition.

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CHAPTER 1. CORROSION CONTROL

1. INTRODUCTION. Corrosion and its control are of primary importance to all operators. Corrosion weakens primary structural members, and if allowed to continue they must be replaced or reinforced in order to sustain loads to which they may be subjected. Such replacements or reinforcements are costly and time-consuming, resulting in unscheduled delays and frequently in keeping the airplane out of service for a considerable time. Preventive maintenance of the aircraft on a regular schedule, as with any valuable equipment, is the only sound practice. It minimizes the cost of total labor expended and productive time lost. It puts both of these costs on a predictable basis and removes uncertainty and guesswork on the actual condition of the equipment.

2. BACKGROUND. Corrosion is a natural phenomenon which destroys metal by chemical or electrochemical action and converts it into a metallic compound such as an oxide, hydroxide, or sulfate. The tendency of most metals to corrode creates one of the major problems in the maintenance of the aircraft particularly in areas where adverse atmospheric or weather conditions exist. See figures 1-1, 1-2, and 1-3.

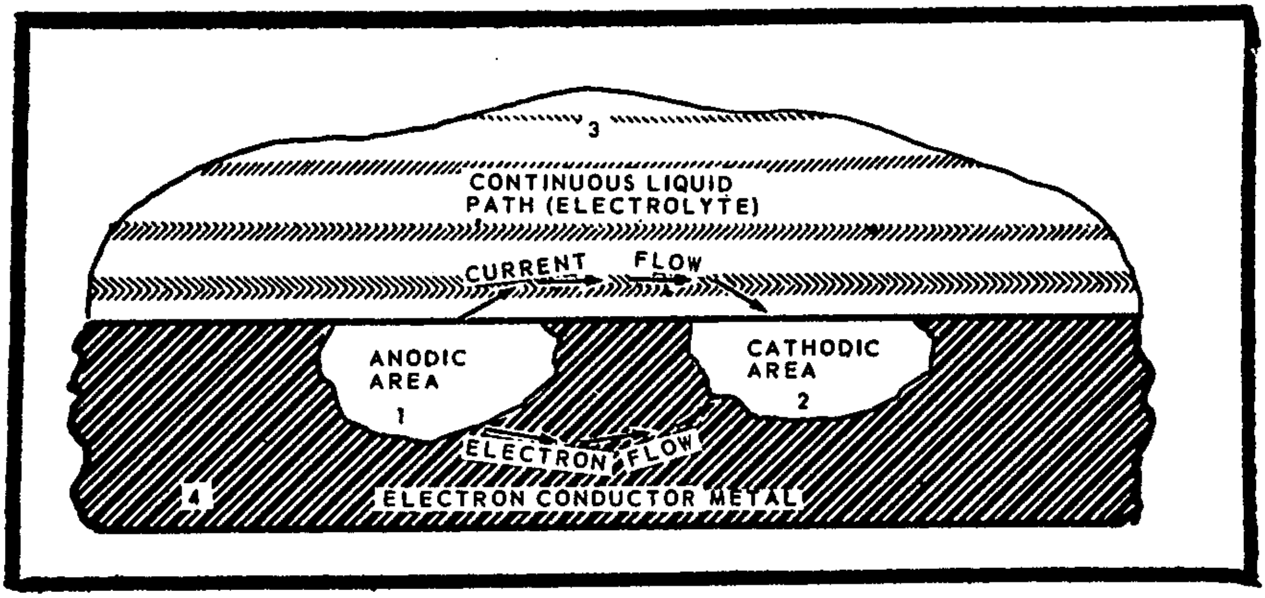


Figure 1-1. Simplified Corrosion Cell Showing Conditions Which Must Exist for Electrochemical Corrosion.

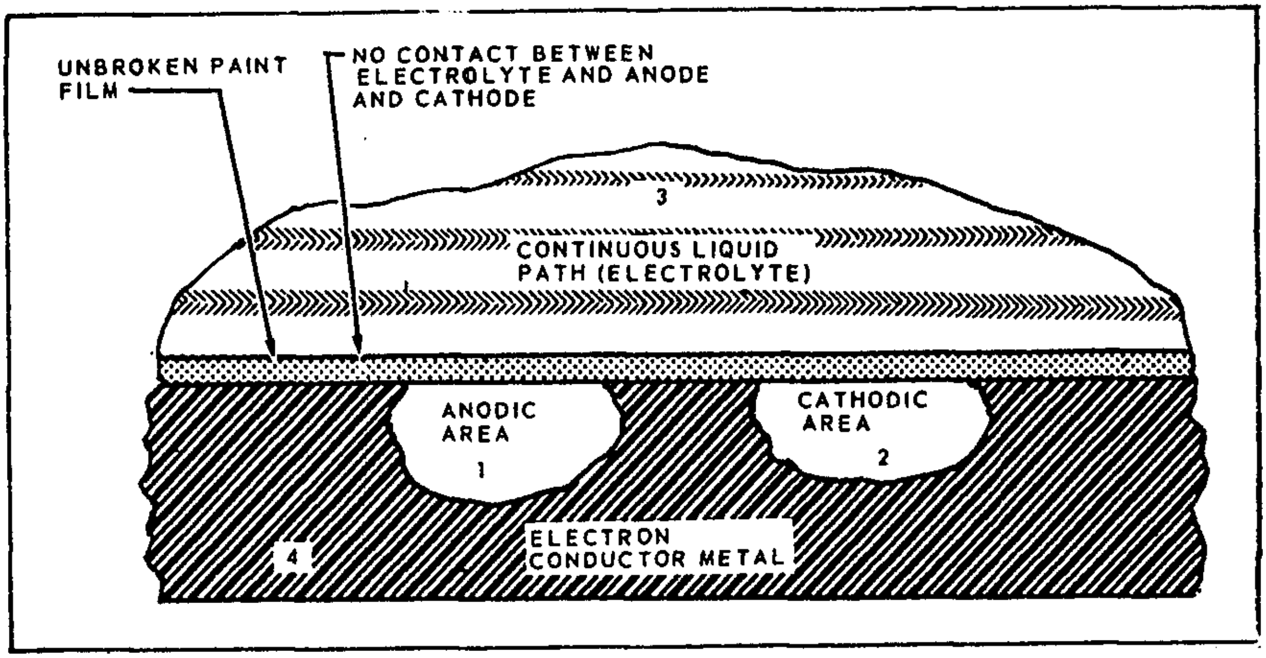


Figure 1-2. Elimination of Corrosion By Application of an Organic Film to Metal Surface.

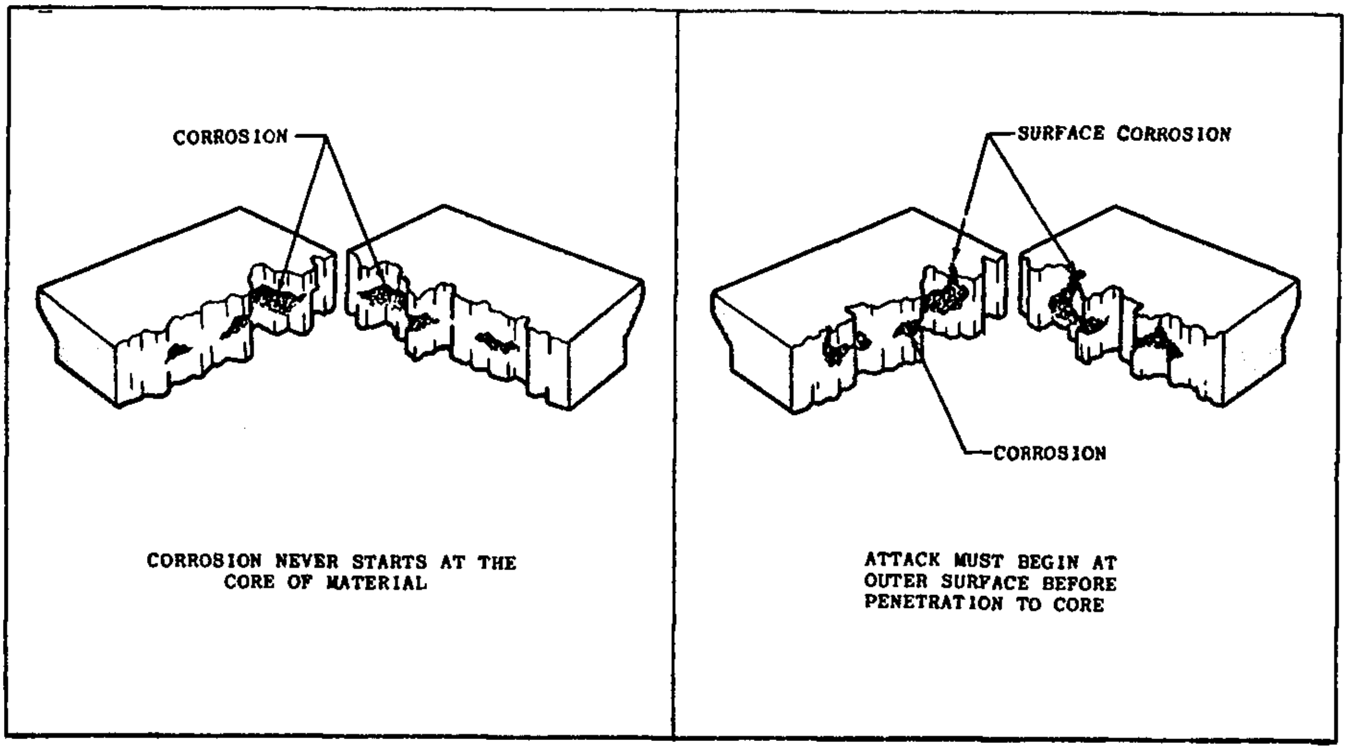


Figure 1-3. Corrosion Attack

3. METAL CLAD. 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 with more corrosion resistant aluminum (alclad). Under normal conditions (that is, when not in contact with salt, dissimilar metals or harmful chemicals) the alclad aluminum is highly resistant to corrosion. However, accumulated soil, salts, industrial fumes and moisture will cause pitting of the alclad surface.

4. METALS, NON-CLAD. Other metals commonly used in airframe structures, such as non-clad high strength aluminum alloys and steel and magnesium alloys, require special preventive measures to guard against corrosion. Aluminum alloys, for example, are usually anodized or chemically treated and painted. Steel (except most stainless steels) and other metals such as brass and bronze require cadmium or zinc plating, or conversion coating, or all three for protection. Magnesium alloys are highly susceptible to corrosion attack especially in marine environments. These materials require special chemical and electrochemical treatments and paint finishes.

5. FACTORS IN CORROSION CONTROL. The degree of severity, the causes, and types of corrosion depend on many factors including the following:

a. Section size. Thick structural sections are generally more susceptible to corrosive attack because of variations in their composition. 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 insure the integrity and strength of major structural parts and maintaining permanent protection over such areas at all times.

(1) When two dissimilar metals are used, contact may develop. If the more active member of the pair is small compared to the less active member, the attack will be severe and extensive depending upon the breaking down of the insulation. If the cathode, or less active member, is small compared to the anode, anodic attack will be superficial or general.

(2) For example, an aluminum fastener in contact with a relatively inert titanium structure may corrode severely, while a titanium bracket secured to a large aluminum member would result in a relatively superficial attack of the aluminum sheet.

b. Material selection. 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. Materials must be selected primarily for structural efficiency, however, and corrosion resistance is necessarily a secondary consideration in design.

(1) 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 constructing airframes, the primary means of preventing corrosion is by use of protective coatings and proper maintenance procedures.

(2) 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 shifted and increased in severity.

(3) 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 have been used as the primary structural materials.

c. Geographical location and environment. This factor concerns systems exposed to marine atmospheres, moisture, tropical temperature conditions, industrial chemicals, and soils and dust in the atmosphere. This factor naturally is controlled by the requirement for operating at specific geographical locations which are not corrosion prone.

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

e. Preventive maintenance. The most vital factor in preventive maintenance, that can be controlled only by field personnel, is the removal of the electrolyte. The term "electrolyte" refers to contaminating materials (moisture, salt, dirt, grease, fluids, etc.) that come in contact with metal surfaces. The resulting corrosive effect is determined by the composition of the contamination, the type of metal and the length of time they remain in contact. The more frequently a surface is cleaned, the less the possibility of corrosive attack. Anodic and chemical treatments, as well as proper paint finishes should be applied in critical areas to protect aluminum and magnesium alloys and steels. These coatings provide a barrier to inhibit the action of corrosive environment. (See Figures 1-4 and 1-5.)

6.-9. RESERVED.

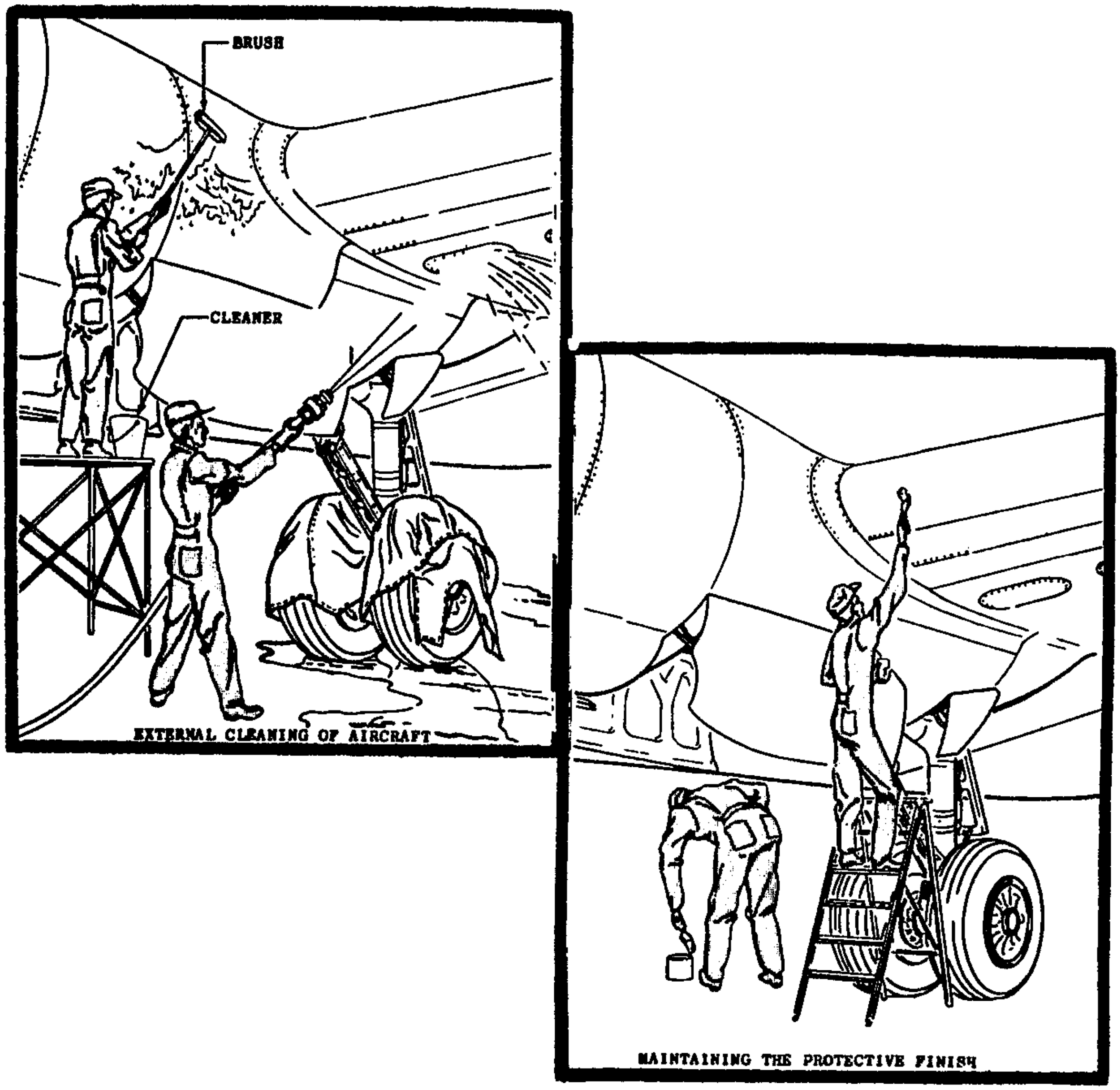


Figure 1-4. Cleaning and Maintenance of Protective Finish

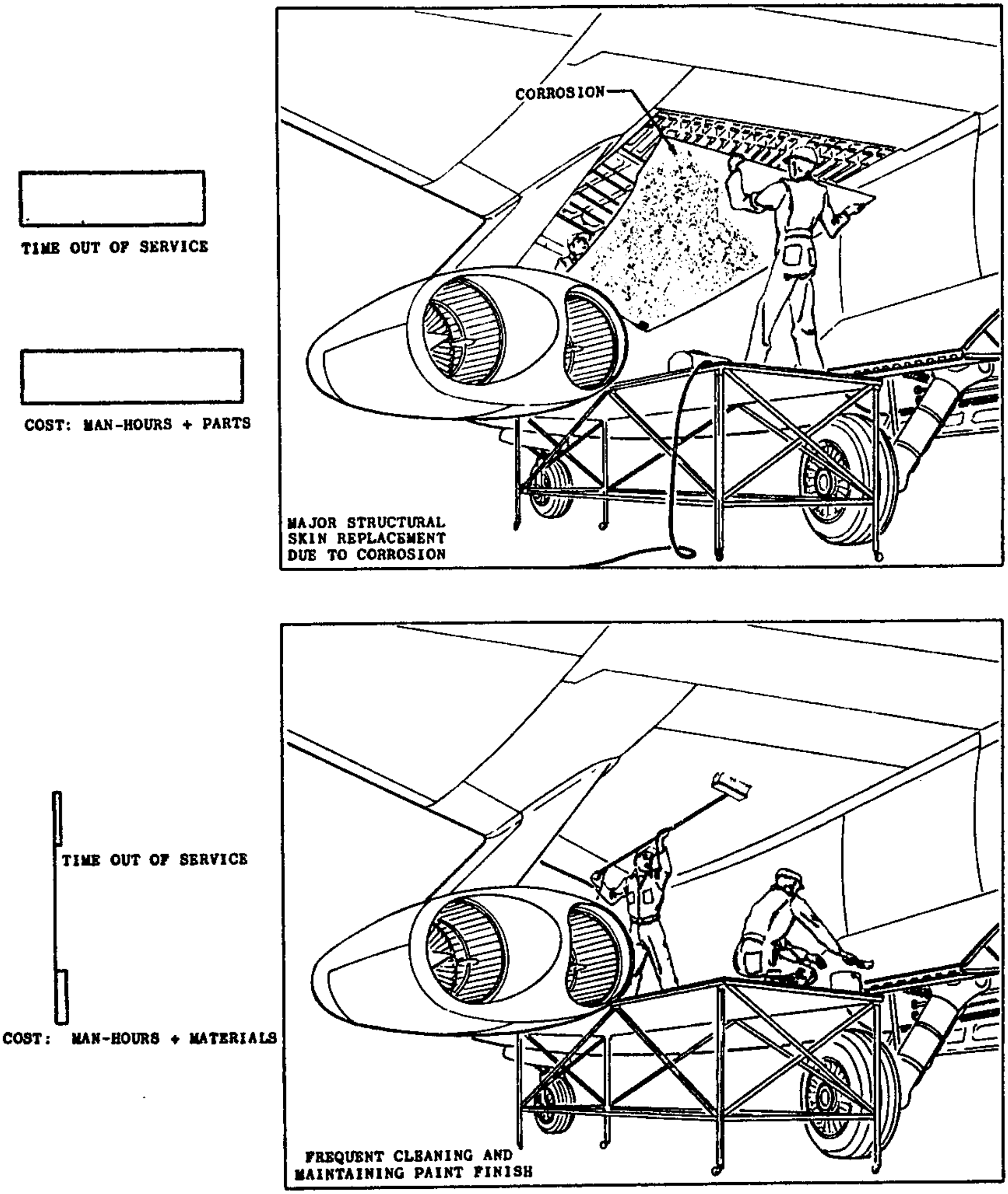


Figure 1-5. Comparison of Neglect Versus Proper Preventive Maintenance

CHAPTER 2. CORROSION PRONE AREAS

10. GENERAL. This chapter lists corrosion problem areas that are common to all aircraft. The list is not necessarily complete, but could be used to set up a maintenance inspection program.

