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IDENTIFIERS Military Curriculum Project

ABSTRACT

This self-paced, individualized course, adapted from military curriculum materials for use in vocational and technical education, teaches students the skills needed to become aviation structural mechanics (second class). The course materials consist of five pamphlets covering the structural maintenance and repair of aircraft. The first pamphlet provides basic and general safety requirements for aircraft ground handling operations and for work performed on the line, in ships, and in the hangar. The second pamphlet provides basic information on the types, uses, and installation and removal of common types of hardware, such as bolts, nuts, and washers as well as miscellaneous hardware, safetying and turnlock fasteners. The types and characteristics of metals used in aircraft construction and the common types of aircraft hardware are the topics covered in the third pamphlet. The two types of aircraft metals (ferrous and non-ferrous), their characteristics, identification and uses in aviation are discussed. Also included are the factors to be considered when substituting and interchanging metals in aircraft construction. The fourth pamphlet presents an overview of the corrosion process, including identification and removal of corrosive damage, and metal surface preservation, while the final pamphlet provides more detail about the corrosion process. Each pamphlet is a student workbook with reading assignments, learning objectives, self-tests, and answers to the tests. Materials are illustrated with line drawings. (KC)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL

Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION

Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

TABLE OF CONTENTS

Aviation Structural Mechanic, Second Class
AM2-0207

Correspondence Course 2-12

Developed by:
United States Coast Guard

Development and Review Dates:
10/8[illegible]

Occupational Area:
Aviation

Print Pages:
223

Availability: The National Center for Research in Vocational Education; ERIC

Suggested Background:

NONE

Target Audiences:

Grade 11 - Adult

Organization of Materials:

Student workbook with objectives, assignments, tests and answers.

Type of Instruction:

Individualized, self-paced

Type of Materials:	No. of Pages:	Average Completion Time:
General Aviation Safety	24	Flexible
General Aircraft Hardware	45	Flexible
Aircraft Metals and Aircraft Structural Hardware	50	Flexible
Basic Corrosion Control and Preservation	57	Flexible
Advanced Corrosion Control and Painting	39	Flexible

Supplementary Materials Required:

NONE

THE NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION
The Ohio State University
1960 Kenny Road
Columbus, Ohio 43210
(614) 486-3655

Course Description:

This course covers the areas concerned with the structural maintenance and repair of aircraft. It is divided into the five areas mentioned before.

The first pamphlet provides basic and general safety requirements for aircraft ground handling operations and for work performed on the line, in ships, and in the hangar.

The primary purpose of the second pamphlet is to provide basic and general information on the types, uses, and installation and removal practices involved with the common types of hardware. The two sections covered are: Bolts, Nuts, and Washers; and Miscellaneous Hardware, Safetying and Turnlock Fasteners.

Outlining the types and characteristics of metals used in aircraft construction and identifying the common types of aircraft hardware are the topics covered in the third pamphlet. The two major topics covered are aircraft metals and aircraft structural hardware. The two types of aircraft metals (ferrous and non-ferrous), their characteristics, identification and uses in aviation are covered. Also discussed are the factors to be considered when substituting and interchanging metals in aircraft construction. Provides information on the common types of structural hardware, identification of various types of hardware, their uses, proper installation and removal procedures, and the special tools required for each type.

Presenting a general overview of the harmful effects caused by corrosion is part of the primary purpose of the fourth pamphlet. Familiarizing the student with the theory of corrosion, corrosion detection and identification, corrosion removal, and metal surface preservation is included, also.

The last pamphlet goes into more detail about the subjects in pamphlet four.

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GENERAL AVIATION SAFETY AND AVIATION MAINTENANCE ADMINISTRATION

AM2-0207

DEPARTMENT OF TRANSPORTATION
U. S. Coast Guard (10/81)

U. S. Coast Guard Institute
PAMPHLET NO. 502

ERIC Full Text Provided by ERIC

4

GENERAL AVIATION SAFETY
AND
AVIATION MAINTENANCE ADMINISTRATION

Second Edition: October 1981

U.S. Coast Guard Institute
Aviation Branch
P.O. Substation 18
Oklahoma City, OK 73169

FTS: 749-4464
COMM: (405) 686-4464

Questions about this text should be addressed to the Subject Matter Specialist for the Aviation Machinist's Mate Rating.

12

ERIC

5

NOTICE TO STUDENT

The primary purpose of this self-paced, nonresident training pamphlet is to present a general overview of aviation safety practices and aviation maintenance administration procedures. The training is designed for aviation second class petty officers.

The pamphlet provides basic and general safety requirements for aircraft ground handling operations and for work performed on the line, in ships, and in the hangar. The administration portion of the pamphlet briefly decribes the Coast Guard Aircraft Maintenance Management System and the Coast Guard, Air Force, and Navy directives systems and publications. Also, various aircraft maintenance forms and reports are described and illustrated, and the aviation supply system is briefly outlined. The pamphlet content is based on the Coast Guard Enlisted Qualifications Manual (CG-311).

IMPORTANT NOTE: This text has been compiled for TRAINING ONLY. It should NOT be used in place of official directives or publications. The text information is current according to the references listed. You should, however, remember that it is your responsibility to keep up with the latest professional information available for your rating. Current information is available in the Coast Guard Enlisted Qualifications Manual (CG-311).

This pamphlet is divided into six sections:

(1) General Aviation Safety
(2) Coast Guard Aircraft Maintenance Management System
(3) Coast Guard Directives, Publications, Forms, and Reports
(4) Air Force Technical Order System
(5) Navy Publications
(6) Aviation Supply System

Each reading assignment is divided into three parts:

Reading assignment and objectives
Reading material
Self-quiz with answers and references. The answers are located on the page(s) immediately following the quizzes.

In addition to the self-quiz after each assignment, a pamphlet review quiz is provided at the end of the pamphlet.

The objectives for each assignment should lead you in the right direction for study purposes. The self-quizzes test your mastery of the objectives. When you complete all the assignments for the course and master each objective, you should have a thorough understanding of the material and should be ready to pass your End-of-Course Test.

REMEMBER--You must receive a score of 80% or better to pass the End-of-Course Test. You should use your spare time to REVIEW the material before you take the EOCT.

SWE STUDY SUGGESTION: Servicewide exam questions for your rate and pay grade are based on the Professional and Military Requirements sections of the Enlisted Qualifications Manual (CG-311). If you use the references from this text and consult the Enlisted Qualifications Manual, you should have good information for review when you prepare for your servicewide exam.

This course is only one part of the total Coast Guard training program. By its very nature, it can take you only part of the way to a training goal. Practical experience, schools, selected readings, and the desire to accomplish are also necessary to round out a successful training program.

CONTENTS

7

CONTENTS *(Continued)*

15

HOW TO STUDY THIS COURSE

You can remember more of what you read if you ....

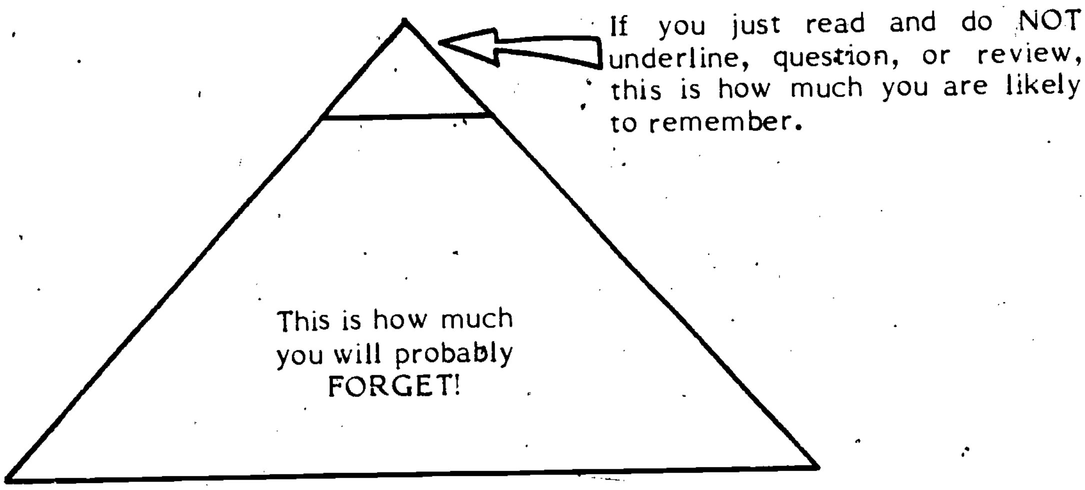
1. "Look over" the reading assignment first. Read the objectives and section headings, and look at the pictures. This gives you an idea of what to expect in the reading assignment and helps you understand the objectives.

2. Question the reading material. Ask yourself questions about a heading or a picture to help you remember what you read.

3. Note points to review later. Don't just run your eyes over a page. Underline important facts and make notes in the margin.

4. Close your pamphlet and repeat important points out loud. Discuss the reading assignment with someone if possible. This helps you recall information for a quiz or end-of-course test.

5. Review your underlined material, notes, quizzes, and objectives. This also helps you remember what you read.



FAA AAC-80-3513

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GENERAL AVIATION SAFETY

Reading Assignment:
Pages 1-1 through 1-17.

OBJECTIVES

After finishing this assignment, you should be able to:

1. State the smoking restrictions you should observe when working around aircraft and engine-powered equipment.
2. State the safety precautions you should observe in the following situations:
   a. Starting and operating tow tractors and other engine-powered equipment.
   b. Operating electrically powered equipment.
   c. Using maintenance stands and other hangar equipment.
3. Explain the proper protection against the following hazards when you are working on or near aircraft:
   a. High-intensity sound
   b. Radar
   c. Radioactivity
4. List steps you should take to avoid injury when working on or near:
   a. Aircraft control surfaces
   b. Vent and drain lines
   c. The cockpit
   d. Aircraft electrical systems
5. List and define aviation safety color codes.
6. Describe the safety precautions for the following:
   a. Fuel, oxygen, and hydraulic servicing
   b. Aircraft towing
   c. Aircraft parking and mooring
7. State the major cause of injuries and equipment damage in shops.
8. State the safety practices you should observe when using shop facilities, electronic equipment, and handtools.

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INTRODUCTION

The purpose of this section is to emphasize the importance of a good aviation safety program. Because of the new and complex equipment used today, maintenance personnel must be aware of the hazards encountered in using this equipment. This section outlines some of these hazards and points out proper safety precautions.

Proper safety measures, rigidly enforced, result in tremendous savings in man-hours and equipment. In aviation, your safety and the protection of the equipment you maintain are of prime importance. Jet-engine-powered aircraft represent a still comparatively new field, and many new hazards have developed which did not exist for reciprocating engine aircraft. New and different types of equipment are being used, and more special tools are being developed. Also, the Coast Guard is now training more and more specialists, with the result that more personnel are constantly working around aircraft. The increase in personnel, the use of new and more complex tools and equipment, and the added dangers at both ends of the aircraft justify the need for a good safety program.

This section will help you to understand the need for and the importance of a safety program throughout the Coast Guard. You will also become familiar with some of the hazards that you may encounter around jet engine aircraft. However, no hazard is so great that it cannot be overcome with a little knowledge and common sense. In the following pages we will present a few of the major hazards and hope that an awareness of them will aid you in your work in aviation.

HANDLING GROUND EQUIPMENT

A knowledge of the proper way to handle ground equipment is very important to you as an aviation petty officer. Improper handling of such equipment is as dangerous as improper use of it. There are three ways of handling equipment: the ideal way, the accepted way (due to conditions and location), and the wrong way. Because of the different working conditions encountered in the vast area covered by the Coast Guard, the ideal way may often differ somewhat from the accepted way. However, the accepted way is as safe as the ideal way.

In the Coast Guard today we have a greater variety of equipment than ever before. We will divide this equipment into various categories and give you a few points on the DO's and DON'Ts of putting the equipment to practical use. For discussion purposes, we will classify this equipment as engine-powered, electrically powered, and hangar equipment.

ENGINE-POWERED EQUIPMENT

This equipment includes everything from the mules and trucks used on the flight-line to the auxiliary power unit used to start the aircraft engine. One of the most important things to remember about engine-driven equipment is that it uses combustible fuel for its operation. Wherever combustible fuel is used, a potential fire hazard always exists. As an emergency measure, fire extinguishers (called fire bottles) are positioned near all engine-driven equipment. To avert the possibility of fire, certain restrictions are placed on maintenance personnel.

Smoking, for example, is restricted within 100 feet of all hangars and aircraft. In some places, smoking is not permitted on the flight line or within 100 feet of any building on the line. This restriction seems a little harsh at times, but suitable smoking areas are provided. To illustrate the dangers of smoking on the flight line, consider the following incident. One day when the ramp was cleared of all aircraft, several of the personnel were talking while standing along the edge of the ramp. From all appearances, no danger was imminent. One of the persons lit a cigarette, and after finishing it, flipped it into one of the ramp drains. Immediately an explosion occurred that tore up the ramp about 30 feet in all directions. Upon investigation it was determined that someone had carelessly poured some contaminated fuel in the drain and created a potentially explosive mixture, which needed only a spark to ignite it. In this instance, two people were guilty of violating safety regulations, but had the smoker observed the rule regarding smoking, the explosion would not have occurred.

Smoking is not the only hazard around engine-powered equipment. Thus, let us investigate some of the other potential hazards where mobile units are used.

The mule is a towing unit often used by maintenance personnel. For this reason we will discuss the safety measures that apply in the use of mules and similar towing vehicles. We know, of course, that the main purpose of a mule is to tow aircraft and to transport equipment to and from the hangar. Many people erroneously believe that a mule is to be used for personal transportation -- a notion that has resulted in many accidents. Since the mule is geared low for power, it may jerk or lurch suddenly while being started. Occasionally, persons seated or standing on it have been thrown off, with resulting injuries to them. Some mules have one single seat, and others have a continuous three-person seat; these seats indicate the maximum number of personnel authorized to ride. If no seat is available, never attempt to ride on the fenders or other parts of the vehicle. If you are riding and want to get off, wait until the mule comes to a complete stop. Never get off any vehicle while it is moving.

While towing equipment, always be on the lookout for trouble. Usually speed is the main cause of accidents; remember that a safe speed is not always governed by the speed limit, but usually by the load you are pulling and the weather conditions. Making a sudden turn with topheavy equipment could cause an upset which would damage the equipment and endanger nearby personnel. When pulling equipment with a mule, hitch the unit to the mule. Since trouble often occurs at the hitch, always be sure your hitch is secure and occasionally doublecheck it to make sure it has not worked loose. When towing a load through a congested area, have someone walk on each side to help you guide the load. If there is ever any doubt about your getting past or between some objects, move them or go around. "I thought I could make it" is never an acceptable excuse; there is no excuse for this type of accident. When you are towing an aircraft in a congested area, a minimum of four people should be used: a towing vechicle operator (usually supervisor), two wing walkers, and someone in the cockpit to operate the brakes. When sharp turns are anticipated or when backing the aircraft, assign a tail walker. Two persons can perform the towing operation satisfactorily in an area where no contact with hazardous objects is possible. If you must tow the aircraft across an active runway or taxi strip, be sure you get clearance from the control tower first. Don't trust your own vision. Your life and that of others may be at stake. Precautions for aircraft towing are discussed in detail later in this section.

Mobile units are not our only engine-driven hazards. As we stated before, wherever there is power there is a potential hazard, and fire is still our greatest hazard. Heat and fuel combined and controlled can be put to many constructive uses, but combined and uncontrolled, they can be very destructive. Fuel confined in a tank is controlled, but fuel on the ground or on a unit is uncontrolled. Never service a unit while it is operating. Always stow flammables in the area designated for their storage. When operating engine-driven equipment, always be sure that the exhaust gases are not coming in contact with any flammable material that may have spilled. Be sure that the equipment is electrically grounded and kept a safe distance from all aircraft. When using engine-driven equipment in an enclosure, be sure to vent the exhaust gases out of the enclosure, or make certain that there is sufficient ventilation to nullify the effects of the fumes, because fumes, visible or invisible, are always dangerous.

Although there are many types of engine-driven equipment, ther are only two ways of starting them -- by automatic cranking (starter) or by manual cranking. The automatic starter presents no hazards, but the handcrank presents several. How many people today know the proper way to handcrank an engine? How many people stop to consider the injuries that can result from one kickback if they do not hold the crank properly? Consider what happened to one person while trying to crank a portable air compressor. After making a visual check of the machine to be sure that it was in operating condition, the person took the crank in both hands, locked the wrists, and tried to turn the crank by pushing downward. During this cranking operation, a kickback occurred. Because of the tight two-handed grip, the person was unable to release the handle and, as a result, suffered a broken wrist and fractured arm. A similar accident happened when a portable hydraulic test stand was being cranked. The person cranking the engine had the proper grip on the crank and was pulling up on the crank with one hand. Midway in the cranking cycle the crank slipped off the shaft and spun around. Another person standing too close was struck on the head and received a slight fracture. Neither accident would have occurred if the person cranking the machine had been thoroughly indoctrinated.

The important thing to remember when cranking an engine is to hold the handle firmly with one hand and crank by pulling up on the handle. Thus, should the engine kick back, the handle will be pulled from your hand instead of being driven into it.

ERIC

ELECTRICALLY POWERED EQUIPMENT

Now that you are aware of the dangers present when you use engine-driven equipment, let us turn our attention to electrically driven equipment. Of course, the danger of fire is decreased because no fuel is used in the actual operation of the equipment. This advantage, however, is offset by the presence of electrical power.

Before using any piece of electrical equipment, you should first know what voltage is required to operate the equipment. The most commonly used voltages are the 110 and 220-volt alternating current (AC) voltage sources. When preparing to use a piece of equipment with which you are not familiar, first look at its data plate and determine the voltage required for its operation; then be certain that you use the correct power outlet. When more than one voltage is available, the receptacles are usually labeled to lessen the possibility of making mistakes. Be sure of the rating of any electrical source before you attempt to use it.

Electrical Hazards

The wide use of electrical facilities and equipment in almost every Coast guard ground operation exposes personnel to many accompanying hazards. Equipment damaged through improper use is costly and can seriously affect your mission.

Static electricity is an electrical hazard you must constantly guard against. It is necessary to make an effective connection between aircraft, equipment, and ground during servicing and maintenance operation and also when aircraft are hangared, moored, or parked. Static ground connections must meet prescribed requirements for low resistance grounds. Applicable aircraft maintenance manuals contain specific grounding instructions which must be observed. This grounding may seem unimportant, but static electricity can cause sparks and fires which could destroy equipment.

HANGAR EQUIPMENT

Hangar equipment is very important to the mechanic. For most aircraft maintenance, major or minor, hangar equipment of some kind must be used. To ensure the safety of the operator as well as the care of the equipment during its use, certain precautions must be taken.

Working on different types of aircraft necessitates the use of maintenance stands. These stands are designed to enable a person to reach high places on the aircraft, where different types of work are to be accomplished. In using these stands, we have to abide by a few rules of common sense. The first rule is to make sure that the stand is in first-class condition (no loose or missing nuts or bolts, no structural defects, no loose or missing steps). The second rule is to make sure that the stand is clean (no grease or oil spots which might make you slip or fall). The third rule is to keep track of your tools. Do not leave tools lying close to the edge of the platform where they can be easily knocked off and possibly injure someone working below you. Here is the fourth rule: Before you put the stand back in its proper area, make sure that it is clean, free from structural defects, and therefore ready for use the next time you need it. When you move the stand to and from the storage area, be sure you have another person help you (one on the front and one on the back). In that way you will not bump into or damage other equipment.

Sometimes during your work, you will need to use jacks. Always check the fluid level before using a jack. When putting jacks under aircraft, make sure they are properly stabilized. After jacking has been completed, adjust and set safety locknuts or safety pins. If the aircraft is to remain on jacks for any length of time, it should be supported by cribs. Before releasing jacks, make sure the area is clear of all personnel and objects. After use, the jack plunger should be completely depressed, and a protective cover should be placed over the jack.

Another item of hangar equipment that you will use is the hoist. A hoist is a lifting device that employs slings, ropes, chains, or cables. Potential hazards attending the use of lifting devices include swinging or falling loads, exposed moving machinery, or the failure of structural members. From the nature of these hazards, you can see the necessity for keeping all nonworking personnel away from the work area during operation of the hoist. You can also see the need for rigging the slings correctly and for inspecting the equipment thoroughly before it is used.

AIRCRAFT SAFETY AND POTENTIAL AIRCRAFT DANGERS

Now we will turn our attention to a few of the more serious potential hazards that confront aviation personnel.