11. 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 2-1. 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 in the horizontal tail surfaces will be considerably slower and sometimes completely absent from certain aircraft models.

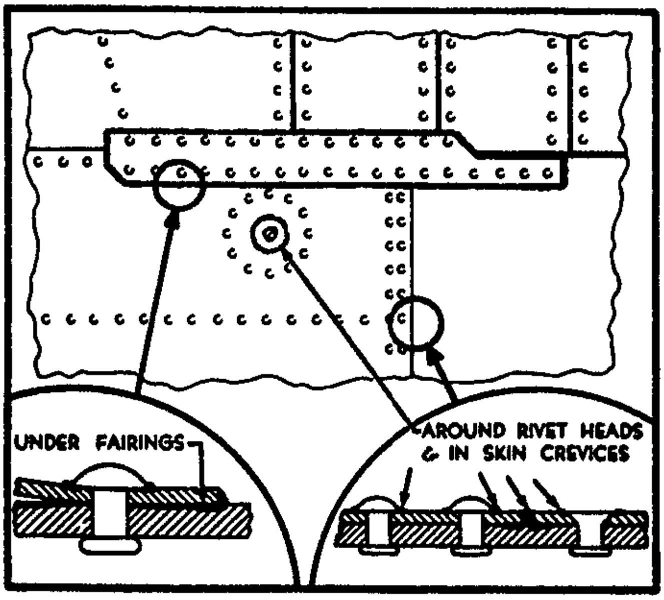


Figure 2-1. Exhaust Trail Area Corrosion Points

12. 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. 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.

13. 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 sets up a hidden chemical cell. Keeping bilge areas free of all extraneous material, including oil, will insure best protection against corrosion. A good vacuum cleaner is necessary to clean such areas.

14. 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 keep paint touched up.

15. 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 2-2.)

a. Frequent cleaning, lubrication, and paint touchup 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) Axle interiors.

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

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

(5) Magnesium wheels, particularly around bolt heads, lugs, and wheel web areas, especially for the presence of entrapped water and its effects.

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

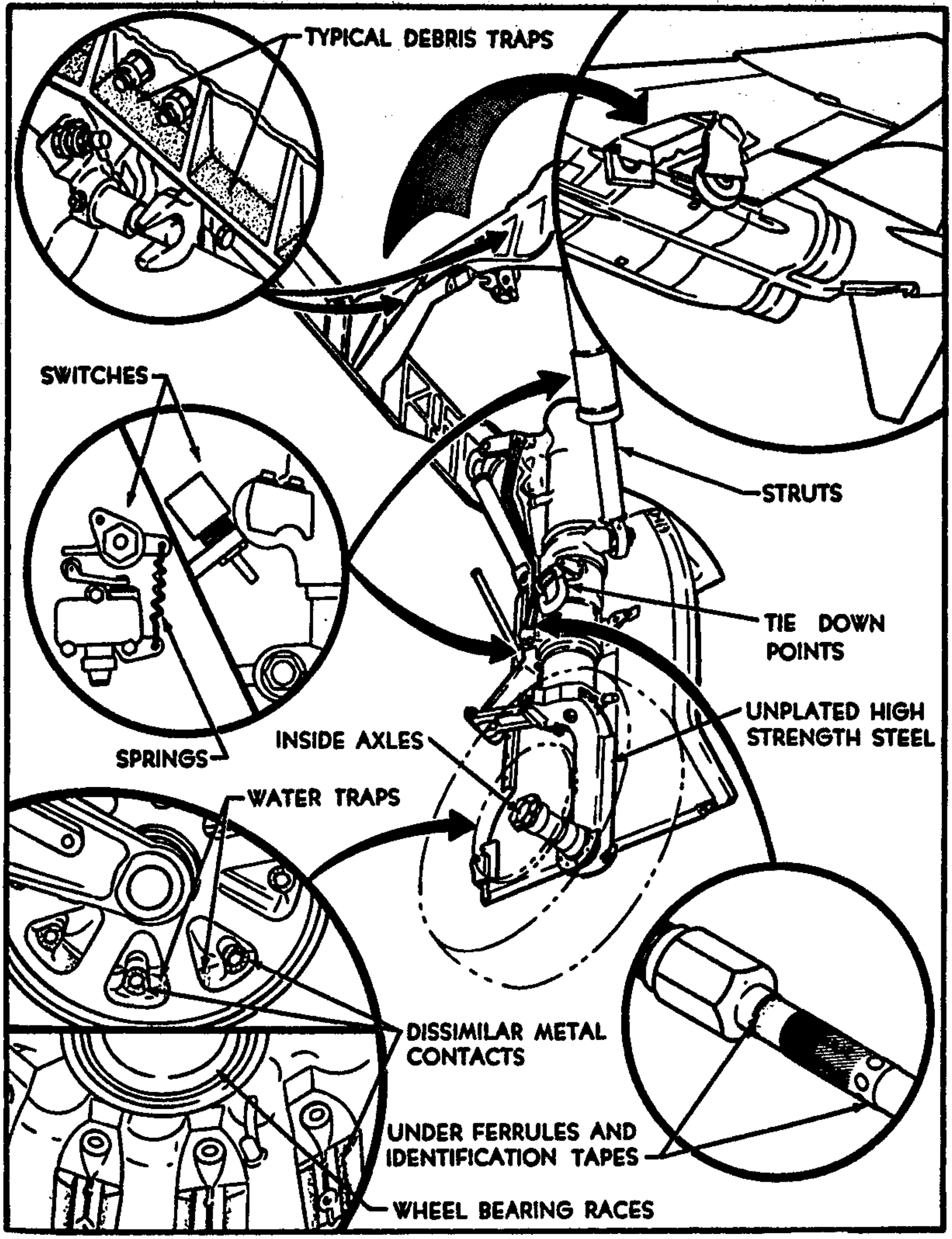


Figure 2-2. Landing Gear and Wheel Corrosion Points

16. EXTERNAL SKIN AREAS. External aircraft surfaces are ordinarily covered with protective paint coatings and are readily visible or available for inspection and maintenance. Much emphasis has been given to these areas in the past, and maintenance procedures are considered as being fairly 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. 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. But trimming, drilling, and riveting destroy some of the original surface treatment which may not be completely restored by touchup procedures.

(1) Some aircraft have steel fasteners installed through magnesium skin with only protective finishes under the fastener beads or tapes 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 salt water attack, all of these conditions work up a potential corrosion problem whenever magnesium is used.

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

b. Spot-welded skins. Corrosion of this type of construction is chiefly the result of the entrance and entrapment of corrosive agents between layers of the metal. (See Figure 2-3.)

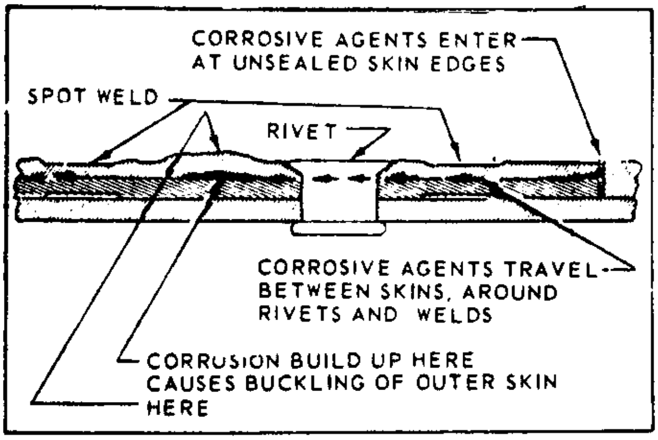


Figure 2-3. Spot-Welded Skin Corrosion Points

(1) Some of the corrosion may be caused originally by fabrication processes, but its progress to the point of skin bulging and spot-weld fracture is the direct result of moisture or salt water 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 spot weld 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 other external or internal faying surfaces but it is usually more prevalent on external areas. More advanced corrosive attack causes skin buckling and eventual spot-weld fracture. Skin buckling in its early stages may be detected by sighting along spot-welded 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 sealant.

c. Piano-type hinges. These are prime spots for corrosion due to dissimilar metal contact between the steel pin and aluminum hinge tangs. Further, they are also natural traps for dirt, salt, and moisture. Where this type of hinge is used on access doors or plates, they are actuated only when opened during an inspection and tend to freeze in closed position between inspections. When the hinges are inspected, they should be lubricated and actuated through several cycles to ensure complete penetration of the lubricant. (See Figures 2-4 and 2-5.)

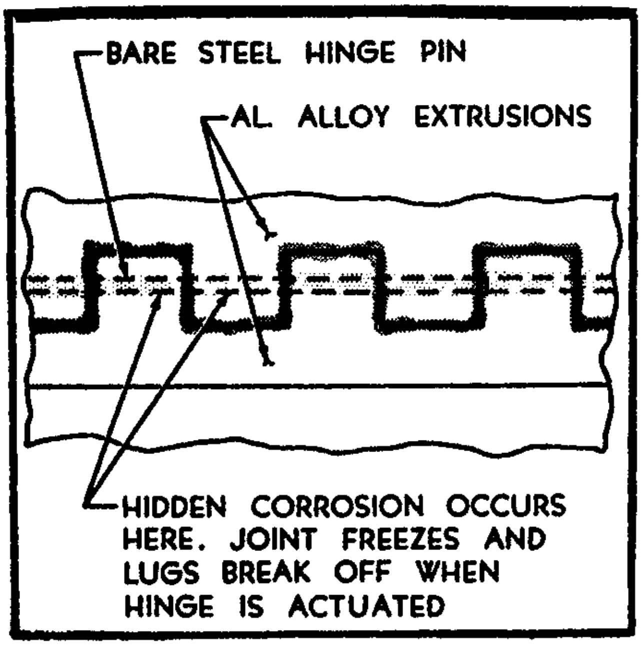


Figure 2-4. Hinge Corrosion Points

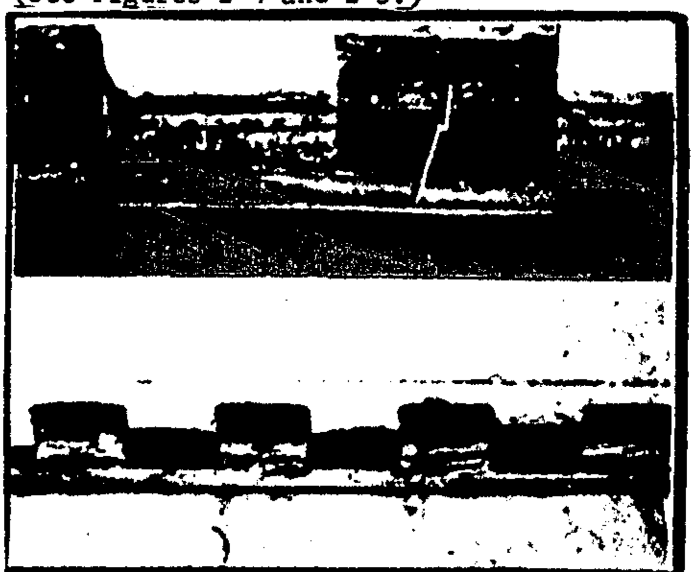


Figure 2-5. Hinge Failure Caused by Corrosion

d. Heavy or tapered aluminum alloy skin surfaces. Heavy or thick sections of heat treated aluminum alloys are susceptible to intergranular corrosion and exfoliation of the metal. When inspecting external skin surfaces, especially around counter-sunk fastener heads, look for metal exfoliation. This is usually first evident as small raised areas or bumps under paint film.

(1) Treatment of this corrosive attack must include removal of all layers of exfoliated metal, blending and polishing of the exposed edges of the damaged area, and restoration of protective surface finishes.

(2) Reworked areas should be well protected with a paint coating and carefully watched for any indications of renewed corrosive activity. Keeping susceptible surfaces well protected with a paint finish is the best defense against such attack.

17. WATER ENTRAPMENT AREAS. Corrosion will result from the entrapment of water. With the exception of sandwich structures, design specifications usually require that the aircraft have drains installed in all areas where water collects. In many cases, these drains are ineffective either due to improper location or because they are plugged by sealants, extraneous fasteners, dirt, grease, and debris. Potential entrapment areas are not a problem when all 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 lowpoint drains would be practical.

18. 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. Further, 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-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 2-6 and 2-7, next page.)

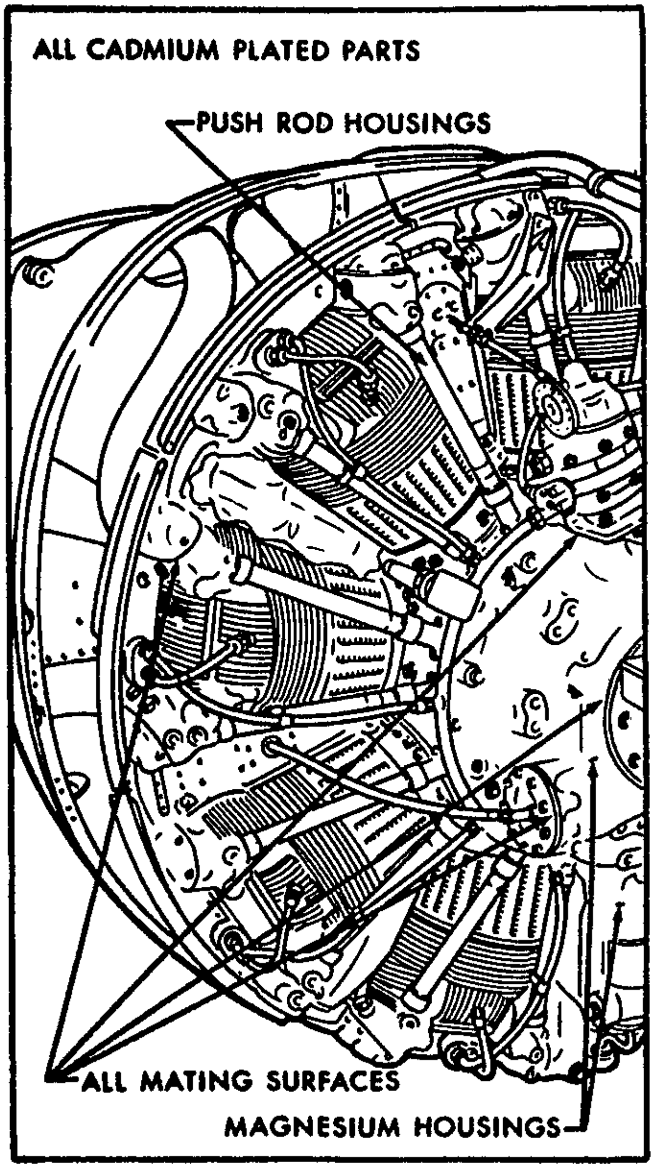


Figure 2-6. Reciprocating Engine Frontal Area Corrosion Points

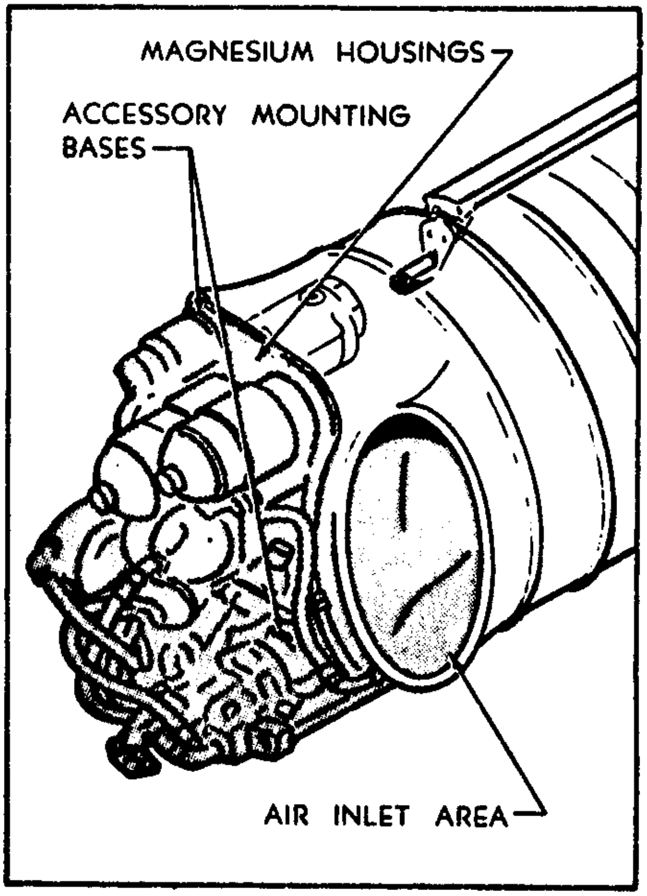


Figure 2-7. Jet Engine Frontal Area Corrosion Points

19. 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 the 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, advantage should be taken of component removals for other reasons with careful inspection for corrosion required before reinstallation.

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

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

a. Any hose assembly in which internal wire braid is present and located in a position subject to frequent water soakage requires some type of protective treatment. Any maintenance program should provide for inspection of installed hose assemblies and correction of those assemblies not previously treated.

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

c. Control cables may present a corrosion problem since plain carbon steel is being used for most applications. Even corrosion-resistant steel cables will corrode under marine operating conditions. The presence of bare spots in the preservative coating is one of the main contributing factors in cable corrosion. Cables should be inspected for condition at each scheduled inspection, followed by cleaning and corrosion-removal as necessary. A preservative should then be reapplied. 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.

d. Top coating materials (Buna - N) used in integral fuel cells are impervious to fuel but not completely impervious to water. Since it is impossible to keep fuel completely free of water, moisture does penetrate through the top coating materials and sometimes causes fretting or intergranular corrosion on aircraft structural parts. It has also been found that micro-organisms which live in fuel (particularly JP types) become attached to the top coating materials and sometimes result in deterioration of such materials. Defense against such attacks is well-managed storage facilities and adequate filtration of fuel. (JP is jet propellant, abbreviated).

e. Electrical connectors may have been potted with a compound to provide more reliability of equipment. The compound prevents entrance of water into the area of connectors where the wires are soldered to the pins.

(1) Loss of pressurization in compartments containing bulkhead connectors is also prevented. Rubber "O" rings are also used to seal moisture out of the mating area of pin connections.

(2) Moisture will occasionally get into electrical plugs and cause failure. Therefore, it is necessary that such plugs be disconnected for inspection. Maintenance personnel will have to determine exact inspection requirements on the basis of past trouble.

(3) Trouble has been found in electrical components, and provisions have not always been made to seal water from such equipment.

* f. Severe corrosion damage to the rear pressure bulkhead below the floor level may occur as a result of contamination by fluids. In the event the corrosion is hidden from visual inspection, the use of appropriate nondestructive testing methods is required.

A catastrophic aircraft accident was attributed to sudden cabin pressure loss through the rear pressure bulkhead. Prior inspection had not considered the possibility of serious corrosion occurring between the bulkhead and periphery doubler at the floor level. Following the accident, inspection access holes were incorporated in the bulkhead area and a revised inspection program was established to require more frequent inspections of the rear pressure *

* bulkhead below the floor level at both front and rear faces (see figures 2-8 and 2-9). A detailed examination with fiber optics can now be accomplished through inspection access holes which have improved aft accessibility. The doubler bond is checked from the forward face using dye penetrant for edge separation. The phasemaster NDT examination is used to detect corrosion and/or separation along the edge of the doubler. (The bonded area is not suitable for X-ray examination.) *

21.-25. RESERVED.

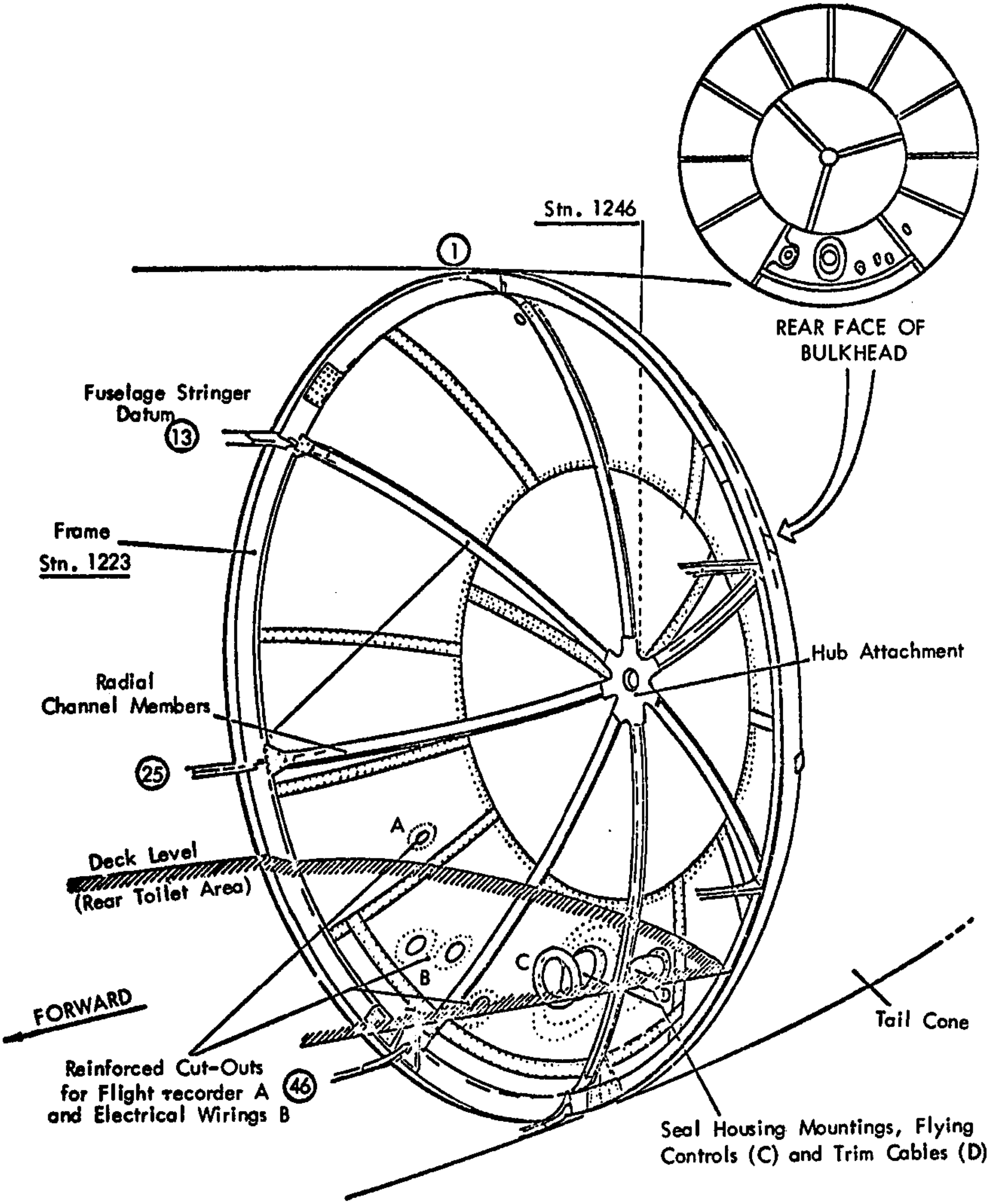


FIGURE 2-8 TYPICAL BASE OF BULKHEAD

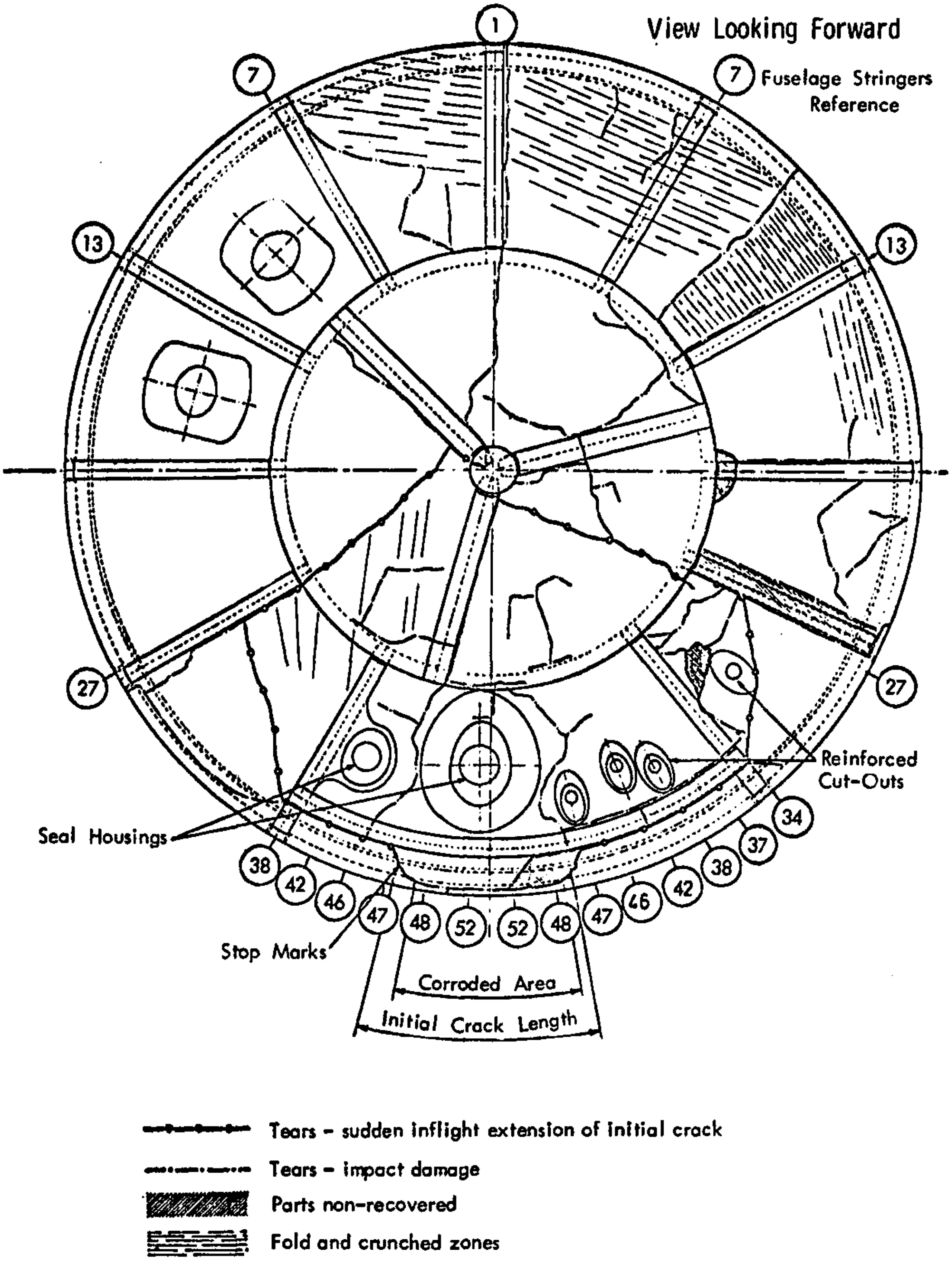


FIGURE 2-9 TEARS IN REAR PRESSURE BULKHEAD

CHAPTER 3. CORROSION DETECTION

26. PRIMARY APPROACH. The primary approach to corrosion detection is visual, but in situations where visual inspection is not feasible, other techniques must be used. The use of liquid dye penetrants, magnetic particle, X-ray, and ultrasonic devices has achieved some success but most of these sophisticated detectors are aimed toward the detection of physical flaws within metal objects rather than the detection of corrosion. These methods have had limited success in the detection of advanced corrosive attack such as stress corrosion cracking, corrosion fatigue cracks, and exfoliation. Visual inspection must be relied upon to find corrosive attack during its incipient stage.

27. VISUAL INSPECTION. A visual check of a metal surface can reveal several signs of corrosive attack, the most obvious of which is a corrosion deposit. Corrosion deposits of aluminum or magnesium compounds 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 on the metal surface. Surfaces protected by paint or plating may only exhibit indications of more advanced corrosive attack by the presence of blisters in the protective film, indicating that the corrosion product has a greater volume than that of the consumed metal. Bulges in lap joints may be indicative of a build-up of corrosion products, although the corrosive attack is well advanced.

b. Sometimes the inspection areas are obscured by structural members, equipment installations, or for some other reason they are awkward to check visually. Mirrors, borescopes, and the like can often provide the means to check an obscured area. The individual's ingenuity should be encouraged as long as the improvised inspection methods are thorough. Magnifying glasses are valuable aids for determining whether or not all corrosion products have been removed during clean-up operations.

28. X-RAY INSPECTION. One of the well-known maintenance tools for inspection of inaccessible areas is X-ray.

a. Briefly, "blind" areas can be inspected by passing X-rays through an object and recording the results on film. Areas of high density in the object are indicated on the film as underexposed areas, while areas of low density result in greater film exposure. X-ray film interpretation will indicate if any defects are present.

b. However, there are basic disadvantages to this form of inspection. First, there is the radiation hazard. Second, interpretation of the film image is likely to be meaningless to anyone but an expert.

c. A third drawback occurs when X-ray techniques are used for corrosion detection. Success in detection has occurred when corrosive attack is severe, coupled with some form of mechanical failure such as stress-corrosion cracking. The problem is the difficulty of evaluating the film image, for the contrast between a corroded area and an unaffected area or an area covered with sealant is not easy to discern.

29. MAGNETIC PARTICLE INSPECTION. This method may be used for the detection of cracks or flaws on or near the surface of ferro-magnetic metals (metals which can be magnetized). A portion of the metal is magnetized, and finely divided magnetic particles (either in liquid suspension or dry) are applied to the object. Any surface faults will create discontinuities in the magnetic field and will cause the particles to congregate on or above these imperfections, thus locating them. There are several limitations to the use of magnetic particle inspections on aircraft components.

a. First, this type of inspection can only be used on those parts that can be magnetized. Many of these parts (depending on their location) should be removed from the aircraft prior to testing because the induced magnetic fields created during the test could affect the operation of delicate instruments in the aircraft.

b. After the tests are concluded, the parts must be demagnetized prior to reinstallation for the same reason. Finally, the only types of corrosion that a magnetic particle inspection can detect are stress-corrosion or corrosion fatigue cracks.

30. LIQUID DYE PENETRANT. Inspection for large stress-corrosion or corrosion fatigue cracks on non-porous ferrous or non-ferrous metals may be accomplished by the use of liquid dye penetrant processes. The dye applied to a clean metallic surface will enter small openings such as cracks or fissures by capillary action. After the dye has had an opportunity to be absorbed by any surface discontinuities, the excess dye is removed and a developer is applied to the surface. The developer acts like a blotter and draws the dye from the cracks or fissures back to the surface of the part, giving visible indication of the location 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.

31. ULTRASONIC INSPECTION. Although ultrasonic inspections have been employed by industry for several years, it was not until recently that ultrasonics have been used as a means of corrosion detection. Presently, this method of corrosion detection is still in the developmental stage and is certainly not infallible, but it has been demonstrated that, within limitations, ultrasonics can provide a fairly reliable indication of corrosion attack. Highly trained personnel must conduct the examination if any useful information is to be derived from the indicating devices. This is compounded by the fact that the results obtained vary, depending on the model and make of equipment used, and on the techniques used by the individual performing the examination.

32.-35. RESERVED.

CHAPTER 4. INSPECTION REQUIREMENTS

36. GENERAL. Except for special requirements in trouble areas, inspection for corrosion should be a part of routine maintenance inspections; i.e., daily or preflight. Overemphasizing a particular corrosion problem when it is discovered and forgetting about corrosion until the next crisis is an unsafe, costly, and troublesome practice. Inspection for corrosion is a continuing problem and should be handled on a day-to-day basis. If corrosion control is assigned to a special crew or group, maintenance checks should be scheduled in such a way that these crews may accomplish their inspections and necessary rework while access plates are removed and components are disconnected or out of the way.

a. Most handbooks of inspection requirements are complete enough to cover all parts of the aircraft or engine, and no part or area of the aircraft should go unchecked. Use these handbooks as a general guide when an area is to be inspected for corrosion.

b. Trouble areas, however, are a different matter, and experience shows that certain combinations of conditions result in corrosion in spite of routine inspection requirements. These trouble areas may be peculiar to particular aircraft models but similar conditions are usually found on most aircraft operating in a marine environment.

37. FREQUENCY OF INSPECTIONS. In addition to the routine maintenance inspections, the following special requirements should be observed:

a. Aircraft operating in a marine atmosphere should be given a special check for corrosion at least once a week.

b. Aircraft operating under semi-arid conditions require an evaluation for condition at least on a monthly basis.

c. Checks should be performed by a crew familiar with corrosion problems and the nature of their treatment.

38. RECOMMENDED DEPTH OF INSPECTION. Generally speaking, the applicability of inspection requirements provides a ready means to insure adequate inspection of all compartments and interior aircraft cavities. When such general requirements are observed, along with a periodic check of the list of common trouble areas, adequate maintenance should be assured for most operating conditions. To assist in assuring complete coverage, the following summary is included:

a. Daily and preflight inspection. Check engine compartment gaps, seams and faying surfaces in the exterior skin; all bilge areas, wheel and wheel well areas, battery compartments, fuel cell drains; and engine frontal areas, including all intake vents.

b. In-depth inspections. In addition to the above more common trouble spots that are readily available for inspection, remove screw-attached panels, access plates, and removable skin sections as necessary to thoroughly inspect the internal cavities. Inspection should also include removal of questionable heavy internal preservative coatings, at least on a spot check basis.

39.-40. RESERVED.

CHAPTER 5. FORMS OF CORROSION

41. CORROSIVE ATTACK. This may have many forms which may occur singly, or in conjunction with each other. When combined with other factors such as stress or fatigue, more forms of corrosive attack may be produced.

42. UNIFORM ATTACK. This form of corrosive attack is spread evenly over large areas of the affected surfaces. Generally, though, the corrosion rate will be about the same over all of the affected portions of the surface. The amount of damage caused by uniform attack is ordinarily determined by comparing the thickness of the corroded metal with that of an undamaged specimen. Uniform corrosion is usually due to direct chemical attack, although electro-chemical attack is not uncommon. A familiar type of uniform attack is caused by the reaction of metallic surfaces with airborne chlorine or sulphur compounds, oxygen, or moisture in the atmosphere and often combinations of these agents may attack a surface simultaneously. Reactive compounds from exhaust gases as well as fumes from storage batteries frequently cause uniform attack.

43. LOCALIZED CORROSION. Corrosive attack is often localized in well-defined areas rather than spread uniformly over an entire surface. Localized corrosion forms are of electro-chemical nature and are categorized as pitting or selective attack.

a. Pitting. Corrosion of this type is confined to very small areas of the metal surface, while the remainder of the surface is unaffected. The corrosion pits are usually randomly located over the surface. Some preferential attack may occur at the grain boundaries of the metal. Usually, the pit has a rather short, well-defined edge with walls that run almost perpendicular to the surface of the metal. All forms of pits have one thing in common regardless of their shape. They may penetrate deeply into a structural member and cause damage completely out of proportion to the amount of metal consumed.

(1) It can be said with a high degree of certainity that pitting results from the chemical action of moisture, acid, alkali, or saline solutions on the metal after the paint surface oxide or other protective film has either been removed or penetrated.

(2) The factors which provide for the origin of pits is a subject of controversy among the metallurgists. However, pits originate in localized areas and propagate by means of concentration cells or galvanic action.

(a) Galvanic cells may originate from localized differences of materials in the surface of an alloy, for the dissimilar metals in alloys provide a basis for galvanic action within the alloys themselves. If an electrolytic medium is provided (like the condensation from a salt-air atmosphere), the metal can literally destroy itself.

(b) Concentration cells, as was mentioned earlier, depend on areas of varying concentrations of dissolved oxygen or metal ions within a solution. Such cells occur in places where water or some other solution that has the potential of being an electrolyte becomes entrapped. If water is allowed to stagnate in a metallic structure, either an oxygen or metal ion concentration cell can develop and sometimes both types will develop simultaneously. (See Figures 5-1 and 5-2). The small deposits of corrosion products may often give an indication of the damage that has been sustained. Measures should be taken, for this reason, to remove corrosion upon its first appearance rather than wait until it is large enough to "bother" with. The latter has resulted in expensive repairs while a little foresight would have paid dividends.

(3) Two forms of corrosion are known by the places where they develop. Crevice corrosion occurs between two pieces of material that are in contact. These two materials may be made of the same metal, dissimilar metals, or in some cases one of the parts may not be a metal at all. The crevice provides an entrapment area for an electrolyte to accumulate, thus encouraging corrosive attack. Another type, deposit attack, occurs when concentration cells form on or near discontinuous deposits of foreign substances on damp metal surfaces.