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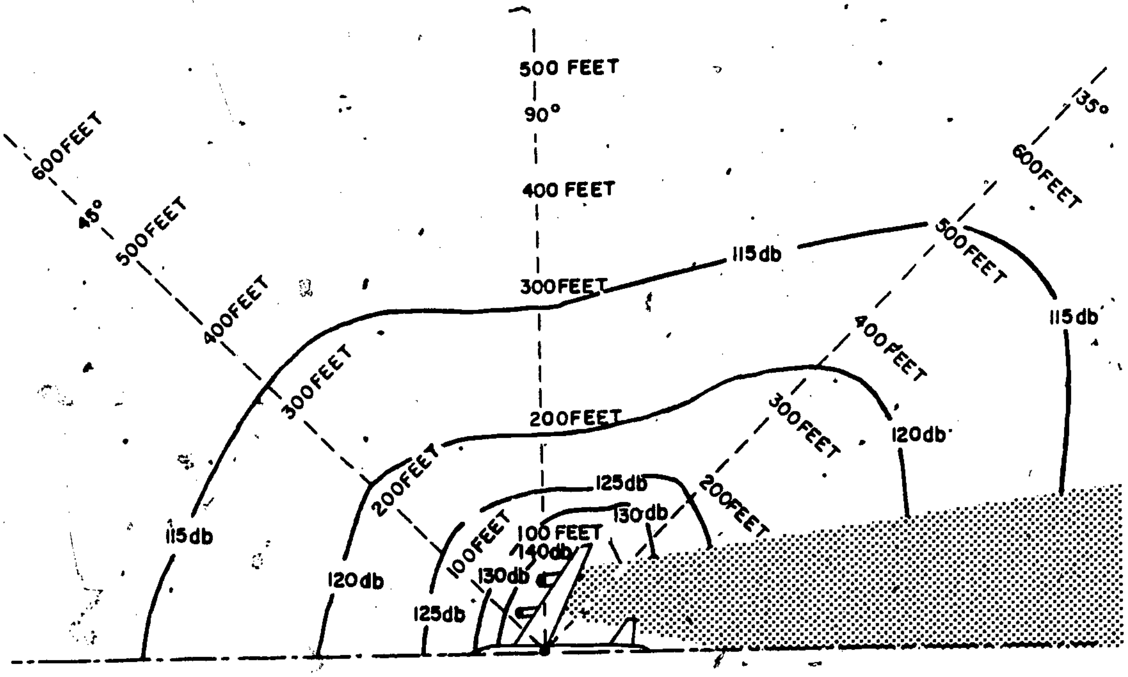

NOISE INTENSITY CONTOURS AT TAKEOFF RATED THRUST. B-52G

NOTE

THE ABOVE NOISE INTENSITY CONTOURS ARE APPLICABLE TO FOUR-ENGINE OPERATION. FOR TWO-ENGINE OPERATION, THE NOISE INTENSITY WILL DECREASE BY 6 DECIBELS AT 200 FEET AND BEYOND. THE DIFFERENCE BETWEEN FOUR- AND TWO-ENGINE OPERATION AT 0 TO 200 FEET IS NEGLIGIBLE.

THE DISTANCES TO 100 AND 110 DECIBEL CONTOURS ARE AS FOLLOWS:

ANGLE	DISTANCE	
	100db	110 db
0°	1400 FEET	500 FEET
45°	1400 FEET	500 FEET
90°	1150 FEET	410 FEET
135°	1500 FEET	660FEET

NOTE

THIS CHART IS PRESENTED FOR CORRELATION WITH AIR FORCE REGULATION 160-3.

OCTAVE BAND	DECIBELS [1]	OCTAVE BAND	DECIBELS [2]
20/75	3	600/200	10
75/150	3	1200/2400	11
150/300	4	2400/4800	6 [2]
300/600	7	4800/10KC	8 [2]

[1] DECIBELS TO BE SUBTRACTED FROM THE OVERALL AT TAKEOFF RATED THRUST. THESE VALUES ARE MINIMUM DIFFERENCES BETWEEN THE OCTAVE BAND AND THE OVERALL NORMALLY EXPECTED AT ANY ANGLE AND DISTANCE.

[2] STRONG PURE TONE COMPONENTS CAN BE EXPECTED IN THESE BANDS AT COMPRESSOR AND/OR FAN BLADE PASSAGE FREQUENCIES.

Figure 1-1. - Noise Intensity Chart, B-52G Aircraft.

High Intensity Sound

Personnel who work near or on aircraft are exposed to extremely hazardous noise potentials, particularly when jet aircraft are being operated. Not only is noise dangerous to a person's hearing and interferes with speech communications, but noise leads to fatigue. This, in turn, leads to faulty maintenance work and increase the number of accidents attributed to "maintenance error," as well as a general increase in the number of preventable ground accidents.

Noise levels of 110 to 120 decibles (db) and above are common in the vicinity of jet aircraft engines in operation as well as over a wide surrounding area. Multiengine jets (Figure 1-1) frequently exceed 130 db, and personnel may suffer physical injuries at these higher levels of exposure unless they are suitably protected.

Protection against noise hazards can be obtained through the use of ear protectors, selected aircraft runup areas, noise-suppression devices, and other precautions. The noise intensity of jet aircraft is greatest to the rear of the engine at an angle of 45° on either side. Do not work or stand in these high-intensity noise areas unless absolutely necessary. Ear protectors alone will not provide enough protection at levels of 130 to 140 db. If you must work in these areas of high-intensity noise, be sure to wear a protective helmet or head set in addition to earplugs and keep the period of exposure as short as possible. Noise levels of 85 db and below are considered relatively safe.

A person who has received an "overdose" of sound will show several symptoms of sickness or injury. The person may have pain, a feeling of fullness, and/or ringing or burning of the ears; sometimes dizziness; impairment of mental concentration; and occasionally nausea, vomiting, or weakness of the knees. Emotional irritability is often a sign of noise fatigue. When any of these symptoms are noted, the affected person should be taken from the noise area immediately and examined by a medical officer.

Radar

You can be burned while working around aircraft. Radar can burn you as quickly as if you had touched a match to your arm. The appearance of a hot spot on a bare portion of your skin would be a very good indication that you are standing too close to an operating unit. Of all human tissue, you will find that the eye tissue is the most sensitive to radar.

Radioactivity

Along this same line of unseenor unheard dangers is RADIOACTIVITY. At some time or other you may come into contact with aircraft contaminated by radioactivity: consequently, there are a few things you should know about radioactivity. Although you cannot see or hear radioactivity, it can make you sick, burn you, or even kill you if you should be subjected to a large enough dose at one time.

If there are signs (Figure 1-2) to the effect that an aircraft is contaminated, stay out of that area unless you are assigned to a decontamination crew. If you are assigned to one of these crews, the base medical center will inform you of what equipment to use and the hygienic factors that affect you. A couple of the more important pieces of equipment you would use are the film badge and a dosimeter, for this equipment tells the base medical center how much radioactivity you have received. In turn, the information will be placed in your medical files for future reference.

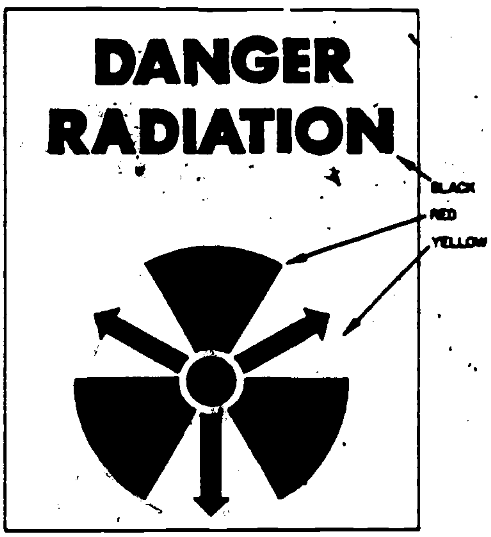

Figure 1-2. - Radiation.

Control Surfaces

There are many other sections of the aircraft which present definite hazards to maintenance personnel. For example, all control surfaces are extremely dangerous. Be moving the control stick left or right in the cockpit, we raise one aileon and lower the other; by moving the control stick forward or rearward, we raise and lower the elevators; and by manaully moving either the ailerons or elevators from the outside, we also move the control stick in the cockpit. Thus, always make sure that personnel are clear of the aircraft before moving any control surface. Let us consider an accident that occurred because someone didn't look before moving the stick. A person working under the wing of an aircraft was changing an aileron eyebolt. To change this bolt, the person had to place several fingers between the stationary skin of the aircraft and the movable surface of the aileron. While removing the bolt, someone in the cockpit, without looking, moved the aileron. The person's fingers were mashed between the fixed and movable surfaces. As a result of someone else's carelessness, the individual suffered the loss of several fingers. To prevent this from happening to you, always have someone hold the moveable surface in the position you desire it, preferably from within the cockpit.

When working on the wing flaps or on any surface which is electrically or hydraulically operated, be sure you have rendered the system inoperative before you begin to work on it. Almost all control surfaces have sharp edges. You must always be alert to keep from bumping into these edges. As a safety measure (Figure 1-3), place a red streamer, piece of red tape, or corner cover over the edges to attract attention to these dangers. In some instances the fixed control surfaces are low enough to come into contact with the body. The only safety precaution to prevent your bumping these surfaces is alertness. Keep your mind on what you are doing and don't let anyone distract you while you are moving around the aircraft.

Vent and Drain Lines

Underneath most aircraft there are numerous vent and drain lines. The ends of these lines are usually cut at an angle to prevent any siphoning action that otherwise might take place during flight. Because of the angle at which these lines are cut, they have sharp edges which can tear your clothes and cut your skin. If you cut yourself on a fuel vent, you run the risk of getting lead poisoning. Since vent lines are left uncovered, it is important that you protect yourself while working under the aircraft.

Cockpit

You may have cause, from time to time, to work in the cockpit, you should familiarize yourself with the location of all the switches you will need to use. While you are in the cockpit, do not move any switches other than the ones that concern your job. Don't be a showoff or a hangar pilot.

Aircraft Electrical Systems

If possible, use an auxiliary power unit when checking a unit for operation. Be sure to keep the aircraft electrically grounded at all times while it is in the hangar or being working on. Never connect electrical power to an aircraft before checking with other persons working on the aircraft; someone might be working with electrical leads or have switches set to actuate some electrically operted mechanism.