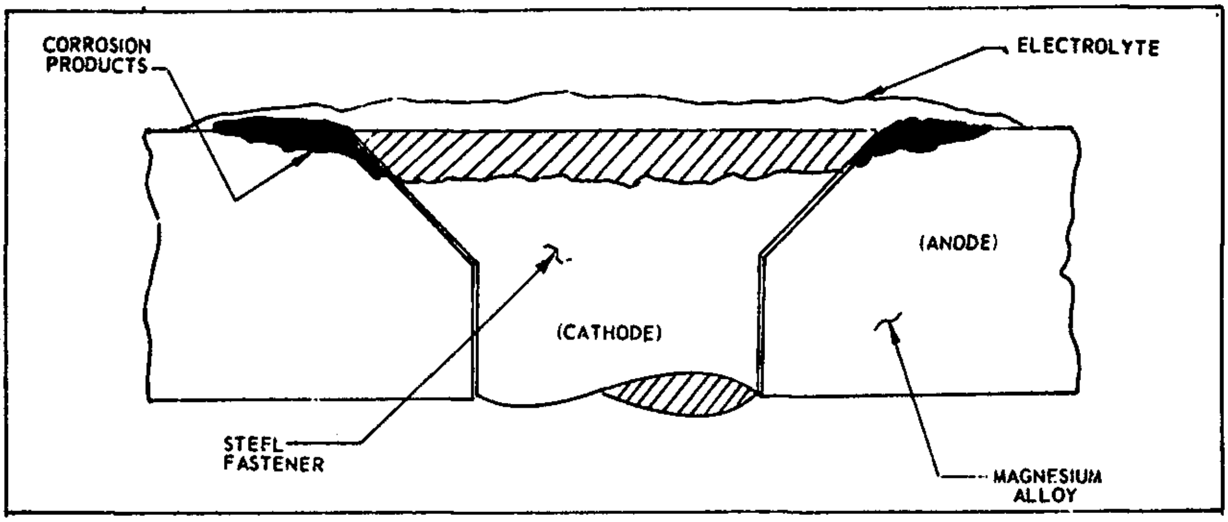


Figure 5-1. Galvanic Corrosion of Magnesium Adjacent to Steel Fastener.

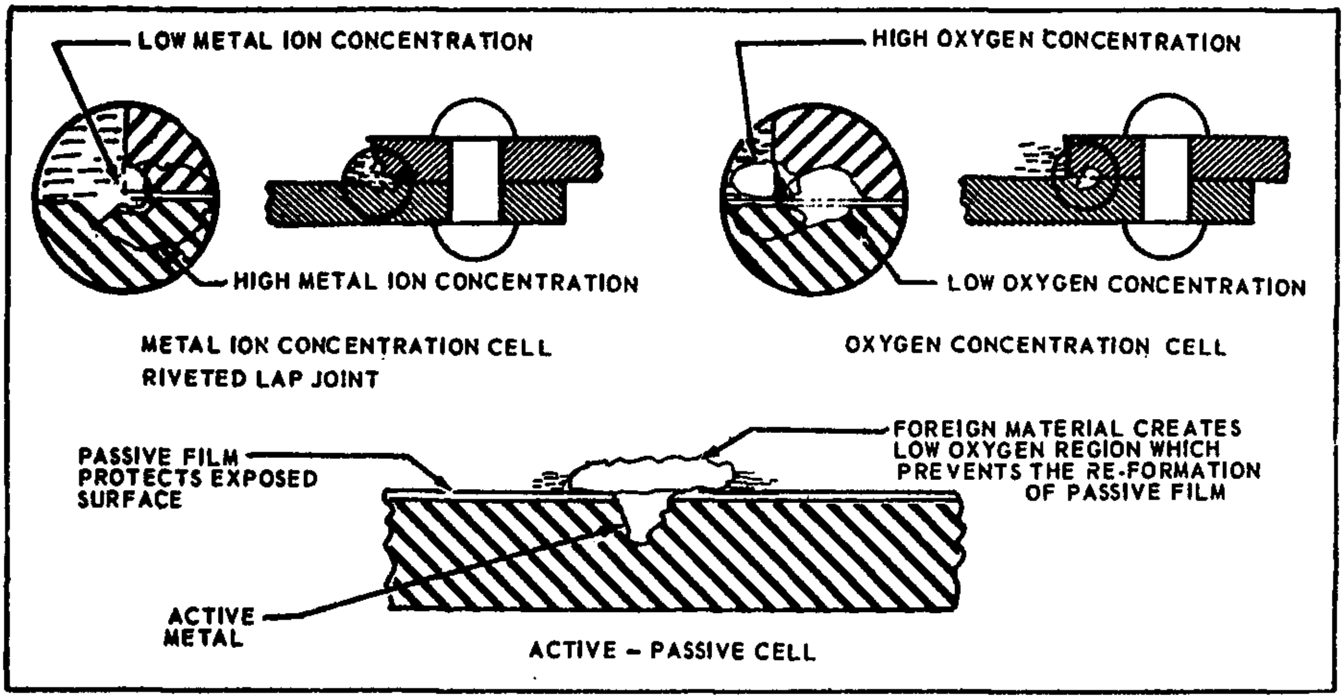


Figure 5-2. Concentration Cell Corrosion.

b. Selective attack. Some forms of corrosion seem to discriminate against one particular phase or constituent of an alloy while other phases are evidently ignored. This type of corrosion is called selective corrosion. The attack generally begins with pitting and progresses inward until it reaches other susceptible areas like the boundaries between grains or boundaries between different phases or constituents.

(1) The main form of selective attack is intergranular attack. This attack is centered on the boundaries of the metal grains, first consuming the material between the grain boundaries, and then attacking the grains themselves. Like pitting, the damage from this form of attack causes a loss of strength and ductility highly out of proportion to the amount of the metal destroyed. (See Figure 5-3.)

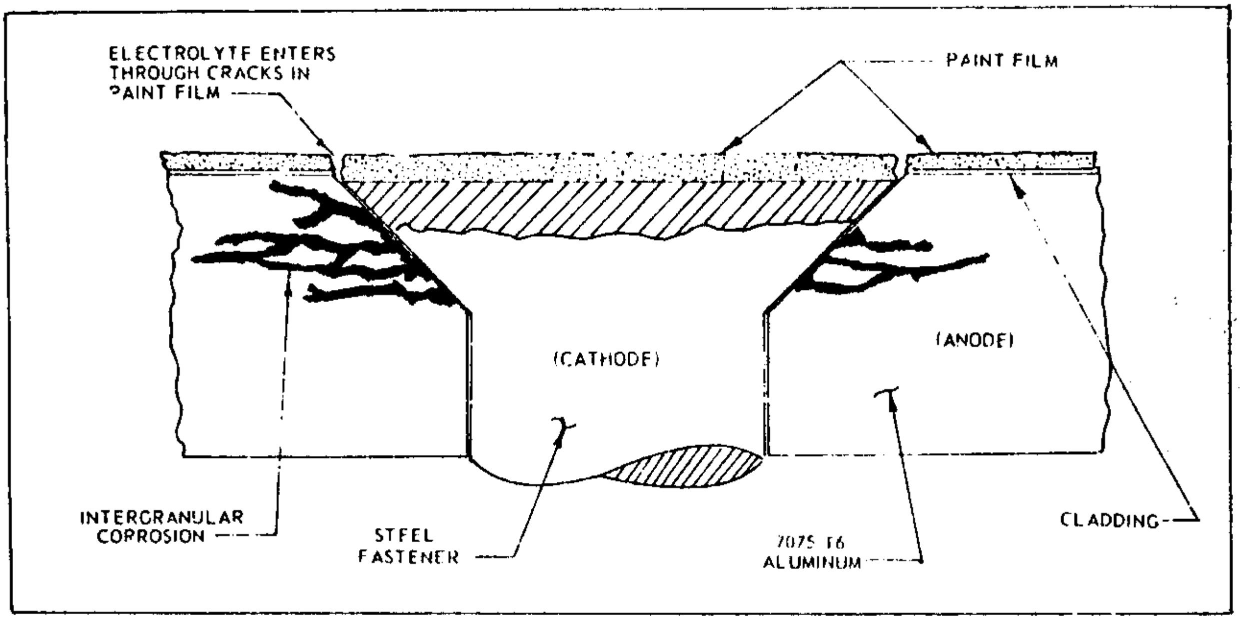


Figure 5-3. Intergranular Corrosion of 7075-T6 Aluminum Adjacent to Steel Fastener.

(2) Exfoliation is a severely destructive form of intergranular corrosion characterized by the actual leafing-out of corroded sections of metal away from the rest of the part. This type of corrosion is found most often on extruded parts because the forming process elongates the grains of the metal. The corrosive attack on the grain boundary material produces corrosion products which take up more volume than that originally occupied by the unaffected grain boundaries, causing the part to swell. By the time exfoliation is detected, the intergranular attack usually is so advanced that the static strength of the part is impaired due to the reduction of its effective cross-sectional area.

(3) Weld decay is another form of intergranular corrosion. It occurs because the process of welding often produces an undesirable heat treatment adjacent to the welded area, in turn producing separate phases of the metal, one of which may be preferentially attacked under adverse environmental conditions.

(4) Filiform corrosion on aircraft skin. This "worm-like" corrosion has shown up in recent years primarily under polyurethane paint. Improved corrosion resistant primers have helped the condition. Reference: Douglas Service letter dated April 9, 1969.

44.-45. RESERVED.

CHAPTER 6. CORROSION AND MECHANICAL FACTORS

46. GENERAL DISCUSSION. Corrosive attack is often aggravated by mechanical factors that are either within the part or applied to the part, such as residual, static or cyclic stress forces, erosion, or poor heat treatment techniques. Corrosive attack that is aided by some mechanical factor usually causes the part to degenerate at an accelerated rate compared to the rate at which the same part would deteriorate if it were subjected solely to corrosive attack. Environmental conditions and the composition of the alloy also influence the extent of attack. Examples of this kind of alliance are stress-corrosion cracking, corrosion fatigue and fretting corrosion.

47. STRESS CORROSION CRACKING. Fracture of metal parts attributed to the combined effects of static applied loads or residual stresses within the metal plus corrosive attack are grouped under the term "stress-corrosion" cracking. Just what constitutes a case of this type may be difficult in determining but the following indications appear with reasonable consistency.

a. The damage is caused by the combined action of sustained stress and corrosive environment applied at the same time.

b. The actual event occurs in two stages: the period of crack initiation, and the period of crack propagation.

c. Generally, crack initiation results from a physical breakdown of protective surface films and the subsequent corrosive attack on the part. Crack propagation often involves an electro-chemical attack on the surfaces of the crack, particularly at the crack's apex, in conjunction with the application of stress forces.

d. The rate of corrosive attack on the sides and outer surfaces of the crack is low in comparison to the rate of attack at the apex of the advancing crack.

e. The cracks may be either intergranular (between the grains) or transgranular (across the grains), but they will be predominantly one way or the other on one particular part. A considerable number of factors determine the direction of crack propagation, such as the alloy type, changes in the composition of the alloy or its environment, the type of heat treatment, the method of metal forming, ad infinitum. Finally, for each type alloy, specific environmental conditions must be present before stress-corrosion can occur.

48. CORROSION FATIGUE. Failure of a part when it is exposed simultaneously to corrosive attack and cyclic stresses is called corrosion fatigue. This type corrosion seems to begin at localized areas on the metal surface when the protective film on the part is ruptured by the push-pull bending induced by cyclic stresses.

a. The corrosive agent attacks the vulnerable localized area, causing a fissure (corrosion pit) to form. The pit continues to deepen until the part is so weakened that the ultimate in cracking occurs -- the part breaks.

b. This simple explanation does not intend to imply that only one pit per part is allowed. However, since the corrosion is highly localized, most of the part will be unaffected. Unfortunately, this is of little consolation if the part breaks.

49. FRETTING CORROSION. Damage can occur at the interface of two highly loaded surfaces which are not supposed to move against each other. However, vibration may cause the surfaces to rub together resulting in an abrasive wear known as fretting.

a. While the fit between two surfaces may be very tight, it is rarely tight enough to prevent oxygen or some other corrosive agent from entering and attacking unprotected surfaces. Mechanical fretting and chemical corrosion in combined action is referred to as fretting corrosion.

b. Many of the basic principles of fretting corrosion are not fully understood and most knowledge is limited to ferrous materials. A suitable lubricant applied generously seems to minimize wear on surfaces prone to this form of damage.

50. HEAT TREATMENT. Heat treatment of airframe materials must be rigidly controlled to maintain their corrosion resistance as well as to improve their essential mechanical properties. For example, improper heat treatment of clad aluminum alloy may change the grain structure of the cladding material and make it susceptible to intergranular corrosion, in turn providing paths for corrosive material to attack the core material.

a. Aluminum alloys which contain appreciable amounts of copper and zinc are highly vulnerable to intergranular corrosion attack if not quenched rapidly during heat treatment or given other special treatment. Aluminum extrusions and forgings, in general, may contain nonuniform areas which in turn may result in galvanic attack along grain boundaries.

b. This type of corrosion is difficult to detect in its original stage, although ultrasonic and eddy current inspections are being used. When the attack is well advanced the metal may blister or delaminate. This is referred to as exfoliation.

51.-55. RESERVED.

CHAPTER 7. COMMON CORROSIVE AGENTS

56. LIST OF AGENTS. Substances that are capable of causing a corrosive reaction sometimes are called corrosive agents. The most common corrosive agents are acids, alkalies and salts. The atmosphere and water, the two most common media for these agents, may sometime tend to act as corrosive agents too.

57. ACIDS. In general, moderately strong acids will corrode most of the alloys used in airframes. The most destructive are sulfuric acid (battery acid), halogen acids (hydrochloric, hydrofluoric and hydrobromic) and organic acids found in the wastes of humans and animals.

58. ALKALIES. Although alkalies as a group are generally not as corrosive as acids, aluminum and magnesium alloys are exceedingly prone to corrosive attack by many alkaline solutions unless the solutions contain a corrosion inhibitor. Particularly corrosive to aluminum are washing soda, potash (wood ashes), and lime (cement dust); however, one alkali, ammonia, is excepted because aluminum alloys are highly resistant to it. Magnesium alloys also are resistant to alkaline corrosive attack -- they develop a protective film when exposed to caustic alkaline solutions.

59. SALTS. It is difficult to generalize about salts, as corrosive agents. However, most salt solutions are good electrolytes and can promote corrosive attack. Some stainless steel alloys are resistant to attack by salt solutions but aluminum alloys, magnesium alloys and other steels are extremely vulnerable to some solutions containing salts. Exposure of airframe materials to salts or their solutions is extremely undesirable.

60. THE ATMOSPHERE. The major atmospheric corrosive agents are oxygen and airborne moisture, both of which are in abundant supply. Corrosion often results from the direct action of atmospheric oxygen and moisture on metal, and the presence of additional moisture often accelerates corrosive attack, particularly on ferrous alloys. However, the atmosphere is also cluttered with many other corrosive gases and contaminants. Two specific types -- industrial and marine atmospheres are unusually corrosive.

a. Industrial atmospheres contain many contaminants, the most common of which are partially oxidized sulfur compounds. When these sulfur compounds combine with moisture, they form sulfur based acids that are highly corrosive to most metals. In areas where there are chemical industrial plants, other corrosive atmospheric contaminants may be present in large quantities, but such conditions are usually confined to a specific locality.

b. Marine atmospheres contain chlorides in the form of salt particles or droplets of salt-saturated water. Since saline moisture is electrolyte, it provides an excellent medium for corrosive attack on aluminum and magnesium alloys which are vulnerable to this type of environment.

61. WATER. The corrosivity of water will depend on the type and quantity of dissolved mineral and organic impurities and dissolved gases (particularly oxygen) in the water. Physical factors such as water temperature and velocity also have a direct bearing on the corrosivity.

a. The most corrosive of natural waters (sea and fresh waters) are those that contain salts. Water in the open sea is extremely corrosive, but waters in harbors are often even more so because they are contaminated by industrial waste and are diluted by fresh water.

b. The corrosivity of fresh water varies from locality to locality due to the wide variety of dissolved impurities that may be present in any particular area. However, soft water and rain water are usually considered to be very corrosive. Hard waters tend to be less corrosive to most metals because they are alkaline, but some metals such as alloys of aluminum and magnesium seem to be allergic to alkaline waters and corrode readily.

62. "BUGS." Micro-organisms live in jet fuel which are contaminated with water and iron oxides or mineral salts. Slime is formed by these fungoid creatures which often serve as excellent electrolytes and promotes excessive corrosion.

a. From the standpoint of corrosion prevention, it is necessary to keep aircraft fuel tanks clean and use only clean, water-free fuel. Water condensate must be drained from the fuel tank frequently. Further, fuel storage facilities should be monitored to ensure that the fuel is clean.

b. Biocide treatment may be used for control of micro-organisms in jet fuel tanks. Refer: Pratt and Whitney letter of August 10, 1967, subject: All jet engines, approval of Biobar JF fuel additive and Boeing Company wire dated September 7, 1968, referencing ATA 2800, Biocide for aircraft fuel.

63. METALLIC MERCURY CORROSION ON ALUMINUM ALLOYS. A number of airlines have experienced this phenomenon. It is quite serious because once started the corrosive action is rapid in both pitting and intergranular attack and very difficult to control. Radiographic inspection has been used to locate the small particles of spilled mercury.

64.-65. RESERVED.

CHAPTER 8. PREPARATIONS AND SAFETY PROCEDURES FOR CORROSION REMOVAL AND SURFACE REWORK

66. GENERAL. When active corrosion is visually apparent, a positive inspection and rework program is necessary to prevent any further deterioration of the structure. The following methods of assessing corrosion damage and procedures for rework of corroded areas could be used during cleanup programs. In general, any rework would involve the cleaning and stripping of all finish from the corroded area, the removal of corrosion products and the restoration of surface protective film.

a. All cleanup should be restricted to the allowable damage limits of the applicable structural manual but should those limits be exceeded during rework, the affected part should be repaired or replaced.

b. In cases of doubt, the aircraft manufacturer should be contacted for rework limits of specific structural components when damage exceeds allowable limits.

67. SAFETY PROCEDURES. General safety precautions, outlined in the following paragraphs, contain guidelines for handling materials with hazardous physical properties and emergency procedures for immediate treatment of personnel who have inadvertently come into contact with one of the harmful materials. Materials having hazardous physical properties are referenced to the pertinent safety precautions and emergency safety procedures. All personnel responsible for using or handling hazardous materials should be thoroughly familiar with the information in the following paragraphs.

a. General safety precautions. When required to use or handle any of the solvents, special cleaners, paint strippers (strong alkalies and acids), etchants (corrosion removers containing acids), or surface activation material (alodine 1200), observe the following safety precautions:

(1) Avoid prolonged breathing of solvents or acid vapors. Solvents and acids must not be used in confined spaces without adequate ventilation or approved respiratory protection.

(2) Never add water to acid. Always add acid to water.

(3) Do not mix chemicals except as prescribed by procedure.

(4) Clean water for emergency use must be available in the immediate work area before starting work.

(5) Avoid prolonged or repeated contact of solvents, cleaners, etchants (acid), or conversion coating material (alodine solution) with skin. Rubber or plastic gloves should be worn

when using solvents, cleaners, paint strippers, etchants, or conversion coating materials. Goggles or plastic face shields and suitable protective clothing must be worn when cleaning, stripping, etching, or conversion coating overhead surfaces.

(6) When mixing alkalies with water or other substance, use containers which are made to withstand heat generated by this process.

(7) Wash any paint stripper, etchant, or conversion coating material immediately from body, skin or clothing.

(8) Materials splashed in the eyes must be promptly flushed out with water and medical aid obtained for the injured person.

(9) Do not eat or keep food in areas where it may absorb poisons. Always wash hands before eating or smoking.

(10) All equipment must be cleaned after work has been completed.

(11) Implement all company safety precautions.

b. Emergency safety procedures. (PERSONNEL SHOULD BE THOROUGHLY FAMILIAR WITH THE FOLLOWING EMERGENCY SAFETY PROCEDURES PRIOR TO USING ANY MATERIALS WHICH ARE REFERENCED TO AN EMERGENCY SAFETY PROCEDURE PARAGRAPH.)

(1) If exposed to physical contact with any of the following materials:

Methyl alcohol	Xylene
Methyl ethyl ketone	Petroleum naphthas
Methyl isobutyl ketone	Chromates
Toluene	Dichromates
Trichloroethylene	Acetates
Epoxy resin	Cyclohexanone
Methylene chloride	Cellosolve
Brush alodine	Carbon Tetrachloride

Treat as follows:

(a) If splashed into eyes, do not rub.

(b) Flush eyes immediately with water for at least 15 minutes. Lift upper and lower eyelids frequently to ensure complete washing.

(c) If splashed on clothing or large areas of body, immediately remove contaminated clothing and wash body with plenty of soap and water. Wash clothing before rewearing.

(d) If splashed onto an easily accessible part of the body, immediately wash with soap and water.

(e) If suffering headache or other obvious symptoms resulting from overexposure, move to fresh air immediately.

(f) If vapors are inhaled and breathing has slowed down or stopped, remove person from exposure and start artifical respiration at once. Call ambulance and continue this treatment until ambulance arrives.

(2) If exposed to physical contact with any of the following materials:

Hydrofluoric acid	Phenol
Nitric acid	Cresols
Phosphoric acid	Tricresyl phosphate

Treat as follows:

(a) If splashed into eyes, quickly wipe eyelids with a soft cleaning tissue and immediately flush eye with gentle stream from a drinking fountain, cup, or other convenient water outlet while holding lids open. Continue this procedure until ambulance arrives.

(b) If splashed onto an easily accessible part of body, immediately drench affected area with water until ambulance arrives.

(c) If splashed onto clothing or large area of body, immediately drench body and remove clothing while drenching until ambulance arrives.

(d) If taken internally, begin following treatment immediately:

1. Person conscious - cause vomiting by placing finger in back of person's throat. Encourage him to drink large quantities of water and repeatedly wash out his month.

2. Person unconscious - do not give any liquid. Start artificial respiration at once. Continue until ambulance arrives. If person regains consciousness before ambulance arrives, proceed as in subparagraph 1. above.

68. REWORK PROCEDURES. All corrosion products must be removed completely when corroded structures are reworked as the corroding process will continue even though the affected surface is refinished. Before starting rework of corroded areas, carry out the following:

a. Position airplane in wash rack or provide washing apparatus for rapid rinsing of all surfaces.

b. Connect a static ground line to the airplane.

c. Remove airplane batteries as required.

d. Protect the pitot-static ports, louvers, airscoops, engine opening, wheels, tires, magnesium skin panels and airplane interior from moisture and chemical brightening agents.

e. Protect the surfaces adjacent to rework areas from chemical paint strippers, corrosion removal agents and surface treatment materials.

69.-70. RESERVED.

CHAPTER 9. CORROSION DAMAGE AND REWORK LIMITS

71. DISCUSSION. Corrosion evaluation will be required after initial inspection and cleaning to determine nature and extent of repair or rework. The first requirement for evaluation is good and sound maintenance judgement. Evaluate corrosion as follows:

   a. Light corrosion - Characterized by discoloration or pitting to a depth of approximately 0.001 inch maximum. This type of damage is normally removed by light hand sanding or a minimum of chemical treatment.

   b. Moderate corrosion - Appears similar to light corrosion except there may be some blisters or evidence of scaling and flaking. Pitting depths may be as deep as 0.010 inch. This type of damage is normally removed by extensive hand sanding or mechanical sanding.

   c. Severe corrosion. General appearance may be similar to moderate corrosion with severe blistering exfoliation and scaling or flaking. Pitting depths will be deeper than 0.010 inch. This type of damage is normally removed by extensive mechanical sanding or grinding.

72. TREATMENT OF CORRODED AREAS. There are two basic methods of corrosion removal - mechanical and chemical. The method used depends upon the type of structure, its location, the type and severity of corrosion, and the availability of maintenance equipment. Mechanical means are generally used on moderate to heavy corrosion, particularly if the part involved has a relatively heavy cross section or is skin of heavy gage. Lighter corrosion is removed by chemical means. Mechanical methods are recommended for heavily corroded areas on all nonclad aluminum alloys and on magnesium alloys.

* *

73. DETERMINING DEGREE OF CORROSION DAMAGE. Determine degree of corrosion damage (light, moderate or severe) with a depth dial gage if accessibility permits. Before measurements are made, visually determine if corrosion is in an area which has previously been reworked. If corrosion is in the recess of a faired or blended area, measure damage to include the material which has previously been removed. The following method outlines the process for taking measurements with the depth gage.

   a. Remove loose corrosion products if present.

   b. Position depth gage as illustrated in Figure 9-1 and determine the measurement reading.

   NOTE: The base of the depth gage must be flat against the undamaged surface on each side of the corrosion. When taking measurements on concave or convex surfaces, place the base perpendicular to the radius of the surface as shown in Figure 9-1.

   c. Take several additional depth readings.

   d. Select deepest reading as being depth of the corrosion damage.

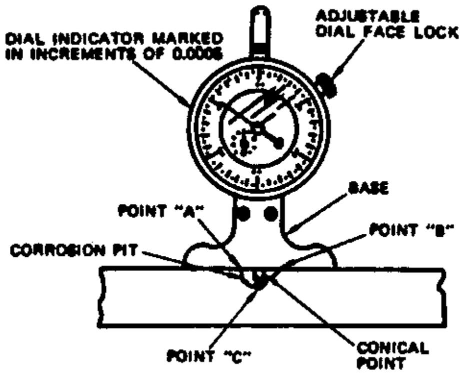
74. DETERMINING REWORK LIMITS. The maximum allowable amount of material removed from any damaged surface may be determined from criteria contained in the allowable damage limit chart in the manufacturer's repair manual. If no criteria is given, contact the aircraft manufacturer for cleanup limits.

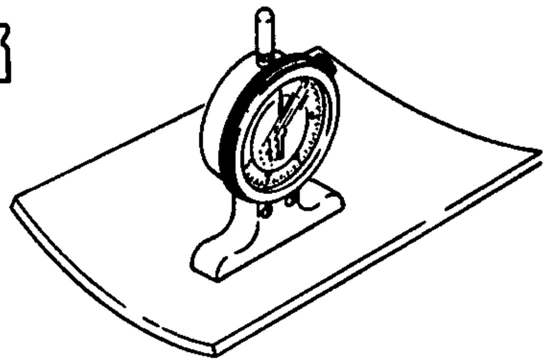
75. DETERMINING MATERIAL THICKNESS REDUCTION AFTER CORROSION CLEANUP. The amount of material which may be removed from a part or panel during corrosion cleanup is usually available in the manufacturer's allowable damage limit charts. To ensure that the allowable limits are not exceeded, an accurate measurement must be made of the material removed or material thickness remaining in the reworked area.

a. Measurement of panel thickness after rework can be made using a ultrasonic tester.

b. Measurement of the depth of blended pits (material removed) can be made using a depth dial gage. (See Figure 9-1.) If the area is inaccessible, clay impressions, or any other means which will give accurate results, may be used to determine material removed. In the event that material removal limits have been exceeded, the area or part must be repaired or replaced. If replacement or repair criteria is not contained in the repair manual, contact the manufacturer.

76.-80. RESERVED.





DETAIL I

DETAIL II

NOTE

- DEPTH DIAL GAGE 0 TO 0.500 INCH RANGE.
- TAKE MEASUREMENT READINGS PERPENDICULAR TO THE RADIUS OF CONCAVE OR CONVEX SURFACES. SEE DETAIL I.
- TAKE MEASUREMENT READINGS ON EDGES ADJACENT TO CORROSION DAMAGE OR BLENDED DEPRESSION (POINTS "A" AND "B"). TAKE SEVERAL READINGS AROUND CENTER OF CORROSION DAMAGE OR BLENDED DEPRESSION (SEE DETAIL II) AND CONSIDER THE DEEPEST READING TO BE POINT "C." DETERMINE DEPTH AS FOLLOWS:

$$\text{DEPTH} = C - \frac{(A + B)}{2}$$

Figure 9-1. Corrosion Damage and Rework Measurement Using Depth Dial Gage.

CHAPTER 10. CORROSION REMOVAL TECHNIQUES

81. STANDARD METHODS. Several standard methods are available for corrosion removal. The methods normally used to remove corrosion are chemical treatments, hand sanding with abrasive paper or metal wool, and mechanical sanding or buffing with abrasive mats, grinding wheels, or rubber mats. However, the method used depends upon the metal and the degree of corrosion. The removal method to use on each metal for each particular degree of corrosion is outlined in the following chapters.

82. SPECIAL TECHNIQUES. In special instances, a particular or specific method may be required to remove corrosion. Depending upon rework criteria, corrosion in a hole may be removed by enlarging the hole. Abrasive blasting may be required for removing corrosion from steel fasteners, side skins, or irregularly shaped parts or surfaces. Whenever such special cases occur, the specific method for corrosion removal must be observed.

83. FAIRING OR BLENDING REWORKED AREAS. All depressions resulting from corrosion rework must be faired or blended with the surrounding surface. Fairing can be accomplished as follows:

a. Remove rough edges and all corrosion from damaged area. (SELECT THE PROPER ABRASIVE FOR FAIRING OPERATIONS FROM FIGURE 10-1.) All dish-outs should be elliptically shaped with the major axis in the longitudinal direction.

METALS OR MATERIALS TO BE PROCESSED	RESTRICTIONS	OPERATION	ABRASIVE PAPER OR CLOTH			ABRASIVE FABRIC OR PAD	ALUMINUM	STAINLESS STEEL	PUMICE 350 MESH OR FINER	ABRASIVE WHEEL
			ALUMINUM OXIDE	SILICON CARBIDE	GARNET					
FERROUS ALLOYS	DOES NOT APPLY TO STEEL HEAT TREATED TO STRENGTHS TO 220,000 PSI AND ABOVE	CORROSION REMOVAL OR FAIRING	150 GRIT OR FINER	180 GRIT OR FINER		FINE TO ULTRAFINE	x	x	x	x
		FINISHING	400				x	x	x	
ALUMINUM ALLOYS EXCEPT CLAD ALUMINUM	DO NOT USE SILICON CARBIDE ABRASIVE	CORROSION REMOVAL OR FAIRING	150 GRIT OR FINER		7/0 GRIT OR FINER	VERY FINE AND ULTRAFINE	x		x	x
		FINISHING	400				x		x	
CLAD ALUMINUM	SANDING LIMITED TO THE REMOVAL OF MINOR SCRATCHES	CORROSION REMOVAL OR FAIRING	240 GRIT OR FINER		7/0 GRIT OR FINER	VERY FINE AND ULTRAFINE			x	x
		FINISHING	400						x	
MAGNESIUM ALLOYS		CORROSION REMOVAL OR FAIRING	240 GRIT OR FINER			VERY FINE AND ULTRAFINE	x		x	x
		FINISHING	400				x		x	
TITANIUM		CLEANING AND FINISHING	150 GRIT OR FINER	180 GRIT OR FINER				x	x	x

Figure 10-1. Abrasives for Corrosion Removal

b. Rework depressions by forming smoothly blended dish-outs (Figure 10-2). Select appropriate abrasive paper from Figure 10-1. In areas having closely spaced multiple pits, intervening material should be removed to minimize surface irregularity or waviness (Figures 10-3 and 10-4).

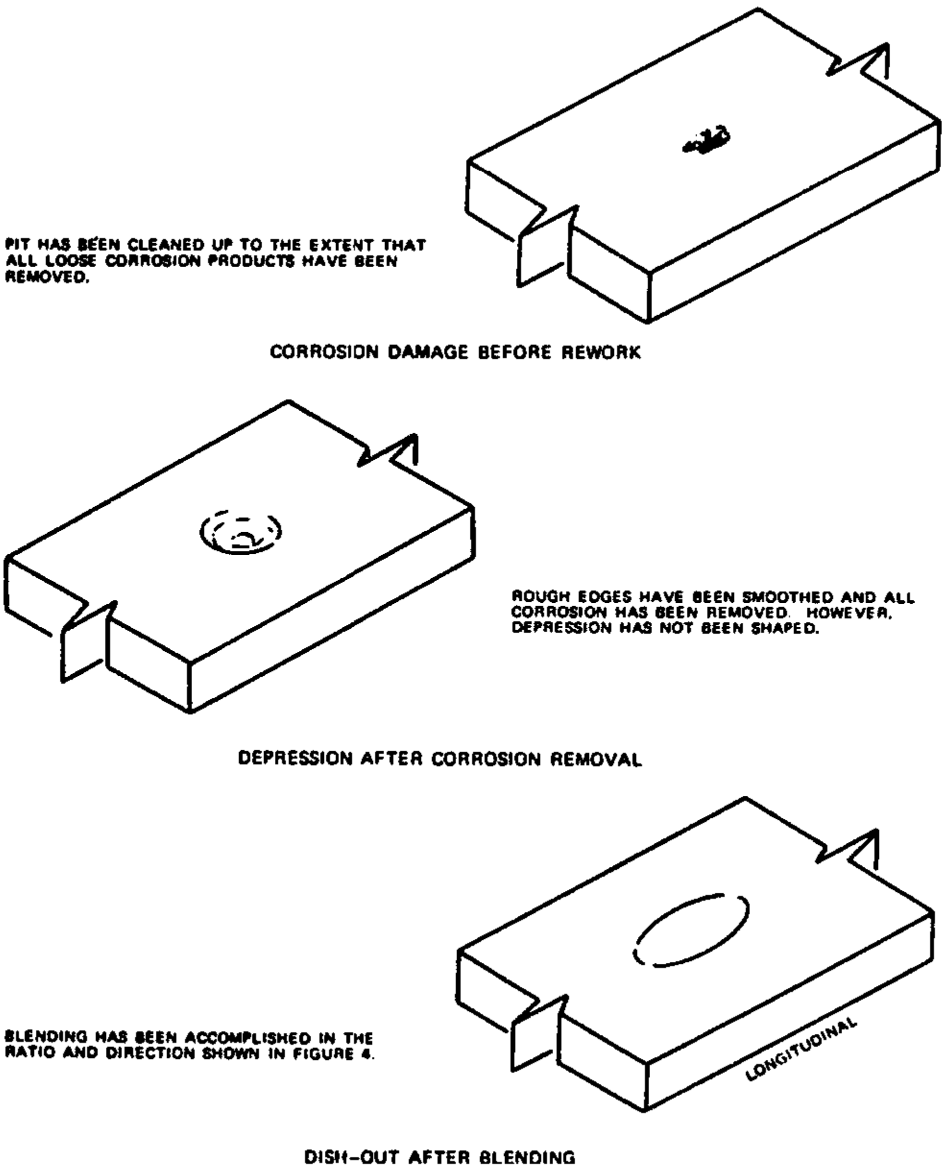


Figure 10-2. Blendout of Corrosion as Single Depression.

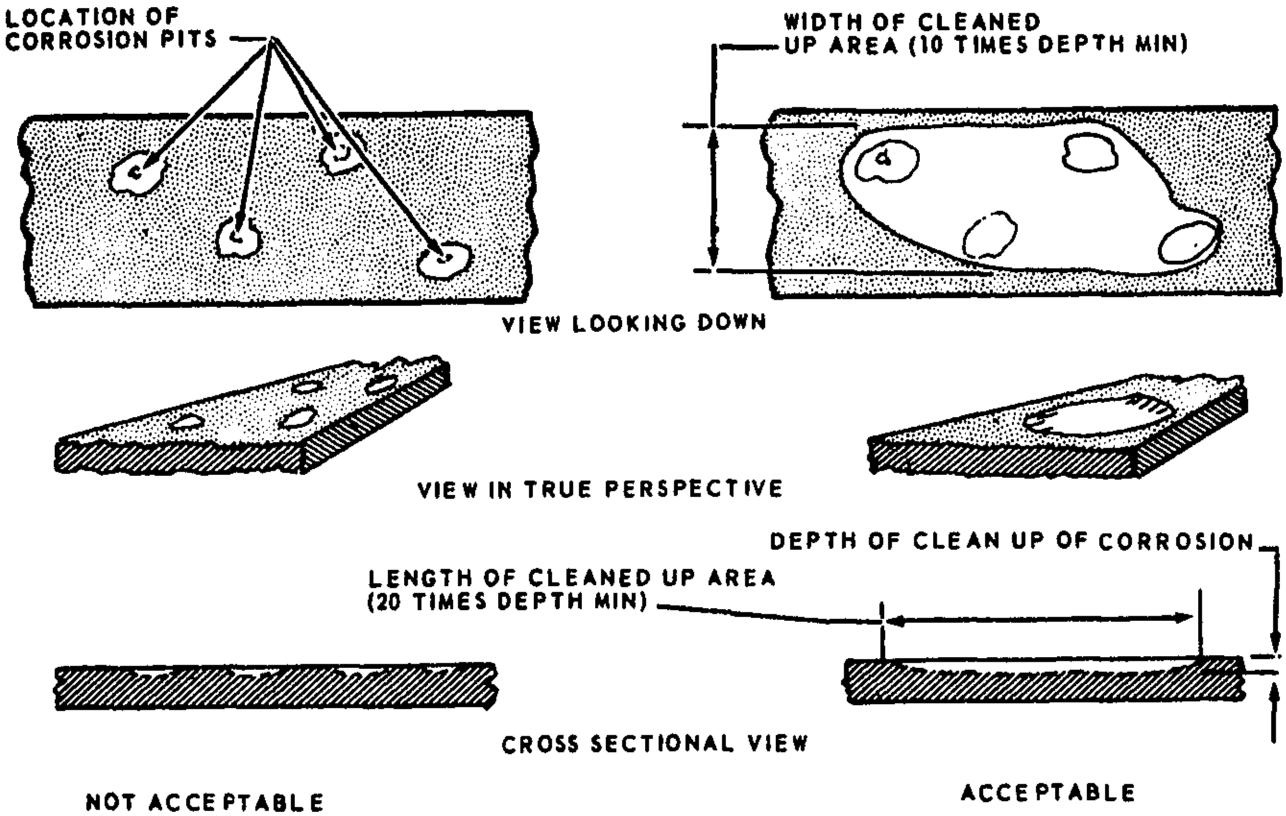
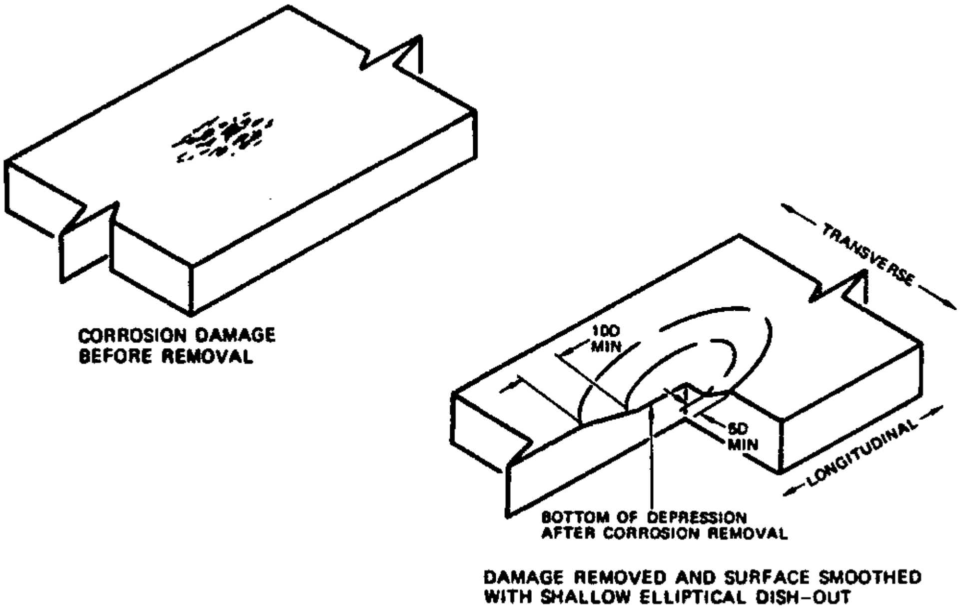
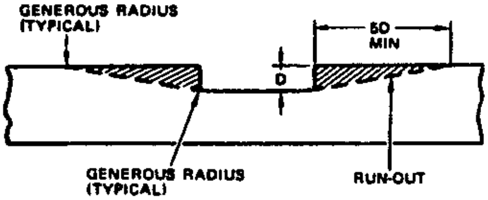


Figure 10-3. Typical Example of Acceptable Clean-Up of Corrosion Pits.