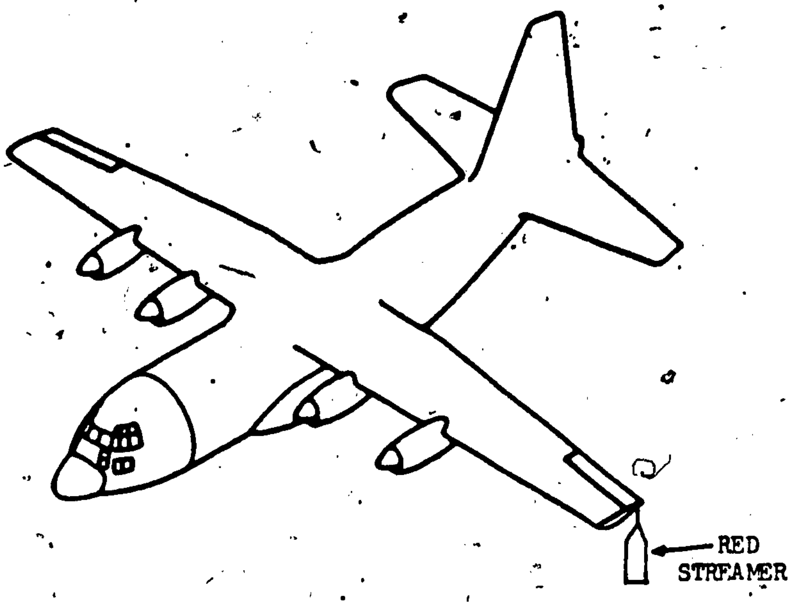

Figure 1-3. - Red Warning Flag.

Fuel and Oxygen Servicing

You may at sometime be required to service an aircraft with fuel and oxygen. When you are refueling an aircraft, make sure that the fuel truck and aircraft are grounded to the earth and to each other as well as the fuel nozzle to the aircraft. If you accidentally spill any fuel, be sure you clean it up. Also be careful not to get any fuel on your clothes or body; fuel-saturated clothing will irritate your skin, and fuel on your skin can penetrate sufficiently to cause lead poisoning.

Do not refuel an aircraft near any operating radio or radar equipment. While operating, this equipment builds up charges of static electricity that can be transmitted to objects 100 feet away; on certain types of radar sets the distance will vary from 100 feet to 1,000 feet, depending on the frequency output of the set. As you know, there are two categories of radar equipment, airborne radar and ground radar. The safety ranges for airborne radar vary from 100 feet to approximately 300 feet. On the ground, radar can be dangerous up to 1,000 feet. One of the best ways to eliminate the danger of refueling an aircraft in an operating radar danger area is to consult the base communications officer. This officer knows the areas in which these sets are located and also the danger range of these sets.

To prevent an explosion when you service an aircraft with oxygen, never allow any grease or oil to come in contact with oxygen or oxygen fittings. When servicing any oxygen system, always service it slowly to prevent excessive heating and to ensure proper system pressure. When you have finished sevicing an aircraft, always return the equipment to its designated area. Aircraft servicing precautions are discussed in detail later in this section.

Safety Color Coding

All designated areas will be marked either by painted surfaces or by informational signs. Since each color of paint has a definite meaning, we are going to discuss a few of the colors commonly used. Red indicates such dangers as an open hole, a red stop light, and petroleum, oil, and lubricant (POL) areas (where gasoline, oil, etc., are stored). Fire extinguishers, fire trucks, and some of the other safety equipment for these danger areas are painted red.

Yellow indicates caution. For instance, at an overhead hoist, the area below the hoist will be painted in yellow stripes. This warning could prevent you from bumping your head on the chain hook hanging from the hoist. Green is the color used to indicate safety, first-aid equipment, location of gas masks, and other safety equipment.

Black, white, or a combination of these two colors is the basic color marking used for traffic, directional, housekeeping, and informational signs and signals. Solid colors, alternate black or white stripes, or black and white checks may be used.

ENGINE SAFETY

It may sometimes be necessary for you to help remove an engine from an aircraft. When removing the engine, you must be sure that the engine sling is securely fastened. After the engine is removed, cover the ends of all open lines and electrical circuits to prevent foreign materials from entering the disconnected lines and to prevent exposed electrical circuits from shorting. As an example of what can happen when lines and circuits are left exposed, let us consider the following incident.

At an air station it was discovered that after a high wind, a large amount of sand and dirt had been blown into the open lines of an HH-52A. Fortunately, the sand and dirt were discovered before a new engine was installed. If the engine had been installed, the sand and dirt would undoubtedly have caused the failure of one or more of the systems in flight; and the loss of the aircraft and possibly the pilot and crew would have resulted. From this example, you can see why it is essential that open lines or circuits be taped or covered when an engine is removed.

After removing the engine from the aircraft, you will find it necessary to place the engine in a stand before working on it. When you place an engine in a stand, be sure that the engine is properly secured. If the engine is not properly secured, it may slip or shift and cause injury to personnel and damage to the engine.

The safety precautions we previously covered regarding equipment also apply to engines. There are, however, additional safety practices that pertain to the care of the engine. Summed up, these methods consist of good maintenance habits. To break them down and give you an idea of what we mean, let us consider safetying devices. Because of engine vibration, it is necessary that we ensure positive security of screws, bolts, and other fastening devices. Safetying devices include safety wire, cotterpins, and self-locking nuts. For safe operation of the engine, you must properly replace safety devices on all units on

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which a safety is required. Sometimes some of these devices may seem unnecessary to you, but always remember that the manufacturer of the engine, through experience, has established the need for them.

At one time or another while working on an aircraft, you will probably drop a nut or something into some inaccessible place. No matter how small the dropped article may be, take time to remove it. Be sure that there are no pieces of safety wire or any other material left lying in the engine compartment. The smallest particle sucked into and through the engine can damage it enough to require major repair or overhaul.

JET AIRCRAFT DANGER AREAS

General safety standards relative to conventional type aircraft also apply to jets; however, ground handling of jet aircraft involves some additional hazards. For example, when a jet engine is in operation, the exhaust blast behind the engine, the suction effect in front of the engine, and the turbine wheel danger area require particular attention of all personnel working in the immediate area. Other hazards include high-intensity sound, radio-frequency radiation, and power-actuated equipment. (Figure 1-4 shows jet and radar antenna danger areas.)

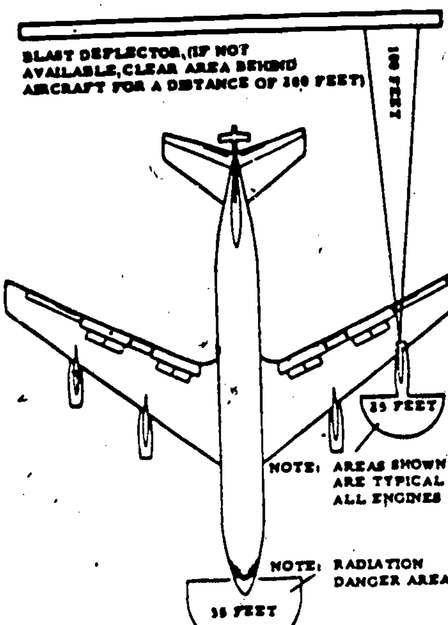

Figure 1-4. - Jet and Radar Antenna Danger Areas.

Turbine Wheel Danger Areas

Do not stand near the red stripe painted on the fuselage or engine nacelles of jet aircraft during engine runup. This stripe and danger area mark the plane of turbine wheel rotation, which is a potentially dangerous area if the turbine fails.

Engine Exhaust Danger Areas

The high-velocity high-temperature exhaust blast of a turbine engine is particularly hazardous to personnel and is to be carefully avoided. Do not pass close behind a jet aircraft with its engine operating. Before starting any jet engine, remove tools, spare parts, and other objects from the blast areas. Too often a person forgets or does not realize how dangerous these areas can be. (See figure 1-4.)

Engine Intake Danger Areas

The suction effect of a jet engine is sufficient to cause fatal injury to personnel and extensive damage to equipment. Do not wear loose clothing or carry objects which might be drawn into the ducts when working on or near jet aircraft. In addition, remove all objects from in front of or in the intake ducts before starting engines.

There have been instances where people have been sucked into the intake of jet aircraft, and, of course, they lost their lives. If you see a sign like that in figure 1-5, observe the warning.

Figure 1-5. - Jet Engine Warning Sign.

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HELICOPTER DANGER AREAS

Helicopter danger areas that you should be aware of include the main rotor blades, tail rotor blades, and engine areas. Keep clear of rotary wing aircraft for at least a distance equal to the length of the craft to prevent injury and damage in case of a quick excessive throttle start which might swing the tail rapidly. During engine operation, keep clear of the plane of rotation of the jet turbine section, main rotor blades, and tail rotor. Use caution when approaching the plane of rotation of the main rotor blades, since they tend to droop at decreased speeds.

PROPELLER AIRCRAFT DANGER AREAS

Danger areas for propeller type aircraft are similar to other aircraft and also require that you be alert and careful. The most hazardous conditions exist when the engines are operating. There have been cases where men, preoccupied with something other than the propeller danger area, have walked right into a turning propeller and out of this world. Your best insurance against this danger is to keep alert and aware of the danger areas. (See figure 1-6.) The plane of rotation of a turning propeller is also a danger area. If the engine is a turboprop type, additional danger areas include the plane of rotation of the exhaust turbine wheel, jet intake ducts, and jet exhaust blast.

AIRCRAFT SERVICING PRECAUTIONS

Aircraft servicing precautions have been inluded in this course for safety purposes. Some procedures that will be performed by other maintenance personnel are included; however, it is important that you know all precautions not only concerning your own work but for work being performed near you.

FUELING PRECAUTIONS

Fueling aircraft from either trucks or hydrants requires the utmost caution on the part of all personnel. Modern fuels used in high-performance aircraft are extremely flammable and easily ignited. Fuel vapors can be ignited by static or friction sparks, hot exhaust pipes, lighted cigarettes, electrical devices, and similar ignition sources. In the case of aviation gas, a temperature of only 540° F. will cause ignition and fire. Early jet fuels were considerably less hazardous than normal aviation gasoline. However, the fuels used in modern jet aircraft are potentially more dangerous than gasoline. Jet fuel, grade JP-4, is a low vapor pressure fuel and has to be handled with the same respect and care as high octane aviation gasoline. Because of its relatively low vapor pressure range, JP-4 requires added precautions in handling. Jet fuel contains more toxic aromatics than aviation gasoline and must be handled with the same health precautions that apply to leaded gasolines. Petroleum vapors, regardless of their toxicity, will displace the oxygen in an area because of heavier weight and may cause asphyxiation. All safety standards detailed in appropriate technical orders must be observed during any fueling operation.