NOTE

- D = DEPTH OF DEPRESSION
- REFER TO SPECIFIC ALLOWABLE DAMAGE LIMITS FOR MAXIMUM ALLOWABLE DEPTH.
- SINCE MAXIMUM DEPTH VARIES AT DIFFERENT LOCATIONS, MAXIMUM SIZE OF DISH-OUT WILL ALSO VARY.
- THE BLENDING RATIO SHALL BE MAINTAINED AT ALL TIMES UNLESS OTHERWISE SPECIFIED IN A SPECIFIC REPAIR.
- SEE DETAIL I FOR EXAMPLE OF BLENDING.



EXAMPLE OF 1:5 BLENDING RATIO
DETAIL I

Figure 10-4. Blendout of Multiple Pits in Corroded Area

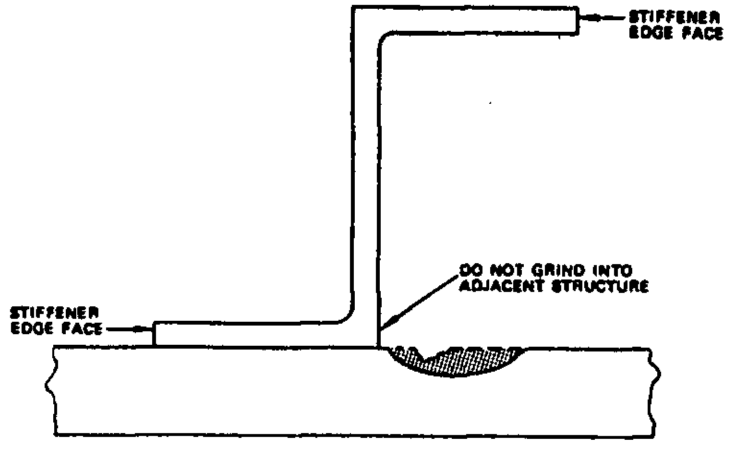


Figure 10-5. Profile of Reworked Corroded Areas in Regions of Limited Access.

84.-85. RESERVED.

CHAPTER 11. IDENTIFICATION OF METALS

86. IMPORTANCE OF IDENTITIES. A serious problem encountered in corrosion control is the identification of the metal on which corrosion occurs. The importance of this identification arises from the fact that all metals possess certain chemical characteristics that are common only to themselves and which vary greatly from metal to metal and from alloy to alloy of the same metal. Since these characteristics are common to all metals and their alloys, chemical cleaning solutions and chemical protective films will react differently with various metals. In some cases, this produces adverse reactions which can severly weaken or destroy the structural capabilities of the metal. Aluminum, steel, and magnesium sheet and plate are stenciled on the back for identification. When these markings are not distinguishable or the metal is not identified in the applicable section, or when a plating material needs to be identified, positive identification can be made by chemical and/or hardness testing.

   a. PERSONNEL SHOULD BECOME THOROUGHLY FAMILIAR WITH THE SAFETY PRECAUTIONS AND EMERGENCY SAFETY PROCEDURES, PRIOR TO PERFORMING ANY CHEMICAL TESTING.

   b. CHEMICAL SPOT TESTING SHOULD BE USED ONLY WHEN ALL OTHER MEANS OF IDENTIFICATION HAVE BEEN EXHAUSTED.

   c. FASTENERS SHOULD NOT BE IDENTIFIED BY CHEMICAL SPOT TESTS.

87. CHEMICAL TESTING. The chemical identification of the various types of metals used in aircraft construction should be accomplished before any tests are conducted. The preliminary surface preparation and primary classification of the metal may be determined by the following procedure.

   a. On the surface to be tested, choose an area where there is no corrosion and remove paint (if present) from a 1-inch square. Paint may be stripped with a cloth soaked in methyl ethyl ketone or paint remover or any equivalent material.

   (ADEQUATE PRECAUTIONS SHOULD BE TAKEN TO PREVENT PAINT REMOVER FROM CONTACTING GLASS CLOTH PARTS.)

   b. Clean area of surface to be tested.

   c. Tentatively identify the exposed metal surface by visually comparing it with samples of previously identified materials.

   d. Identify the metal as ferrous or nonferrous by placing a magnet on the exposed surface.

(1) Magnetic attraction classifies the base metal as a ferrous magnetic material (iron or steel).

(2) The absence of magnetic attraction classifies the base metal as either an austenitic steel or a nonferrous metal (aluminum, magnesium, etc.)

e. Hardness test magnetic metals prior to chemical spot testing. If the metal is nonmagnetic, proceed with paragraph 89.

88. CHEMICAL SPOT ANALYSIS OF MAGNETIC METALS. The magnetic metals usually employed in aircraft construction are ferrous alloys (low alloy steel and chromium-nickel-iron alloys sometimes called stainless steels). These magnetic alloys, when plated, are generally plated with either chromium, nickel, zinc, cadmium, silver, or with a combination of these platings.

a. If a magnetic alloy has been plated with cadmium, zinc, or chromium, it will exert magnetic attraction. Nickel plating will show slight magnetic attraction even if the substrate or base metal is not magnetic.

b. If positive identification of the metal plating is necessary, the identification should be made after accomplishing a hardness test.

DO NOT PERFORM CHEMICAL SPOT TEST ON STEELS HEAT-TREATED TO 220,000 PSI AND ABOVE.

c. Place a drop of 10% hydrochloric acid (HCL) on the prepared metal surface. Ensure that surface is dry before applying acid.

(1) A rapid reaction producing a dark deposit indicates that the metal is zinc.

(2) A slow or no reaction indicates that the metal may be cadmium, chromium, nickel, or steel.

CAUTION: THE ADDITION OF SODIUM SULFIDE (Na2S) TO ACID PRODUCES A POISONOUS GAS. ADEQUATE VENTILATION MUST BE PROVIDED WHEN THESE TESTS ARE BEING PERFORMED. DO NOT ALLOW LARGE QUANTITIES OF SODIUM SULFIDE (Na2S) AND ACID TO BE MIXED.

d. After one minute, add a drop of sodium sulfide (Na2S) to the drop of hydrochloric acid (HCL).

(1) A white precipitate identifies the metal as zinc.

(2) A yellow ring formed around a white precipitate identifies the metal as cadmium.

(3) A black ring formed around a white precipitate identifies the metal as iron or steel.

(4) A black precipitate indicates that the metal is chromium or nickel.

e. Confirm the cadmium, zinc, iron, or steel test by placing a drop of 20% nitric acid (HNO_3) on a fresh spot. After one minute, add a drop of sodium sulfide (Na_2S) to the drop of nitric acid (HNO_3).

(1) A white precipitate identifies the metal as zinc.

(2) A yellow precipitate identifies the metal as cadmium.

(3) A black spot identifies the metal as iron or steel.

f. Confirm the chromium test by placing a drop of 10% hydrochloric acid on a fresh spot. Add a drop of concentrated sulfuric acid (H_2SO_4) to the drop of hydrochloric acid. A color change to green after one or two minutes identifies the metal as chromium.

g. Confirm the nickel test by placing a drop of dimethylglyoxime solution on a fresh spot. Add a drop of ammonium hydroxide (NH_4OH) to the drop of dimethylglyoxime solution. A pink to red precipitate identifies the metal as nickel.

h. Clean and refinish as detailed in paragraph 90.

89. CHEMICAL SPOT ANALYSIS OF NONMAGNETIC METALS. The most common nonmagnetic metals used in aircraft construction are aluminum, magnesium, and austenitic steels (generally used as 18-8 stainless steel). The positive identification of these nonmagnetic metals is accomplished by the following procedure:

a. Place a drop of 10% hydrochloric acid (HCL) on the prepared metal surface and allow to stand for one minute. Ensure that surface is dry before applying acid. (Zinc deposits on nonmagnetic metals will react with 10% hydrochloric acid but will produce a black spot.)

(1) A rapid or violent reaction that produces a black spot indicates that the metal is magnesium.

(2) A slow reaction indicates that the metal is aluminum.

(3) No reaction indicates that the metal is an austenitic steel or a nonmagnetic plating material.

b. If a reaction that did not produce a black spot is noted in paragraph a(1), determine if zinc is present as detailed in paragraph 88.

c. If the results of step b are negative, confirm the magnesium and aluminum tests by placing a drop of 10% sodium hydroxide (NaOH) on a fresh spot. Check for the following:

(1) No reaction which will identify the metal as magnesium.

(2) A reaction that produces a colorless spot to identify the metal as a bare-aluminum alloy.

d. If an aluminum alloy is identified in step c, further test to distinguish the different alloys by placing a drop of 10% cadmium chloride on a fresh spot.

(1) A dark gray deposit forming within a few seconds will identify the metal as 7075 or 7178 bare-aluminum alloy.

(2) A dark gray deposit forming within two minutes will identify the metal as 7075 or 7178 clad-aluminum alloy.

(3) No deposit formation in the time specified for 7075 or 7178 clad will identify the metal as 2024 aluminum alloy (a faint deposit will form after 15 to 20 minutes).

e. Confirm the austenitic steel test by dissolving 10 grams of cupric chloride ($CuCl_2.2H_2O$) in 100 cubic centimeters of hydrochloric acid and placing a drop of the solution on a fresh spot. After two minutes, add three or four drops of distilled water to the drop of hydrochloric acid solution and dry the surface. The appearance of a brown spot identifies the metal as an austenitic steel.

f. If no reaction was noted in step a or e, test for a plating material as detailed in paragraph 88.

g. If step f reveals the presence of plating on the nonmagnetic metal, the plating must be removed by mechanical abrasion and the base metal identified by the visual and/or chemical methods outlined in Chapter 11.

h. Clean and refinish as required in paragraph 90.

90. <u>POST IDENTIFICATION CLEANING AND REFINISHING</u>. THE RE-AGENTS USED IN THE CHEMICAL SPOT TESTS ARE EXTREMELY CORROSIVE. After identification of the metal is completed, clean the area as follows:

a. <u>Blot</u> any remaining chemicals with a dry cloth.

b. <u>Swab</u> the area several times with a water moistened cloth.

c. <u>Test</u> the surface by placing a piece of litmus paper on the moistened surface. If the litmus paper changes color, repeat steps (2) and (3) preceding until no color change occurs.

d. <u>Dry</u> surface thoroughly.

e. <u>Remove corrosion</u>, if present, and refinish the surface as applicable.

91.-95. RESERVED.

CHAPTER 12. CORROSION REMOVAL PROCEDURES

SECTION 1. ALUMINUM AND ALUMINUM ALLOYS

96. GENERAL. Aluminum and its alloys are the most widely used materials in the construction of commercial airplanes. Aluminum is characterized by an excellent strength-to-weight ratio, thermal and electrical conductivity, and high reflectance. In addition, this metal is nonmagnetic, nontoxic, and will not spark when struck against other metals. The formation of a tight adhering oxide film on pure aluminum or clad surfaces which carry a bonded coating of pure aluminum, or corrosion resistant aluminum alloy coating, offers increased resistance in most corrosive conditions. Corrosive attack on aluminum surfaces is usually obvious; the corrosion products are generally white and more voluminous than the original base metal. Even in the early stages of corrosion, damage is evident as general etching, pitting, and roughness of the surface.

97. SURFACE ATTACK. General surface attack of aluminum penetrates slowly but is accentuated in the presence of dissolved salts. 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:

a. The penetrating pit-type corrosion through walls of aluminum tubing.

b. Stress corrosion cracking of materials under sustained stress and corrosive environment.

c. The intergranular attack which is characteristic of certain improperly heat-treated aluminum alloys.

98. TREATMENT. In general, corrosion of aluminum can be more effectively treated in place rather than an attack occurring on other structural materials used in aircraft. Treatment includes the mechanical removal of as much of the corrosion products as practicable, the inhibition of residual materials by chemical means, followed by the restoration of permanent surface coatings. Details of treatment vary depending on whether or not the aluminum surfaces are to be left bare in use or are to be protected by paint coatings. (See section 6 of this chapter for information on mechanical corrosion removal by blasting.)

99. PROCESSING OF ALUMINUM SURFACES.

a. Bare aluminum surfaces. While few unpainted aircraft are used under marine conditions, some general information is included on the nature of alclad surfaces and their treatment. Relatively pure aluminum has greater corrosion resistance than the stronger aluminum alloys. Advantage is taken of this by laminating a thin sheet of relatively pure aluminum, one to five mils thick, over the base higher strength aluminum alloy surface. The protection obtained is good, and the alclad surface can be maintained in a polished condition. In cleaning such surfaces, however, care must be taken to prevent staining and marring of the exposed aluminum and, more important from a protection standpoint, to avoid unnecessary mechanical removal of the protective alclad layer and the exposure of more susceptible but stronger aluminum alloy base material.

b. Additional processing of aluminum surfaces prior to paint finishes. Aluminum surfaces that are to be subsequently painted can be exposed to more severe cleaning procedures and can also be given more thorough corrective treatment prior to painting.

c. Special treatment of anodized or alodine surfaces. Anodizing is the most common surface treatment of aluminum alloy surfaces. Tank processing is accomplished during manufacture or rework of a part or component and frequently prior to its fabrication from sheet stock. The aluminum sheet or casting is made the positive pole in an electrolytic bath in which chromic acid or other oxidizing agent produces a supplemental protective oxide film on the aluminum surface. Aluminum oxide is naturally protective and anodizing merely increases the thickness and density of the natural oxide film. When this coating is damaged in service it can only be partially restored by chemical surface treatment. Therefore, any processing of anodized surfaces should avoid unnecessary destruction of the oxide film.

(1) Use of steel wool, steel wirebrushes, or severe abrasive materials should be prohibited on any aluminum surfaces. Aluminum wool, fiber bristle brushes, and mild abrasives are acceptable tools for cleaning anodized surfaces, but care must be exercised in any cleaning process to avoid unnecessary breaking of the protective film particularly at the edges of the aluminum sheet.

(2) Tampico fiber brushes are preferred and are adequate to remove most corrosion. Producing a buffed or wire brush finish by any means should be prohibited. Take every precaution to maintain as much of the protective coating as practicable. Otherwise, treat anodized surfaces in the same manner as other aluminum finishes. Vacuum blasting is an acceptable corrosion removal method on exterior surfaces. (See Figures 12-1, 12-2, and 12-3.)

(3) Alodine (Specification MIL-C-5541B) is a chemical surface treatment used on aluminum alloys to inhibit corrosion and to provide a proper surface for paint finishing.

d. Special processing of intergranular corrosion in heat-treated aluminum alloy surfaces. Intergranular corrosion is an attack along grain boundaries of improperly or inadequately heat-treated alloys resulting from precipitation of dissimilar constituents following heat treatment. In its most severe form, actual lifting of metal layers (exfoliation) occurs. The mechanical removal of all corrosion products and visible delaminated metal layers must be accomplished in order to determine the extent of the damage and to evaluate the remaining structural strength of the component.

(1) Use metal scrapers, rotary files, or abrasive wheels to assure that all corrosion products are removed and that only structurally sound aluminum remains.

(2) Rotary files must be sharp to insure that they cut the metal without excessive smearing. A dull cutting tool will smear the metal over corrosion cracks or fissure and give the appearance that corrosion has been removed.

(3) Carbide tip rotary files or metal scrapers should be utilized since they stay sharp longer. Blasting is not a satisfactory method to remove intergranular corrosion.

(4) Inspection with a 5- to 10-power magnifying glass or the use of dye penetrant will assist in determining if all unsound metal and corrosion products have been removed.

(5) When complete removal has been attained, blend or fair out the edges of the damaged areas. Blending, where required, can best be accomplished by using aluminum oxide impregnated, rubber-base wheels.

(6) Chemically inhibit the exposed surfaces completely and restore paint coatings in the same manner as on any other aluminum surface. (See Figures 12-4, 12-5, and 12-6.)

(7) Any loss of structural strength in critical areas should be evaluated by cognizant engineers. Further, if damage exceeds the permissible limit chart in the handbook of structural repair for the aircraft model involved, the manufacturer should be contacted.

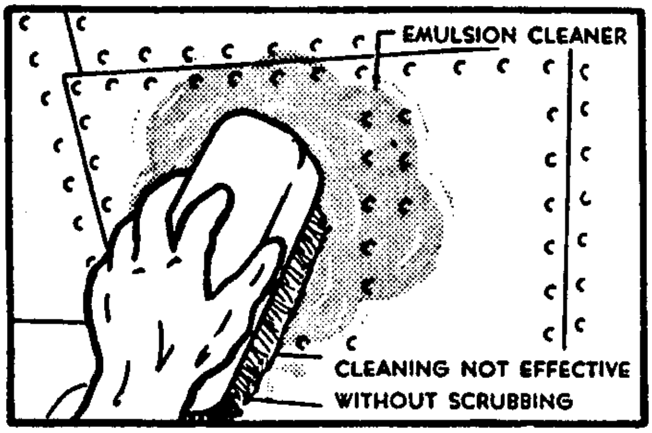


Figure 12-1. Removing Oil and Surface Dirt

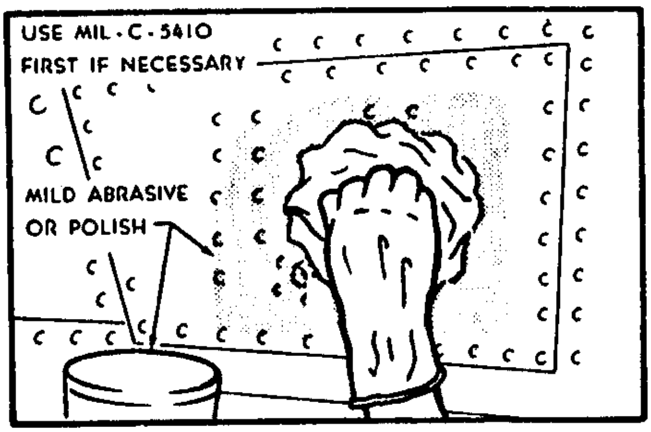


Figure 12-2. Polishing and Brightening Alclad Surfaces

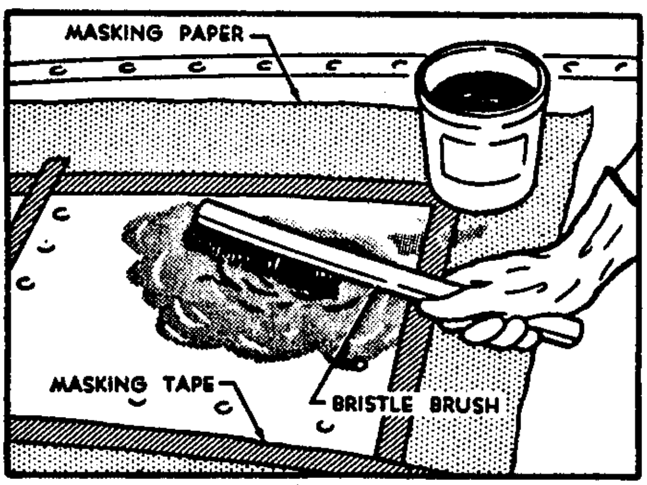


Figure 12-3. Cleaning and Stripping Paint

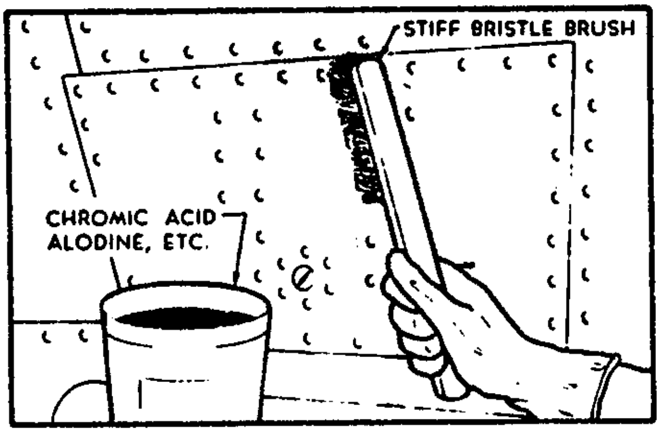


Figure 12-4. Cleaning and Inhibiting Corroded Aluminum Surfaces.

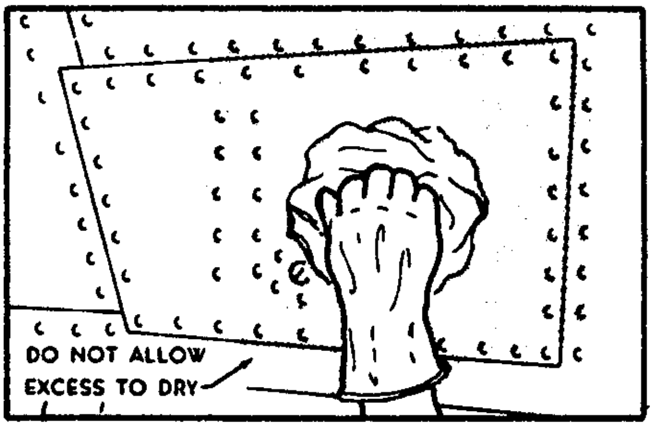


Figure 12-5. Removing Excess Inhibitor Solution

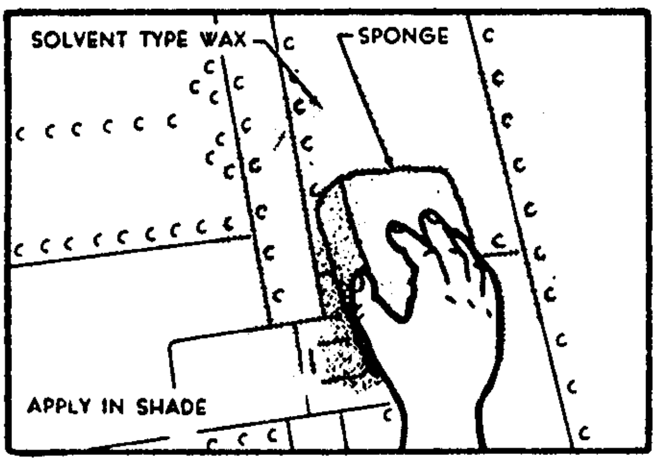


Figure 12-6. Applying Wax to Cleaned Surfaces

100. REPAIR OF ALUMINUM ALLOY SHEET METAL AFTER EXTENSIVE CORROSION REMOVAL. After blending of aluminum alloy skin panels or plates, surface treat.

a. If water can be trapped in blended areas, fill with structural adhesive or sealant to the same level as the original skin. When areas are small enough that structural strength has not been significantly decreased, no other work is required prior to paint.

b. If sufficient metal has been removed to affect structural strength, it is then necessary to prepare a doubler to regain the necessary strength.

c. Structural repair manuals for each particular model aircraft must be used as a guide for making all such repairs.

d. Where exterior doublers are allowed, it is necessary to seal and insulate them adequately to prevent further corrosion.

e. Doublers should be made from alclad when available, and the sheet should be anodized after all cutting, drilling, and countersinking has been accomplished.

f. All rivet holes should be drilled, countersunk, surface treated, and primed prior to installation of the doubler.

g. Apply a suitable sealing compound in the area to be covered by the doubler. Apply sufficient thickness of sealing compound to fill all voids in the area being repaired.

h. Install rivets with wet primer. Sufficient sealant should be squeezed out into holes so that all fasteners, as well as all edges of the repair plate, will be sealed against entrance of moisture.

i. Remove all excess sealant after fasteners are installed. Leave a one-quarter inch bead around the edge of the plate. After sealant has cured, strip any exposed primer and refinish.

101. CORROSION REMOVAL AROUND COUNTERSUNK FASTENERS IN ALUMINUM ALLOY. Intergranular corrosion in aluminum alloys often originates at countersunk areas where steel fasteners are used. Removal of such corrosion is difficult and sometimes impossible to accomplish with fasteners in place.

a. When corrosion is found, it is usually best to remove the fasteners in order to assure complete corrosion removal. It is imperative that all corrosion be removed to prevent further corrosion and loss of structural strength. To prevent this type of attack, it is necessary that anodize or alodine be used after holes are countersunk.

b. Each time steel fasteners are removed, they should be coated with zinc chromate primer prior to installation. It is preferred that the primer be wet at the time the fasteners are installed, but the protection from the dry primer is still better than alodine or anodize treatment alone. Zinc chromate primer will not prevent all metal-to-metal contact but will act to reduce entry of moisture and will reduce the extent of corrosion where moisture does penetrate.

102. EXAMPLES OF REMOVING CORROSION FROM ALUMINUM AND ALUMINUM ALLOYS.

a. Prepare the aircraft for corrosion rework as provided in paragraph 68 and remove corrosion products as follows. Observe the safety precautions and procedures of paragraph 67.

b. Positively identify the metal as aluminum as detailed in Chapter 11.

c. Clean area to be reworked. Strip paint if required.

d. Determine extent of corrosion damage as covered in Chapter 9. To remove light corrosion, proceed with paragraph e, following. To remove moderate or severe corrosion, proceed with paragraph f, following.

e. Remove light corrosion by light hand-sanding operations or by chemical means as follows. Do not use the chemical removal process at temperatures above 100°F or below 40°F.

(1) Protectively mask adjacent areas to prevent brighteners from contacting magnesium, anodized aluminum, glass, plexiglass, fabric surfaces, and all steel. Wear acid-resistant gloves, protective mask, and protective clothing when working with corrosion removing compounds. If corrosion removing compounds accidentally contact the skin or eyes, flush off immediately with plenty of clear water. Consult a physician if eyes are affected or if skin is burned.

(2) Dilute corrosion removing compound with two parts water. Mix the compound only in wood, plastic, or plastic lined containers. The diluted solution of corrosion removing compound may be applied to large exterior surfaces with a nonatomizing spray, starting from lower surfaces and working upwards.

(3) Apply diluted solution by brush, starting from lower surfaces and working upward to minimize runs and streaks.

(4) Leave the solution on surface from 5 to 30 minutes, depending on the temperature and the amount of corrosion present. Agitate occasionally with the brush used for application. Do not allow solution to dry on surface, as streaking will result. (On large exterior surfaces, remove solution by high pressure water rinse.)

(5) Wipe off solution with a clean, moist cloth; frequently rinse the cloth in clear water. Wipe area several additional times with fresh cloth dampened and rinsed frequently in clear water.

(6) Dry area with clean, dry cloth and inspect for corrosion. IF CORROSION STILL REMAINS AFTER SECOND ATTEMPT, MECHANICALLY REMOVE CORROSION AS DETAILED IN SECTION 6 OF THIS CHAPTER.

(7) Repeat the procedure outlined in this paragraph e if any corrosion remains.

(8) After all corrosion has been removed, proceed with paragraph f(4), following.

f. Mechanically remove moderate or severe corrosion by the appropriate methods as follows. WEAR GOGGLES OR FACE SHIELD TO PROTECT AGAINST CORROSION PARTICLES THAT BREAK LOOSE AND FLY OFF. PROTECT ADJACENT AREAS TO PREVENT ADDITIONAL DAMAGE FROM CORROSION PRODUCTS REMOVED DURING MECHANICAL REMOVAL.

(1) Remove loose corrosion products by hand scraping with a carbide-tipped scraper or fine-fluted rotary file. (For alternate method of dry abrasive blasting, refer to section 6 of this chapter.)

(2) Remove residual corrosion by hand sanding or with approved hand-operated power tool. Select appropriate abrasive from Figure 10-1.

(3) Blend into surrounding surface any depressions resulting from rework and surface finish with 400-grit abrasive paper.

(4) Clean reworked area; do not use kerosene.

(5) Determine depth of faired depressions to ensure that rework limits have not been exceeded.

(6) Prepare and apply alodine.

103.-104. RESERVED.

SECTION 2. MAGNESIUM ALLOYS

105. GENERAL. Magnesium is the most chemically active metal used in airplane construction and is, therefore, the most difficult to protect. By the same token, 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. Magnesium corrosion 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, the restoration of surface coatings by chemical treatment, and a reapplication of protective coating.

106. TREATMENT OF WROUGHT MAGNESIUM SHEETS AND FORGINGS. Magnesium skin attack will usually occur around edges of skin panels underneath hold-down washers, or in areas physically damaged by shearing, drilling, abrasion, or impact. Entrapment of salt water under and behind skin crevices is frequently a contributing factor. If the skin section can be easily removed, this should be accomplished in order to assure complete inhibition and treatment.

a. Complete mechanical removal of corrosion products should be practiced insofar as practicable. Such mechanical cleaning shall normally be limited to the use of stiff bristle brushes and similar non-metallic cleaning tools, particularly during treatment in place under field conditions.

b. Any entrapment of steel particles from steel wire brushes or steel tools, or contamination of treated surfaces by dirty abrasives can cause more trouble than the initial corrosive attack. The following procedural summary is recommended for treatment of corroded magnesium areas when accomplished under most field conditions.

107. ALUMINUM INSULATING WASHERS. When aluminum insulating washers no longer adhere to magnesium panels, corrosion is likely to occur under the washers if corrective measures are not taken.

a. When machine screw fasteners are used, they should be removed from all loose insulating washer locations in order to surface treat the magnesium panel.

b. Where fasteners other than machine screws are used, the insulating washer should be partially removed so that only the portion under the head remains in place.

c. When located so that water can be trapped in the counterbored area where the washer was located, use sealants to fill the counterbore. If necessary to fill several areas adjacent to each other, it may be advantageous to cover with a strip of sealant.

d. If corrosive attack has penetrated to the seating surfaces under the heads or in the countersunk areas of fasteners, it will be necessary to remove the fasteners for adequate corrosion treatment.

108. REPAIR OF MAGNESIUM SHEET METAL AFTER EXTENSIVE CORROSION REMOVAL. The same general instructions when making repairs in magnesium as in aluminum alloy skin apply except that two coats of zinc chromate primer may be required on both the doubler and skin being patched instead of only one coat. Where it is difficult to form magnesium alloys in the contour necessary, aluminum alloy may be utilized. When this is done, it is necessary to insure that dissimilar metal insulation is effective. Sealants are adequate if properly used. Vinyl tape will insure positive separation of dissimilar metals, but edges will still have to be sealed to prevent entrance of moisture between mating surfaces at all points where repairs are made. It is therefore recommended that only sealant be used, since it serves a dual purpose.

109. IN-PLACE TREATMENT OF MAGNESIUM CASTINGS. Magnesium castings, in general, are more porous and more prone to penetrating attack than wrought magnesium skin. However, treatment in the field is, for all practical purposes, the same for all magnesium areas. Engine cases are among the most common examples of cast magnesium encountered in modern aircraft. Bellcranks, fittings, and numerous covers, plates, and handles are also magnesium castings. When attack occurs on a casting, the earliest practicable treatment is required if dangerous corrosive penetration is to be avoided. Engine cases in salt water can develop "moth holes" and complete penetration overnight.

a. If it is at all practicable, faying surfaces involved should be separated in order to effectively treat the existing attack and prevent its further progress. The same general treatment sequence as detailed for magnesium skin should be followed. Insofar as engine cases are concerned, baked enamel overcoats are usually involved rather than acrylic lacquer finishes. A good air drying enamel can be used to restore protection.

b. If extensive removal of corrosion products from a structural casting is involved, a decision from the aircraft manufacturer may be necessary in order to evaluate the adequacy of structural strength remaining. Structural repair manuals usually include dimensional tolerance limits for critical structural members. The aircraft manufacturer should be referred to if any questions of safety are involved.

110. EXAMPLE OF REMOVING CORROSION FROM MAGNESIUM. If possible, corroded magnesium parts should be removed from aircraft. When impossible to remove the part, make aircraft preparations detailed in paragraph 68. When using that procedure, observe the safety precautions and procedures of Chapter 8.

a. Positively identify metal as magnesium. (refer to Chapter 11)

b. Clean area to be reworked.

c. Strip paint if required.

d. Determine extent of corrosion damage as detailed in Chapter 9. To remove light corrosion, proceed with paragraph e, following. To remove moderate or severe corrosion, proceed with paragraph f, following.

e. Remove light corrosion by light hand-sanding or chemically as follows. Do not use the following procedure for adhesive bonded parts or assemblies, areas where the brush-on solution might become lodged, or local areas bared specifically for grounding or electrical bonding purpose.

(1) Remove loose corrosion with aluminum wool.

(2) Mask off other materials and parts, especially rubber parts, bearings, and cast or pressed inserts to prevent contact with the treating solution or its fumes.

(3) Prepare corrosion treating solution in the following proportions: 1½ pounds of sodium dichromate and 1½ pints of concentrated nitric acid per gallon of water. Mix as follows but prepare and store the solution in clean polyethylene or glass containers.

(a) Fill a suitable container with a volume of water equal to one-fourth the desired total quantity of solution.

(b) Add full quantity of sodium dichromate in proportions indicated and agitate solution until the chemical is dissolved.

(c) Add water until quantity of solution is equal to approximately two-thirds the desired total quantity.

(d) Slowly add total volume of nitric acid to solution and mix thoroughly.

(e) Add remaining water until total desired quantity of solution is reached and stir until entire solution concentration is equal.

(4) Remove remaining corrosion by swabbing the corroded surface one to two minutes with the nitric acid solution, then wipe dry.

(5) Rise thoroughly with clean water while scrubbing with a mop or brush and wipe dry.

(6) Repeat the preceding sequence, as necessary, until all corrosion has been removed.

(7) After all corrosion has been removed, proceed with paragraph g below.

f. Mechanically remove moderate or severe corrosion. Wear goggles or a face shield to preclude injury from corrosion particles breaking loose and flying off. DO NOT USE CARBON STEEL WIRE BRUSHES OR SILICONE CARBIDE ABRASIVES ON MAGNESIUM. Protect adjacent areas to prevent additional damage from corrosion products removed when using this procedure.

(1) Remove heavy corrosion products by hand wire brushing with a stainless steel brush.

(2) Remove residual corrosion by hand sanding or with approved hand-operated power tool.

(3) After removing all corrosion visible through a magnifying glass, apply corrosion treating solution.

g. Fair depressions resulting from rework as detailed in Chapter 10 and surface finish with 400-grit abrasive paper.

h. Clean reworked area. Do not use kerosene.

i. Determine depth of faired depressions as detailed in Chapter 9. Ensure that rework limits have not been exceeded.

j. Prepare and apply magnesium conversion coating as follows:

(1) Measure 1 gallon of distilled water into a clean polyethylene or glass container.

(2) Add 1.3 ounces (dry) of chromium trioxide.

(3) Add 1 ounce of calcium sulfate dehydrate.

(4) Vigorously stir for at least 15 minutes to ensure that the solution is saturated with calcium sulfate. (Let chromate solution stand for 15 minutes prior to decanting.)

(5) Prior to use, decant solution (avoid transfer of undissolved calcium sulfate) into suitable usage containers (polyethylene or glass).

(6) Apply solution by swabbing until the metal surface becomes dull golden to dark brown in color. Use caution in swabbing on the solution. Severe rubbing of the wet surface will damage the coating. HIGH PRESSURE SPRAYING OR RUBBING ABRASION WILL DAMAGE THE FRESH COATING.

(7) Rinse with clean, cold water, then allow to dry at ambient temperature. Force air dry if possible.

k. Apply original finish.

l. Remove masking and protective covering.

111.-114. RESERVED.

SECTION 3. OTHER METALS AND ALLOYS

115. NOBLE METAL COATINGS - CLEAN UP AND RESTORATION. Silver, platinum, and gold finishes are generally used in aircraft assemblies because of their resistance to ordinary surface attack and their improved electrical or heat conductivity. Silver-plated electrodes can be cleaned of brown or black sulfide tarnish as necessary by placing them in contact with a piece of magnesium sheet stock while immersed in a warm water solution of common table salt mixed with baking soda. If assemblies are involved, careful drying and complete displacement of water is necessary. In general, cleaning of gold or platinum coatings is not recommended in the field.

116. COPPER AND COPPER ALLOYS. Copper and copper alloys are relatively corrosion resistant, and attack on such components will usually be limited to staining and tarnish. Generally such change in surface condition is not dangerous and should ordinarily have no effect on the function of the part. However, if it is necessary to remove such staining, a chromic acid solution of 8 to 24 ounces per gallon of water containing a small amount of battery electrolyte (not to exceed 50 drops per gallon), is an effective brightening bath.

a. The stained part should be immersed in the cold solution. However, surfaces can also be treated in place by applying the solution to the stained surface with a small brush.

b. Care must be exercised to avoid any entrapment of the solution after treatment. The part should be cleaned thoroughly following treatment with all residual solution removed.

c. Serious copper corrosion is very evident by the accumulation of green-to-blue copper salts on the corroded part. These products should be removed mechanically, preferably by use of stiff bristle brushes, and a surface coating reapplied over the corroded area. Again, a chromic acid treatment will tend to remove the residual corrosion products.

d. Most brass and bronze structural parts will be protected by cadmium surface plate. The mottling of the protective cadmium coat should not be removed, and mechanical surface cleaning should not be attempted unless actual copper corrosion products are beginning to appear. Under these conditions, any mechanical removal of the protective cadmium should be held to a minimum and limited to the immediate area of the copper attack.

117. TITANIUM ALLOYS. Titanium is generally corrosion resistant. However, corrosive attack on titanium surfaces is difficult to detect. It may show deterioration from the presence of salt deposits and metal impurities at elevated temperatures so periodic removal of surface deposits is required.

a. If titanium surfaces require cleaning, hand polish with aluminum polish and a soft cloth until all traces of corrosion or surface deposits are removed.

b. Treat the cleaned surface with a solution of 13 to 26 ounces (weight) of sodium dichromate per gallon of water.

c. Chlorinated Hydrocarbon cleaners should not be used on titanium alloys which are subject to elevated temperatures in service. Such solvents can cause stress corrosion working in titanium.