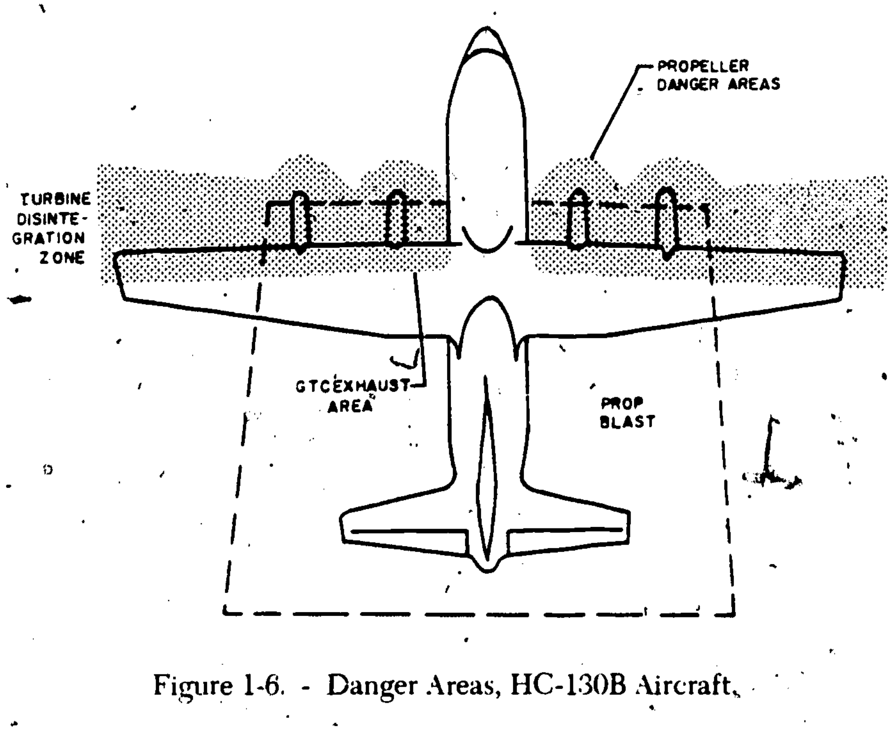

Figure 1-6. - Danger Areas, HC-130B Aircraft.

Normally only personnel actually engaged in the fueling operation will be allowed in the area, but they must not carry matches, lighters, or other sparking or flame-producing devices on their persons. Aircraft pneumatic, oil, and water alcohol systems may be serviced concurrently with fueling operations when it is essential to meet established operational requirements: all safety precautions must be observed, and no electrical circuitry other than that required for fueling operations must be activated. Smoking is not permitted within 100 feet of aircraft. Personnel must use utmost caution and strictly adhere to safety precautions during these operations.

All operating servicing equipment ground powerplants, ground heaters, air compressors, and similar equipment must be shut down before the start of fueling or defueling operations. If the equipment is not needed during the fueling or defueling operations, it must be moved to a point not less than 50 feet away from the aircraft. If the equipment is needed immediately before or after fueling or defueling operations, it may be left connected to the aircraft during the operations. Make sure the equipment is shut down before starting the operations. The connected equipment must be positioned at a maximum distance from fueling points and vents and must not be restarted until fuel vapors have dissipated.

All personnel must be particularly careful not to come in contact with fuels, inhale fuel vapors, or swallow aviation gas or jet fuels. When aircraft fuels come in contact with the skin, a solvent action occurs, removing natural fats. Fuels act as direct irritants to the skin and quite frequently cause contact dermatitis. Extensive vapor inhalation may cause serious illness, and accidental swallowing of fuels will result in internal injury and possible death. Personnel subjected to splashed or sprayed fuel, whose clothing become more than slightly damp, should immediately depart the area and remove their clothing. A shower should be taken a quickly as possible to prevent irritation of the skin. Clothing contaminated with fuel must not be removed near any source of possible ignition. Such clothing should be exposed to free air drying (out of buildings) as soon as removed and should be washed in soap and water before being worn again.

The applicable aircraft maintenance manuals contain instructions concerning specific aircraft.

Oxygen Servicing Precautions

The use of oxygen in Coast Guard operations presents many serious safety problems. There is the possibility of personnel injury, of course, but there is the even more serious possibility of fire and explosion. Although oxygen itself is not flammable, it will support combustion in other flammable material. If oxygen is permitted to mix with flammable gases, the result can be highly explosive. Another source of danger occurs if oxygen is subjected to pressures. These pressures cause excessive stress and strain on lines and tanks, an effect which could result in rupture and explosion. Because of the hazards involved in handling oxygen, particularly in aircraft servicing operations, only qualified personnel are permitted to handle this potentially hazardous substance. All personnel engaged in oxygen handling and servicing opertions must stricitly observe the safety standards in pertinent publications.

Ignition Sources

Before beginning oxygen servicing operations, make sure that all sources of power are turned off and any other source of flame or sparks is removed from the area. No flames or spark-producing devices are permitted within 50 feet of oxygen-servicing operations. Aircraft oxygen systems must not be serviced or drained within 50 feet of hangars, structures, and/or fuel spills. Make sure that aircraft and oxygen servicing trailers are adequately grounded before beginning oxygen transfer and are not left unattended after hookup to the aircraft. Pressure oxygen must not be used to inflate landing gear shock struts, pressure accumulators, tires, etc.

Grease and Oil

High-pressure oxygen reacts violently with grease or oil. To reduce the fire hazard, personnel must be sure their hands, clothing, tools, and equipment are free of grease or oil before servicing with oxygen.

Handling Cylinders

Handle oxygen cylinders carefully to avoid damage. If a cylinder is dropped or allowed to fall over, a valve may be damaged or broken off, resulting in the cylinder being propelled through the air like a rocket. Store oxygen containers in cool areas out of the direct rays of the sun and away from other compressed gases.

HYDRAULIC SERVICING PRECAUTIONS

Although servicing aircraft hydraulic systems is not as hazardous as fuel or oxygen servicing, hydraulic fluids under high pressures do involve certain dangers and require maintenance personnel to take precautions. For example, when adding fluid to a pressurized hydraulic reservoir, slowly depressurize the reservoir before removing the filler cap, and dump hydraulic pressure (reduce it to zero) before servicing with fluid or accumulator pressure. Since different aircraft have different hydraulic systems, the servicing procedures and precautions will also differ. Detailed servicing instructions and precautions are contained in the applicable aircraft maintenance manual for the hydraulic component being serviced. The hydraulic systems of some aircraft are serviced with a hydraulic test stand attached and operating; this involved observing precautions for the stand as well as the aircraft. Servicing with clean hydraulic fluid of the correct type is extremely important to prevent failure of the sytem. It is necessary to service accumulators with dry filtered air or nitrogen (as prescribed) to the correct pressures under specified conditions. A hydraulic accumulator should never be serviced with high-pressure oxygen. Any hydraulic fluid spilled in or on the aircraft must be removed and the area wiped clean. Be careful not to spill hydraulic fluid on other components such as electrical or electronic units.

AIRCRAFT GROUND HANDLING PRECAUTIONS

Aircraft maintenance involves certain precautions and procedures necessary for proper and safe care of the aircraft on the ground. This includes precautionary measures for prevention of injury to personnel as well as damage to equipment and property. Ground handling operations discussed here include towing and parking, plus the related hazards concerning aircraft walkways and nostep areas.

AIRCRAFT TOWING

Aircraft ground handling personnel shall be thoroughly familiar with all procedures pertaining to the types of aircraft being towed and the local operating procedures regarding the ground movement of aircraft. Newly assigned personnel will complete an adequately supervised on-the-job training program before assignment to ground handling of aircraft. Only competent personnel, properly checked out will head the aircraft towing team. The following procedures shall be observed:

1. When possible, a minimum of four people shall be employed when towing aircraft in a congested area. A trained team member shall operate the tow vechicle and will normally be in charge of the operation. The towing team member in charge shall ensure that members of the towing crew are qualified for their assignments. When the aircraft is being towed in an area where no contact with hazardous objects is possible, the wing and tail personnel may be dispensed with. The MINIMUM aircraft towing crew shall be two towing team members.

2. The towing vehicle driver shall be responsible for operating the vehicle in a safe manner and shall obey emergency stop instructions given by any team member. The operator shall be a qualified driver and have a current U.S. Government Motor Vehicle Operator's Identification Card.

3. The person in charge shall assign team personnel as wing walkers. A wing walker shall be stationed at eachwing tip in such a position that will ensure adequate clearance of any obstruction in the path of the aircraft. A tail walker shall be assigned when sharp turns are to be made or when the aircraft is to be backed into position.

4. A qualified team member shall be in the pilot's seat of the towed aircraft to observe and operate the aircraft brakes as required by towing team signals. When necessary, another qualified team member shall be stationed to watch and maintain hydraulic pressure if the man in the pilot's seat is unable to do so.

5. The team member in charge of the towing operation shall verify that the locking scissors or rudder lock (on some aircraft) are disconnected on aircraft with steerable nose wheel(s) prior to towing the aircraft. The locking device(s) shall be reset after the tow bar has been removed from the aircraft.

6. Under no circumstances shall personnel walk or ride between the nose wheel of an aircraft and the towing vechicle, nor will they ride on the outside of a moving aircraft. In the interest of personnel safety, no person (except in an emergency situation) shall attempt to board or leave a moving aircraft or towing vechicle.

7. The towing speed of the aircraft shall not exceed that of the walking team members. The aircraft's engines shall not be operated at any time the aircraft is being towed into position.

8. The aircraft brake system shall be charged, before each towing operation. Aircraft with faulty

brakes shall only be towed into position for repair of brake systems, and then only with personnel standing by ready with chocks for emergency use. Chocks shall be readily available in case of any emergency during any towing operation.

9. To avoid possible personnel injury and aircraft damage during towing operations, entrance doors shall be closed, ladders retracted, and gear locks installed.

10. Prior to towing any aircraft, towing team members shall check all tires and landing gear struts for proper inflation.

11. When towing aircraft, the vechicle operator shall not jerk the aircraft or start and stop suddenly. Cockpit personnel shall not apply aircraft brakes during towing operations unless an emergency exists, and then only on command from one of the tow team members.

12. Aircraft shall be parked in specific areas only. Generally, the distance left between rows of parked aircraft shall be enough to allow immediate access of emergency vehicles in case of fire and also permit free movement of equipment and materials.

13. Prior to any movement of aircraft across runways or taxiways, contact shall be made with airport control tower for clearance to proceed.

AIRCRAFT PARKING AND MOORING

Personnel engaged in aircraft parking operations must comply with all pertinent regulations and existing directives. If aircraft are to remain parked for an extended period or if high wind conditions are expected, aircraft should be tied down. Strict adherence to applicable directives will ensure the safety of parked aircraft.

Wheel Chocking

Wheel chocks, fabricated according to Coast Guard specifications, are placed fore and aft of the main landing gear. Wood chocks must be constructed so that no metal parts which would create sparks are exposed. Metal chocks may be used when parking areas are covered by ice and snow.

Guidelines

Guidelines painted on ramps and parking areas aid in the safe movement of aircraft. Additional guides for positive control of vehicle traffic are painted on ramp surfaces.

Mooring

The applicable -2 aircraft technical manuals contain mooring instructions. Ropes must be tied with approved knots to designated mooring fittings on the aircraft. If any stress occurs from tire and strut deflation or rope shrinkage, these knots will allow enough slack to prevent the stress from damaging wing surfaces, fittings, and even the rope itself.

Grounding

Parked aircraft must be securely and effectively grounded to reduce the fire hazard. Applicable -2 aircraft technical manuals contain ground instructions to be observed at all times.

Safeguarding Aircraft in High Winds

Serious structural damage to aircraft can be caused by high-velocity surface winds. Therefore, when at all possible, aircraft are evacuated to safe weather areas when tornadoes, hurricanes, or unusually high winds are predicted. When wind velocity exceeds 30 knots (sustained or gusts), light aircraft in temporary docks, or extended outside hangars, are towed clear and parked in compliance with pertinent -2 aircraft technical manuals. When wind velocity exceeds 50 knots (sustained or gusts), medium or heavy aircraft in temporary docks, or extended outside hangars, are towed clear and then parked in compliance with pertinent -2 aircraft technical manuals.

Tiedowns

All installed exterior control locks, chocks, mooring ropes, rods and eyes, including those on aircraft used intermittently, must be inspected before use and after being used during high wind conditions.

Personnel Precautions

Personnel must not stand under aircraft during electrical storms or high winds.

AIRCRAFT WALKWAYS AND NO-STEP AREAS

The aerodynamic efficiency of aircraft can be materially affected by damage resulting from maintenance personnel walking on aircraft surfaces. When repair work makes it necessary to walk or step on the aircraft, use the designated walkways and under no circumstances walk or step on areas designated as no-step areas. (See figure 1-7.)

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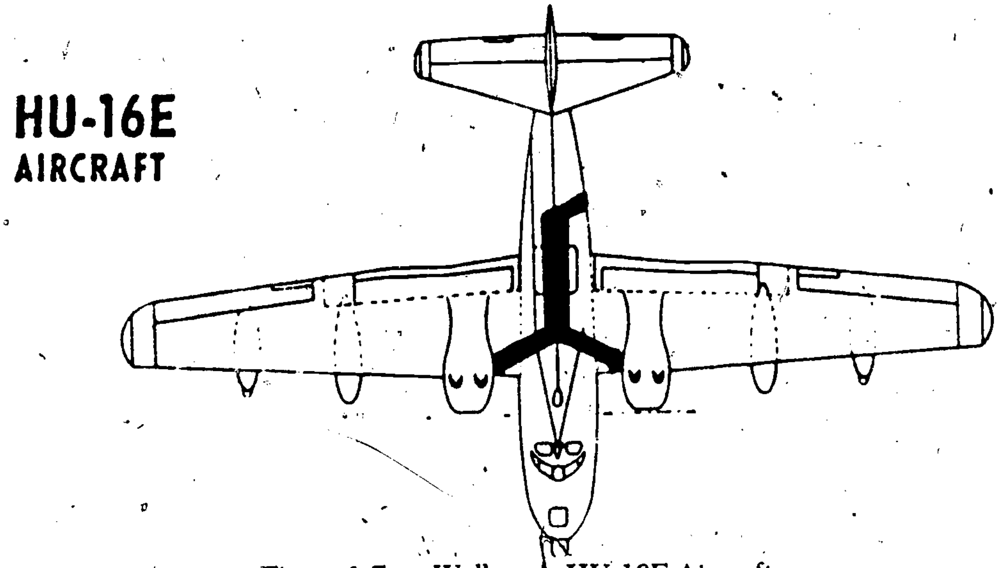

Figure 1-7. - Walkways HU-16E Aircraft.

All external surfaces of the aircraft, except those shown as nonskid areas, have a smooth finish which should not be marred. Surface smoothness of high-speed aircraft cannot be overemphasized; for this reason, use extra care when climbing onto or walking on external surfaces other than nonskid areas. Wear either suitable soft-soled shoes or protective pads. Take care not to walk on honeycomb surfaces or no-step areas.

SAFETY PRECAUTIONS FOR USING SHOP FACILITIES AND ELECTRONIC EQUIPMENT

Electrically operated equipment and machinery are used widely in various maintenance shops, and electronic equipment is used in the avionics shop. Using this equipment exposes personnel to many accompanying hazards. Poor judgment in the use of electrical and electronic equipment is a major cause of injuries and equipment damage. You are constantly exposed to the dangers of severe electrical shocks, burns resulting from contact with "hot" circuits, and injuries received in fires caused by improper use of electrical facilities and equipment. Short circuits, overloading, accidental grounding, poor electrical contacts, and misuse are all responsible for major accidents involving electricity.

Adequate training in equipment use and repair and proper instruction in safety requirements will help immeasurably in reducing accidents caused by electrical and electronic equipment. However, there is is still the possibility of human error. Often, we are so thoroughly familiar with our jobs we become negligent. This negligence results in preventable accidents. The safety standards discussed in the following paragraphs are intended to offset this human error.

SHOP FACILITIES

You should never operate power equipment unless you are thoroughly familiar with the equipment's controls and operating procedures. When in doubt, consult the appropriate operating instruction or ask someone who knows.

You must realize, too, that exposed moving parts on electrical equipment constitute a source of danger. Many people are injured every day because they fail to follow directions. Let us consider an emery wheel, for example. Nearly all emery wheels have a shield and bear a sign stating: "For use by authorized personnel only. Do not operate this machine without safety glasses." Yet, not long ago a person went to the machine shop to get a knife sharpened. Because everyone was busy, the individual asked permission to use the emery wheel. After being told to go ahead, the individual proceeded to do so without putting on the safety glasses or putting the safety shield down. The individual had no sooner touched the knife blade to the wheel than a piece of material from the wheel flew into the person's eye. Fortunately, the individual did not completely lose the sight of the eye. You might not be so lucky. Therefore, never ignore a warning sign; it is there to protect you. Certainly it is better to profit from someone else's bitter experience than to have someone profit from yours.

Safety Procedures

Do not distract or in any way distrub another person while they are operating a power tool.

Never try to clear jammed machinery before removing the source of power.

Electrical equipment is expensive, so don't overload it. Too often a small electric drill is operated too long under excessive loads. As a result, the drill will overheat and ultimately fail. This premature failure can be prevented by intermittent use, which alows time for the drill to cool. Overheating may also cause some electrical element to "short out" and give the user a shock or severe burn. Under certain conditions such a shock could prove fatal. Also, a "short" will usually result in damage to valuable equipment.

After using a power tool, turn off the power, remove the power source, wait for all rotation of the tool to stop, and then clean the tool. Remove all waste and scraps from the work area and stow the tool in the assigned location.

SAFE USE OF ELECTRONIC EQUIPMENT

High-voltage electronics equipment carries certain hazards to which all operators and repairmen are exposed. One of the most treacherous features of electricity, and particularly a high-voltage circuit, is that the electricity's presence cannot be detected by any of the human senses until it is too late. Electricity cannot be seen, heard, tasted, or smelled. Treat all electronics and electrical devices with respect and caution.

Equipment Adjustments

Do not attempt to adjust any part of electronics equipment when there is a possibility of receiving injuries from unprotected high-voltage components. In special cases where equipment must be adjusted in the presence of high-voltage potentials, the work must be done only when authorized.

Safety Observers

In special cases, repairs to equipment carrying high voltages are authorized. The repair work must not be started until a qualified safety observer is present to disconnect the power immediately in the event of an accident. The observer's primary responsibilities are to:

Enforce safety procedures.

Know and be capable of using emergency first-aid treatment, including artificial respiration.

Permit no one to approach the equipment without first giving positive warning of the potential dangers.

Stand where all personnel who are working on the equipment can be plainly seen and where the main power switch can be easily reached in an emergency.

Immediately disconnect the power source at the first sign of an emergency or accident.

Technical Orders

You must comply with all the instructions in the appropriate equipment technical orders, manuals, handbooks, and/or other applicable directives.

Personal Jewelry

Do not wear any metal objects, such as rings, dog tags, medals, wrist watches, or metal rim glases, when working on high-voltage circuits and equipment. Repair personnel must not use metal rules or uninsulated tools near circuits carrying high voltages.

Making Adjustments

Make adjustments to energize circuits only when a power-on-condition is essential, because standard practice is to work with the power off. When working on circuits that are "hot," use extreme caution. Operators and technicians must be familiar with the location of power switches and danger areas on the equipment before starting any repairs.

Accidental Grounds

Adjustments must not be made to any high-voltage potential when it is possible to accidentally touch a ground connection, equipment frame, or exposed circuit component. When working on energized equipment, be particularly careful if your clothing is wet from perspiration or other mositure.

Workbenches

Workbenches must be kept clean at all times. When voltage is applied to equipment being repaired and tested, other equipment and tools not essential to the test should be removed from the bench.

Grounding

Electrical circuits must be grounded at the exact point of intended repair or adjustment before you actually make contact with that particular area of the energized equipment. Use grounding clips or shorting sticks on potentially hot circuits, and do not remove them until repairs are completed.