118.-120. RESERVED.

SECTION 4. PLATED PARTS

121. CHROMIUM AND NICKEL PLATED PARTS. Nickel and chromium platings are used extensively as protective coatings particularly over steel parts. Chromium and nickel plate provide protection by forming a somewhat impervious physical coat over the underlying base metal. When breaks occur in the surface, the protection is destroyed.

a. The amount of reworking that can be performed on chromium and nickel-plated components is limited. This is due to the critical requirements to which such components are subjected.

b. The rework should consist of light buffing to remove corrosion products and produce the required smoothness. This is permissible provided the buffing does not take the plating below the minimum allowable thickness.

c. Whenever a chromium or nickel-plated component requires buffing, coat the area with corrosion preventive compound, if possible.

d. When buffing exceeds the minimum thickness, or the base metal has sustained corrosive attack, the component must be removed and replaced.

e. The removed component can be restored to serviceable condition by having the old plating completely stripped and replated in accordance with acceptable methods and specifications.

122. CADMIUM AND ZINC-PLATED PARTS. Cadmium plate particularly is used extensively in aircraft construction as a protective finish over both steel and copper alloys. Protection is provided on a sacrificial basis in which the cadmium is attacked rather than the underlying base material. Properly functioning cadmium surface coatings may well show mottling, ranging from white to brown to black spots on their surfaces. These are indicative of the protection being offered by the cadmium coat, and under no condition should such spotting be removed merely for appearance sake. In fact, cadmium will continue to protect even when actual breaks in the coating develop and bare steel or exposed copper surfaces appear.

a. Where actual failures of the cadmium plate occur and the initial appearance of corrosion products of the base metal develops, some mechanical cleaning of the area may be necessary but should be limited to removal of the corrosion products from the underlying base material.

b. Under no condition should such a coating be cleaned with a wire brush. Treatment of 10 percent chromic acid solution will tend to inhibit any remaining corrosion products present and restore protective surface finishes. If further protection is needed, a touchup with primer or a temporary preservative coating should be applied. Restoration of the plate coating is impracticable in the field.

c. Zinc coatings offer protection in an identical manner to cadmium, and the corrective treatment for failure is generally the same as for cadmium-plated parts. However, the amount of zinc on aircraft structures is very limited and does not present a maintenance problem.

123.-125. RESERVED.

SECTION 5. FERROUS METALS

126. GENERAL. One of the most familiar kinds of corrosion is red iron rust, generally resulting from atmospheric oxidation of steel surfaces. Some metal oxides protect the underlying base metal, but red dust is not a protective coating. Its presence actually promotes additional attack by attracting moisture from the air and acting as a catalyst in causing additional corrosion to take place.

a. Red rust first shows on boltheads, hold-down nuts, and other unprotected aircraft hardware. Red rust will often occur under nameplates which are secured to steel parts. Its presence in these areas is generally not dangerous and has no immediate effect on the structural strength of any major components. However, it is indicative of a general lack of maintenance and possible attack in more critical areas.

b. When paint failures occur or mechanical damage exposes highly stressed steel surfaces to the atmosphere, even the smallest amount of rusting is potentially dangerous in these areas and must be removed and controlled.

127. MECHANICAL REMOVAL OF IRON RUST. The most practicable means of controlling the corrosion of steel is the complete removal of corrosion products by mechanical means. Except on highly stressed steel surfaces, the use of abrasive papers, small power buffers and buffing compounds, and wire brushing are acceptable for clean-up procedures. However, it should be recognized that in any such use of abrasives, residual iron rust usually remains in the bottom of small pits and other crevices. (See Figures 12-7 and 12-8.)

a. The best method to use on exterior surfaces is abrasive blasting which has the ability of removing nearly all rust.

b. Paint the cleaned metal surface as soon as possible after corrosion removal, and in any event do not allow the surface to become wet before painting.

128. CHEMICAL SURFACE TREATMENT OF STEEL SURFACES. There are acceptable methods for converting iron rust to phosphates and other protective coatings. Parco Lubrizing and use of phosphoric zinc preparations are examples of such treatment. However, these processes require shop installed hot tanks and are impracticable for use in the field.

a. Other preparations are effective rust converters where tolerances are not critical and where thorough reusing and neutralizing of residual acid is also possible.

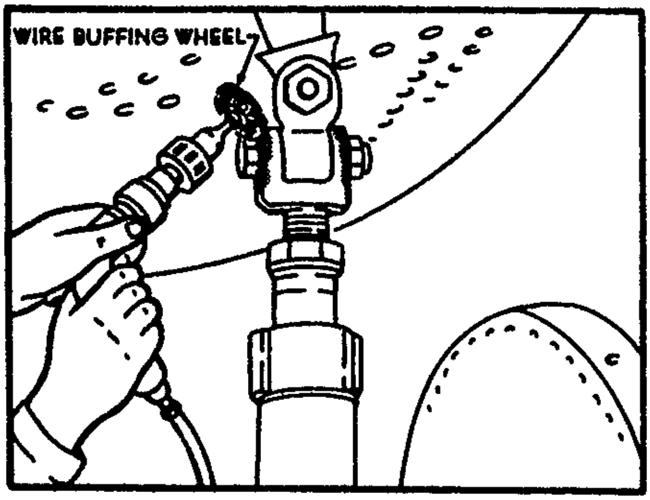


Figure 12-7. Removing Corrosion Products From Ordinary Steel Surfaces.

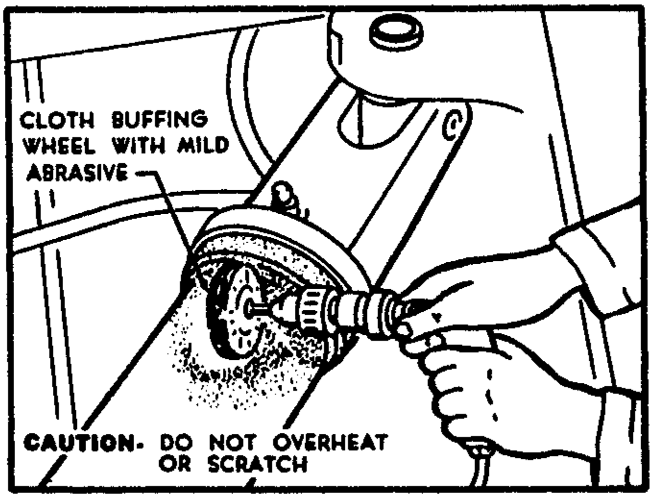


Figure 12-8. Removing Corrosion Products From Highly Stressed Steel Parts.

b. These situations are generally not applicable to assembled aircraft and use of chemical inhibitors on installed steel parts is not only undesirable, but very dangerous.

c. The possibility of entrapping of corrosive solutions and resulting uncontrolled attack which could occur when such materials are used under field conditions outweighs any advantage to be gained from their use.

129. REMOVAL OF CORROSIVE PRODUCTS FROM HIGH-STRESSED STEEL PARTS. Do not use wire brushes on high-stressed steel parts. Any corrosion on the surface of a highly stressed steel part is potentially dangerous, and the careful removal of corrosion products is mandatory. Surface scratches or change in surface structure from overheating can cause sudden failure of these parts. Removal of corrosion products may be accomplished by careful processing using mild abrasive papers, such as rouge or fine grit aluminum oxide, or fine buffing compounds on cloth buffing wheels.

a. It is essential that steel surfaces not be overheated.

b. Abrasive blasting is also a satisfactory corrosion removal method for high-strength steel located on aircraft exteriors.

c. After careful removal of surface corrosion, protective paint finishes should be applied immediately.

130. SPECIAL TREATMENT OF STAINLESS STEEL ALLOYS. Do not use chemical cleaners on stainless steels. Stainless steels are of two general types: magnetic and nonmagnetic. Magnetic steels are of the ferritic or martensitic types and are identified by numbers in the 400 series. Corrosion often occurs on 400 series stainless steels and treatment is the same as specified in paragraph 129. Nonmagnetic steels are of the austenitic type and are identified by numbers in the 300 series. They are much more corrosion resistant than the 400 series steels, particularly in a marine environment.

a. Austenitic steels develop corrosion resistance by an oxide film which should not be removed even though the surface is discolored. The original oxide film is normally formed at time of fabrication by passivation. If this film is broken accidentally or by abrasion, it may not restore itself without repassivation.

b. If any deterioration or corrosion does occur on austenitic steels and the structural integrity or serviceability of the part is affected, it will be necessary to remove the part.

131. EXAMPLE OF PROCESS FOR REMOVAL OF CORROSION FROM STEEL PARTS. If possible, corroded steel parts should be removed from the aircraft. When impossible to remove the part, observe the aircraft preparations and safety precautions in Chapter 8. No chemical removal or chemical conversion coatings are allowed on steel parts.

a. Positively identify the metal as steel as detailed in Chapter 11, and establish its heat value.

b. Clean area to be reworked.

c. Strip paint if required.

d. Remove all degrees of corrosion damage from steels heat-treated below 220,000 psi as required by paragraph e. Corrosion removal on steels treated to 220,000 psi and above should be accomplished only by dry abrasive blasting. (Refer to Section 6 of this chapter.)

e. Mechanically remove all degrees of corrosion from steel parts heat-treated below 220,000 psi as follows. USE GOGGLES OR FACE SHIELD TO PRECLUDE INJURY FROM FLYING PARTICLES. PROTECT ADJACENT AREAS TO PREVENT ADDITIONAL DAMAGE FROM CORROSION PRODUCTS REMOVED BY MECHANICAL PROCESS.

(1) Remove heavy deposits of corrosion products using a stainless steel hand brush. Alternatively use dry abrasive blasting process as detailed in section 6 of this chapter. EXERCISE EXTREME CARE TO PREVENT OVERHEATING SURFACES WHEN USING POWER TOOLS ON HIGH STRESS STEELS.

(2) Remove residual corrosion by hand sanding or with approved hand operated power tool. Select appropriate abrasive from Figure 10-1.

(3) The surface is highly reactive immediately following corrosion removal; consequently, primer coats should be applied within one hour after sanding. After removing all corrosion visible through a magnifying glass, continue with paragraph f.

f. Fair depressions resulting from rework as covered in Chapter 10 and surface finish with 400-grit abrasive paper.

g. Clean reworked area. Do not use kerosene.

h. Determine depth of faired depressions as required to ensure that rework limits have not been exceeded.

i. Apply protective finish or specific organic finish as required. Remove masking and protective covering.

132.-135. RESERVED.

SECTION 6. MECHANICAL CORROSION REMOVAL BY BLASTING

136. GENERAL. Abrasive blasting is a process for cleaning or finishing metals, plastics, and other materials by directing a stream of abrasive particles against the surface of the parts. Abrasive blasting is used for the removal of rust and corrosion and for cleaning prior to further processing such as painting or plating. Standard blast cleaning practices should be adopted with the following requirements being made.

a. Any form of blast cleaning equipment may be used; but in-cabinet blasting is preferred.

b. External gun blasting may be used if adequate confinement and recovery are provided for the abrasives.

c. Use only glass bead abrasive.

137. SAFETY PRECAUTIONS. Avoid excessive inhalation of abrasive dust. Provide ventilation as required. Magnesium creates a fire hazard when abrasive blasted. Dry abrasive blasting of titanium alloys and high tensile strength steel creates sparking. Care must be taken to assure that no hazardous concentration of inflammable vapors exists. Static ground the dry abrasive blaster and the material to be blasted.

a. The part to be blast-cleaned should be removed from component if possible. Otherwise, areas adjacent to the part must be masked or protected from abrasive impingement.

b. Parts must be clean of oil, grease, dirt, etc., and dry prior to blast cleaning.

c. Close-tolerance surfaces, such as bushings, bearing shaft, etc., must be masked.

d. Blast-clean only enough to remove corrosion coating. Proceed immediately with finishing requirement using surface treatments as required.

138.-140. RESERVED.

CHAPTER 13. MERCURY SPILLS/CORROSION DAMAGE

141. GENERAL. The presence of mercury and mercury salts in air cargo is a definite possibility. Loading, unloading, and general shifting of such cargo can and does result occasionally in damaged containers, cartons, electronic tubes, etc., with subsequent possible leakage of mercury on aircraft structure.

a. Spillage of mercury or mercury compounds within an airplane requires immediate action for its isolation and recovery to prevent possible corrosion damage and embrittlement of aluminum alloy structural components, stainless steels (300 and 400 series), and unplated brass components such as cable turnbuckle barrels.

b. Mercury, by the amalgamation process, can penetrate any break in the finish (anodize/alodine), paint and seal coating of a metal structural component. Bright, polished, shining, or scratched surface will hasten the process, as well as moisture. Mercury or mercury compounds attack the metal grain boundaries and seriously embrittles and reduces the strength of parts. Corrosive attack of freshly scratched aluminum alloy is very rapid, and complete penetration of sheet material is known to occur within three or four minutes.

142. PERSONAL SAFETY. Mercury is highly toxic and spreads very easily from one surface to another. It adheres to hands, shoes, clothes, tools, etc. The following precautions for mercury spills should be strictly adhered to:

a. Avoid contact with surfaces suspected of being contaminated. Use wood or fiber sheets to support body while working in the area. DO NOT ATTEMPT TO PICK UP MERCURY BY HAND.

b. Wear wing socks in contaminated area, to prevent scratching metal surfaces. Throw the socks away after use.

c. Do not wear clothing used in contaminated areas on jobs in uncontaminated areas. Shake mercury off clothing and shoes into unused metal container outside of aircraft. Discard mercury on ground in isolated area.

d. Have clothing cleaned. Wash shoes with soap and water. Clean all tools that have been used in contaminated area with steam or hot water and soap. Discard any drill bits used on mercury contaminated areas. Thoroughly clean vacuum cleaner, if used.

e. Always wash thoroughly with soap and water after contacting mercury. Keep hands away from mouth. Do not eat, smoke, or blow nose without first washing your hands thoroughly.

f. ALWAYS PROVIDE GOOD VENTILATION WHILE CLEANING MERCURY CONTAMINATED AREAS. Appreciable amounts of mercury will vaporize at normal temperatures. A stagnant air will become dangerous to personal health.

g. Do not use cleaning aids such as solvents, solids, or polishes on contaminated area. Such materials may promote corrosion.

h. If hands become contaminated with mercury while working with cleaning equipment, do not touch any exposed metal in surrounding area, as you may contaminate it.

143. INSPECTION PROCEDURE. There have been cases where mercury spills in aircraft caused no adverse effects because of protective films of paint, dirt, grease, or oil. The fact that mercury spillage may not, in all cases, result in serious damage must not be relied on. Each instance of mercury or mercury compound spillage should be considered hazardous, and immediate action should be taken to safeguard the aircraft. Inspect for mercury and corrosion as follows:

a. Determine point at which mercury was spilled. Remove any mercury on floor covering, and then remove covering.

b. When mercury is found on floor, do not remove access/inspection plates, screws, rivets, bolts, etc., from floor. Any hole which is left open in the contaminated area of the floor may allow mercury to spread to structure underneath the floor.

c. Inspect the metal floor, seat tracks, cargo rails, and adjacent structure for mercury and corrosion. Inspect skin and internal structure below point of spillage, and also inspect lowest point in fuselage below cargo compartment floor if mercury spill has occurred in cargo area. Mercury liquid will flow to lowest level.

d. Inspect areas suspected of having mercury contamination using a 10X magnifying glass. If corrosion of aluminum has started, there will be a light grayish "Christmas Tree" fuzz or gray powdery dust deposit, and severe structural damage may follow.

e. If corrosion is evident and cleanup cannot be completed immediately, coat contaminated area with corrosion preventative oil or automobile engine oil. This helps to slow down the corrosion rate and also helps to prevent spreading of mercury contamination.

f. When mercury spills occur in lower cargo compartment, use a portable X-ray machine (if available) along the outside lower surface of fuselage to check suspected hidden corrosion areas between the skin, stringers, and frames below the floor. Droplets of mercury will show on a radiograph as small white spots. Corrosion and embrittlement will appear as tree-like forms completely penetrating a structural component.

g. Inspect bronze/brass control cable turnbuckle barrels for mercury discoloration. Replace if slightest discoloration is detected.

144. REMOVAL PROCEDURE AND PRECAUTIONS. Remove spilled mercury as follows:

SCRATCHING OF METAL MUST BE AVOIDED DURING MERCURY REMOVAL.

a. Use a high capacity vacuum cleaner with a trap-type glass container attached to the large vacuum hose. The size of the pick-up hose from the container should be about 1/4-inch diameter to increase the amount of suction applied to the mercury. Due to the weight of mercury, the container will catch the mercury before it can enter the vacuum cleaner hose.

CAUTION: VACUUM AIR PASSING OVER THE MERCURY DEPOSITED IN THE GLASS CONTAINER PICKS UP MERCURY VAPORS AND EXHAUSTS THEM FROM THE VACUUM CLEANER. AVOID BREATHING MERCURY VAPORS.

b. An all rubber storage battery water syringe, or a medicine dropper, may be used to remove mercury if the trap-type glass container and vacuum cleaner are not available. Cellulose tape may be used to pick up very tiny particles of mercury.

c. General cleanup and inspection (using equipment available) must be made immediately after spillage occurs or is detected.

CAUTION: AN AIR HOSE SHOULD NOT BE USED TO DISLODGE MERCURY FROM AIRCRAFT UNDER ANY CIRCUMSTANCES.

CHAPTER 14. CORROSION PROTECTION FOR AGRICULTURAL AIRCRAFT

151. GENERAL. Practically all chemicals used in dusting and spraying operations are corrosive by nature and hasten deterioration of fabric, metal, and wood. It is essential to safe operation that precautions be taken to prevent corrosion and deterioration of wood, metal, and fabric. Cleanliness of the airplane is one of the most important precautions of all. If it were practicable and feasible to clean the airplane thoroughly, that is, give it a thorough dry washing inside and out after each day's work, probably no special corrosive preventative measures would be necessary.

152. PRECAUTIONS. Since thorough daily cleaning is not practicable, the following precautions should be taken:

a. All fittings and metal structures should be covered with two coats of zinc-chromate primer, paralketone, or similar materials. This coating should be applied to items such as wing-root fittings, wing-strut fittings, control-surface hinges, horns, mating edges of fittings and attach bolts, etc.

b. Nonstainless steel control cables should be coated with paralketone or other similar protective coating, or should be replaced with corrosion-resistant cables.

c. Periodic inspection of all critical portions of the aircraft structure should be made. Structural parts showing corrosion should be cleaned and refinished if the corrosion attack is superficial. If the part is severely corroded, it should be replaced with a corrosion proof part.

d. Experience has shown that additional access openings to permit ready inspection of lower and rearward portions of the fuselage are particularly desirable.

e. Provide additional drainage and ventilation for all interiors to prevent collection of moisture.

f. At the time of recovering, both metal and wood airplane structural members should be coated with zinc-chromate primer (two coats), followed by dopeproof paint or wrapping with cellophane tape.

g. Spray interiors of metal-covered wings and fuselages with an adherent corrosion inhibitor.

h. Wash exterior surfaces with clear fresh water at least once a week. Interior surfaces should also be washed, taking care to prevent damage to electrical circuits or other items subject to malfunctioning due to moisture.

i. Openings in the wings, fuselage, and control-surface members, such as tail-wheel wells, openings for control cables, etc., should be sealed as completely as possible to prevent entry of dust or spray.

153.-155. RESERVED.

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