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Safety Devices

Do not depend on equipment safety devices, such as interlock switches, disconnect relays, or automatic circuit grounders, as protection from electrical shock. Since these devices are subject to failure, always take necessary precautions when working on hot equiment. Do not make safety interlocks inoperative or bypass them when making equipment repairs or adjustments. When any safety device is found to be defective, it must be tagged with an appropriate warning sign; for example, "Safety Interlock Disabled."

Unplugging Components

The various components of electronics and electrical equipment carrying high voltages must not be unplugged with the power on.

Equipment Cleaning

Use only approved fire-resistant solvents for cleaning electronics and electrical equipment. Provide adequate ventilation whenever solvents are used in equipment cleaning, and be careful not to breathe the solvent fumes or allow too much of the liquid to contact your skin. Protect your eyes from spatter when using cleaning solvents; do not rub your eyes when cleaning solvent is on your hands.

HANDTOOL SAFETY PRACTICES

Every day numerous accidents are caused by the use of hand equipment. Usually the accidents are not as severe as those that occur with power equipment: however, they are painful and cause a large number of lost man-hours. There are very few maintenance personnel who have not at one time or another had a skinned hand or a mashed finger. If you happen to be around when a person knocks the skin off a knucle or mashes a finger, that individual will probably blame the accident on some particular tool or the part upon which that person is working. You will seldom, if ever, get people to admit that they use tools incorrectly. Yet, this is invariably the reason for many accidents. Almost all maintenance personnel who have worked any length of time around aircraft and engines have developed their own methods for doing different jobs. Although these methods may differ considerably, the final result will be the same. Actually there are very few strict rules governing the use of hand tools, but the following four precepts are important:

(1) Always use the tool in the proper way.

(2) Do not substitute one tool for another.

(3) Always keep your working area and your tools clean.

(4) Wipe tools off and put them back in their particular places when you are finished with them.

Keep your tools clean and put them back where they belong. Let us see what could happen if you failed to keep your tools and work area clean and orderly. Suppose you are working under the wing of a large aircraft where there is a small pool of oil on the floor; your tools are scattered over a considerable area. While working, you forget about the oil on the floor and walk through it several times. Now you have oil on your shoes, and they are slippery. The next time you reach for a tool your foot slips, and you fall. If you're lucky, you will have no more than a jarring fall, but since your tools are spread around, you are more likely to fall on one of them and injure yourself more severely. As another example, personnel working around an engine quite often get their hands greasy. However, if they use, say, a wrench while their hands are greasy, they are asking for trouble, because when the wrench slips, the results are apt to be anything from skinned knuckles to broken bones. Thus, when you finish with a tool, clean it and put it back where it belongs.

All good mechanics and technicians have special places for their tools. When they want a certain tool, they can reach it without even looking. This system not only increases the working efficiency of mechanics or technicians, but also serves as a safety factor for these people and those working with them. You have probably heard the old saying that you can always judge people by the way they keep a house. The same saying also applies to maintenance personnel. If you were going to have your car worked on, would you take it to a garage where you could see tools and parts lying around a dirty, greasy floor? Wouldn't you rather take it to a garage where everything was placed on shelves or racks and where the floor was kept compartively clean? Put yourself in the pilot's shoes. If you came out to fly an aircraft and saw spare parts and tools lying all around the area, would you be very eager to fly that aircraft?

Tools are safe only when they are maintained properly. Tools with cracked -- handles or blades,or mushroomed heads, are the ones that cause trouble. Don't throw cutting tools into a box where the cutting edge will get dulled or where you will cut yourself when searching for them again.

HAMMERS

Keep the heads of your hammers in good condition so that chips from the hammer head can't fly off in your face. The hammer head should be secured to the handle by a metal wedge. If the wedge starts coming out, it should be driven back into the end of the handle; if the wedge is missing, a new one can be made from a flat piece of steel. Neglecting to inspect hammer heads may some day put a bump on someone's head. Use the right hammer for the right job.

SCREWDRIVERS

Look around and you'll see screwdrivers being used as a subsitute for hammers, ice picks, or chisels. When used this way, screwdrivers are rendered useless when needed for their primary function. Screwdrivers used by electricians should have an insulated handle. One further point: avoid using a screwdriver with one hand and holding the work in the other hand, lest you someday have the screwdriver sticking through your hand.

PLIERS

Grasp pliers at the handle end and not next to the hinge point. When clipping wire ends, hold the work so that the cut ends will be flipped toward the floor and not across the hangar or shop. Always keep your face well above the level of the work.

WRENCHES

There are many kinds and sizes of wrenches, each for a particular kind of work. Make sure that the wrench is the right one for the job and that it is in good condition. Use a wrench correctly. Always pull on a wrench. When you have to pull hard on the wrench, as in lossening a tight nut, make sure the wrench is seated squarely on the flats of the nut. If the position of the work is such that the wrench cannot be pulled, open your hand and use the base of your palm to push the wrench.

In closing, if an accident, no mater how small, does happen to you, report it at once. It is far better to be a live human figure than one more cold statistical figure!

SUMMARY

Accidents are so costly, in both dollars and manpower, that we should contribute all we can toward safety. Join this all-out effort and work toward an accident-free career for yourself and for your buddies.

Since horseplay and practical jokes account for a large percentge of accidents, they should not be tolerated. Also, overconfidence and lack of attention to details can cause mishaps.

Accidents involving handtools and accidents caused by inattentiveness rank high on the list, and much can be done to reduce such accidents. Each tool is designed for a particular purpose and should be used for that purpose alone. If you don't know how to use a particular tool or piece of equipment, don't be ashamed to ask questions about it. In this way you protect yourself, the equipment, and the other personnel who trust their lives to your work. While at work, keep your mind and eyes on what you are doing. Finally, observe all the safety precautions that have been laid down for your protection.

SELF-QUIZ #1

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the stated objectives. To pass the EOCT, you must study all the course material.

1. Smoking is prohibited within a MAXIMUM of ________ feet from all hangars and aircraft.

2. What determines the number of people authorized to ride on a mule?

3. When you tow an aircraft in a congested area, what is the MINIMUM number of people required?

4. Why should you properly ground electrical equipment being used around aircraft?

5. Before you return a maintenance stand to the proper area, the stand must be clean and ________.

6. If you do not have proper ear protection, the MAXIMUM safe noise level is ________ decibels.

7. Which human tissue is MOST sensitive to radar?

8. Before moving the cockpit controls for an aircraft's control surfaces, you should ensure that ________.

9. What is the BEST way to eliminate the dangar of refueling an aircraft in an operating radar danger area?

10. A yellow safety color code indicates ________.

11. The red stripe on the fuselage or nacelles of jet aircraft indicates ________.

12. If ground servicing equipment is NOT needed during aircraft fueling operations, you should move the equipment AT LEAST ________ feet from the aircraft.

13. Frequent skin contact with aircraft fuel can cause ________.

14. Before towing an aircraft with faulty brakes, you must ensure that ________.

15. Before you tow an aircraft, entrance doors should be ________.

16. What is the MAJOR cause of injuries and equipment damage in shops?

17. Before attempting to clear jammed machinery, you should ________.

18. At the first sign of an emergency during repairs to energized high-voltage equipment, the safety observer must immediately ________.

19. When used to clean electrical or electronic equipment, solvent must be an approved ________ type.

20. If the position of the work prevents you from pulling a wrench, how should you move the wrench?

27

ANSWERS TO SELF-QUIZ #1

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

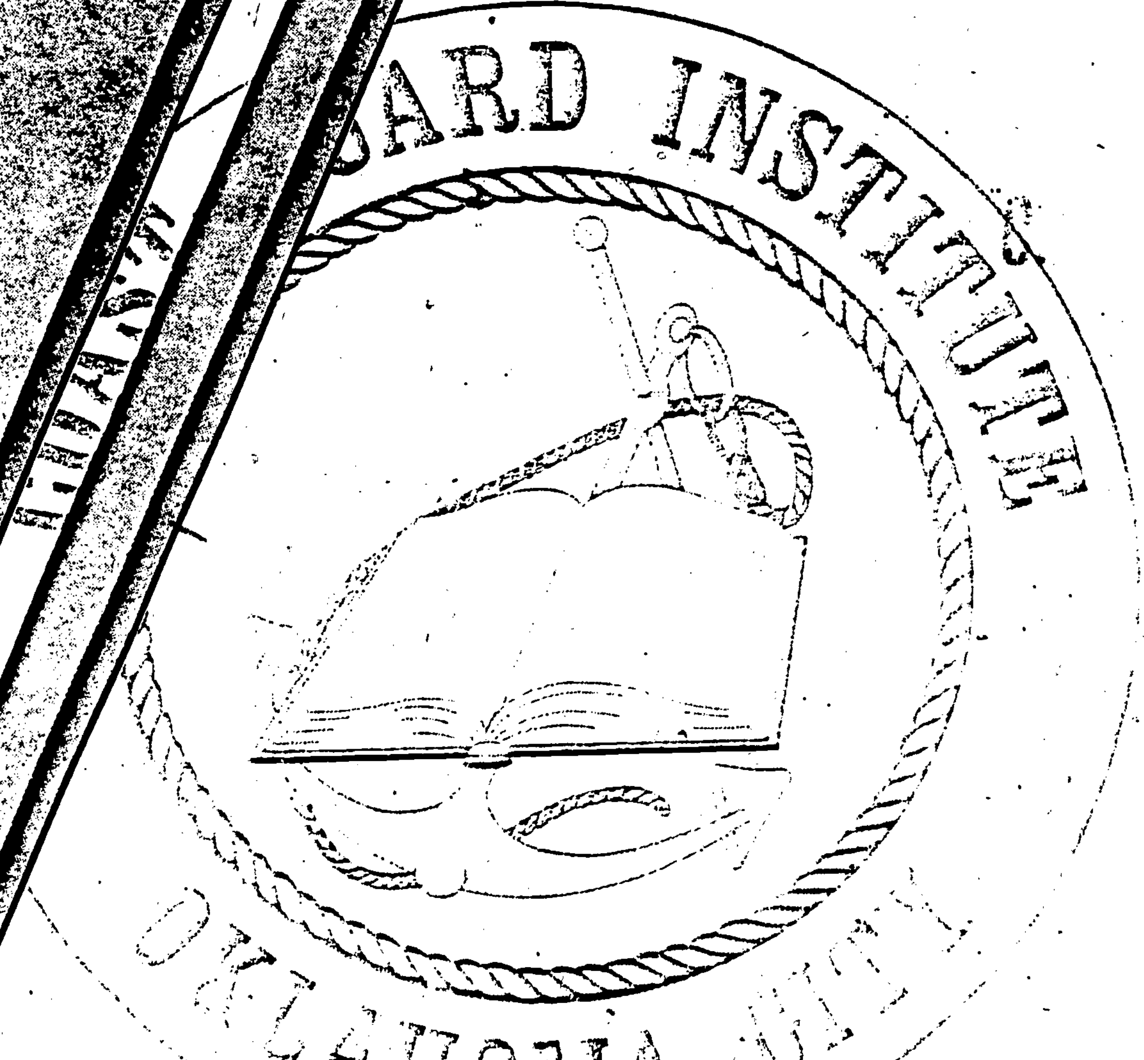
QUESTION	ANSWER	REF.
1	100 feet	1-2
2	number of seats available	1-3
3	four	1-3
4	Grounding may seem unimportant, but static electricity can cause sparks and fires which can destroy equipment.	1-4
5	free from structural defects	1-4
6	85 decibels	1-6
7	eye tissue	1-6
8	all personnel are clear	1-7
9	Consult the base communication officer.	1-8
10	caution	1-8
11	a danger area marking the plane of turbine wheel rotation	1-9
12	50 feet	1-11
13	dermatitis	1-11
14	personnel are standing by with chocks	1-12 & 1-13
15	closed	1-13
16	poor judgment	1-14
17	remove the power source	1-15
18	disconnect the power source	1-15
19	fire-resistant	1-16
20	Open your hand and use the base of your palm to push the wrench.	1-17

MODIFICATIONS

The remaining pages of this publication has been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

28

GENERAL AIRCRAFT HARDWARE



36

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29

GENERAL AIRCRAFT HARDWARE

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U. S. Coast Guard Institute
Aviation Branch
P.O. SubStation 18
Oklahoma City, OK 73169

FTS: 749-4464

Questions about this text should be addressed to the Subject Matter Specialist for the Aviation Structural Mechanic Rating.

37

30

REFERENCES

TECHNICAL ORDERS

* Aircraft Structural Hardware Technical Manual, T.O. 1-1A-8

NAVY PUBLICATIONS

* Aviation Structural Mechanic AMS 3 & 2, NAVTRA 10308-C

* Excerpted material from these sources is contained in this pamphlet.

38

NOTICE TO STUDENT

The primary purpose of this self-paced, nonresident training pamphlet is to present a general overview of the various types of common aviation hardware. The training is designed for aviation second class petty officers.

This pamphlet provides basic and general information on the types, uses, and installation and removal practices involved with the common types of hardware. The pamphlet content is based on the Coast Guard Enlisted Qualifications Manual (CG-311).

IMPORTANT NOTE: This text has been compiled for TRAINING ONLY. It should NOT be used in place of official directives or publications. The text information is current according to the references listed. You should, however, remember that it is YOUR responsibility to keep up with the latest professional information available for your rating. Current information is available in the Coast Guard Enlisted Qualifications Manual (CG-311).

This pamphlet is divided into two sections:

(1) Bolts, Nuts, and Washers
(2) Miscellaneous Hardware, Safetying, and Turnlock Fasteners

Each section has three parts:

(1) Reading assignment and objectives.
(2) Reading material.
(3) Self-quiz with answers and references. The answers are located on the pages immediately following the quizzes.

In addition to the self-quiz after each assignment, a pamphlet review quiz is provided at the end of the pamphlet.

Study the objectives for each section as they will aid you in determining the important points in each section. The self-quizzes test your mastery of the objectives. When you complete all the assignments for the course and master each objective, you should have a thorough understanding of the material and should be ready to pass your End-of-Course Test.

REMEMBER—You must receive a score of 80% or better to pass the End-of-Course Test. You should use your spare time to REVIEW the material before you take the EOCT.

32

SWE STUDY SUGGESTION: Servicewide exam questions for your rating and pay grade are based on the Professional and Military Requirements sections of the Enlisted Qualifications Manual (CG-311). If you use the references from this text and consult the Enlisted Qualifications Manual, you should have good information for review when you prepare for your servicewide exam. However, this course covers only a few of the qualifications tested on the SWE.

This course is only one part of the total Coast Guard training program and can take you only part of the way to your training goal. Practical experience, schools, selected reading, and the desire for accomplishment are also necessary to round out a successful training program.

40

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CONTENTS

34

HOW TO STUDY THIS COURSE

You can remember more of what you read if you ....

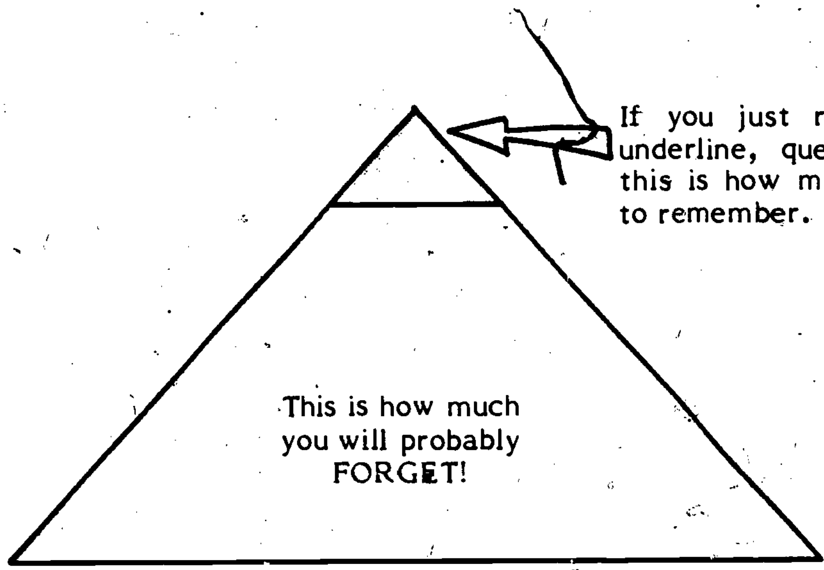
1. "Look over" the reading assignment first. Read the objectives and section headings, and look at the pictures. This gives you an idea of what to expect in the reading assignment and helps you understand the objectives.

2. Question the reading material. Ask yourself questions about a heading or a picture to help you remember what you read.

3. Note points to review later. Don't just run your eyes over a page. Underline important facts and make notes in the margin.

4. Close your pamphlet and repeat important points out loud. Discuss the reading assignment with someone if possible. This helps you recall information for a quiz or end-of-course test.

5. Review your underlined material, notes, quizzes, and objectives. This also helps you remember what you read.



If you just read and do NOT underline, question, or review, this is how much you are likely to remember.

42

BOLTS, NUTS and WASHERS

Reading Assignment:
Pages 1-1 through 1-13

OBJECTIVES

After finishing this assignment, you should be able to:

1. Explain how to determine proper bolt dimensions.
2. Describe the different types of boltheads.
3. State how bolt material is identified.
4. Explain what information a bolt part number provides.
5. Explain how nut material is identified.
6. Name the two groups of nuts.
7. List the three classes and different uses of washers.
8. State the formula for calculating torque when using a torque wrench with an extension attached at an angle.

Aircraft hardware is a term used in reference to a great many items used in aircraft contruction. Included are such things as electrical and powerplant hardware, rivets, turnlock fasteners, bolts, screws, nuts, washers, wire and cables, and related hardware.

Because of the small size of most hardware items, their importance is often overlooked; however, the safe and efficient operation of any aircraft is greatly dependent upon correct selection and use of aircraft hardware. This pamphlet discusses some of the common items, and provides information which will aid in the selection and correct use of aircraft hardware.

BOLTS

Many types of bolts are used on aircraft, and each type is used to fasten something in place. However, before we discuss some of these types, it might be helpful at this point to list and explain some commonly used bolt terms. You should know the names of bolt parts. You should also be aware of the bolt dimensions that must be considered in selecting a bolt. Figure 1-1 illustrates both types of information.

The three principal parts of a bolt are the HEAD, THREAD, and GRIP. Two of these parts may be well known, but perhaps the "grip" is an unfamiliar term. If so, notice that the grip is the unthreaded part of the bolt shaft and that this part extends from the threads to the bolthead. The head is the larger diameter of the bolt and may be one of many shapes or designs. The head retains the bolt in place in one direction, and the nut used on the threads retains the bolt in the other direction.

To choose the correct replacement for an unserviceable bolt, you must consider several

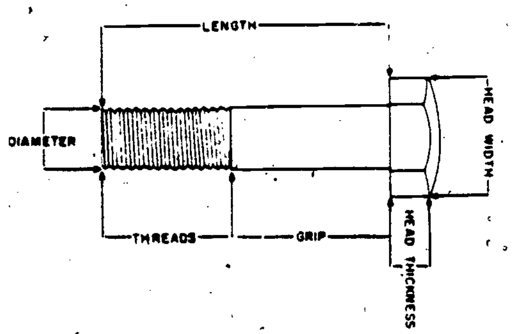


Figure 1-1. - Bolts terms and dimensions.

bolt dimensions. One dimension is the length of the bolt. As shown in figure 1-1, the bolt length is the distance from the tip of the threaded end to the head of the bolt. The bolt length is correct when the chosen bolt extends through the nut at least two complete threads (figure 1-1). If the bolt is too short, it may not extend out of the bolthole far enough for the nut to be securely fastened. It the bolt is too long, it may extend so far that it interferes with the movement of nearby aircraft parts. Unnecessarily long bolts, especially in numbers, can affect weight and balance and reduce the aircraft payload capacity.

In addition, if a bolt is too long or too short, its grip will usually be the wrong length. As shown in figure 1-2, grip length should be approximately the same as the thickness of the material to be fastened. If the grip is too short, the threads of the bolt will extend into the bolthole and may act like a reamer when the material is vibrating. To prevent this condition, make certain that no more than two threads extend into the bolthole. Also make certain that any threads that enter the bolthole extend only into the thicker member that is being fastened. If the grip is too long, the nut will run out of threads before it can be tightened. In this event a bolt with a shorter grip should be used. If the bolt grip extends only a short distance through the hole, a washer may be used.

A second bolt dimension that must be considered is diameter. As shown in figure 1-1,

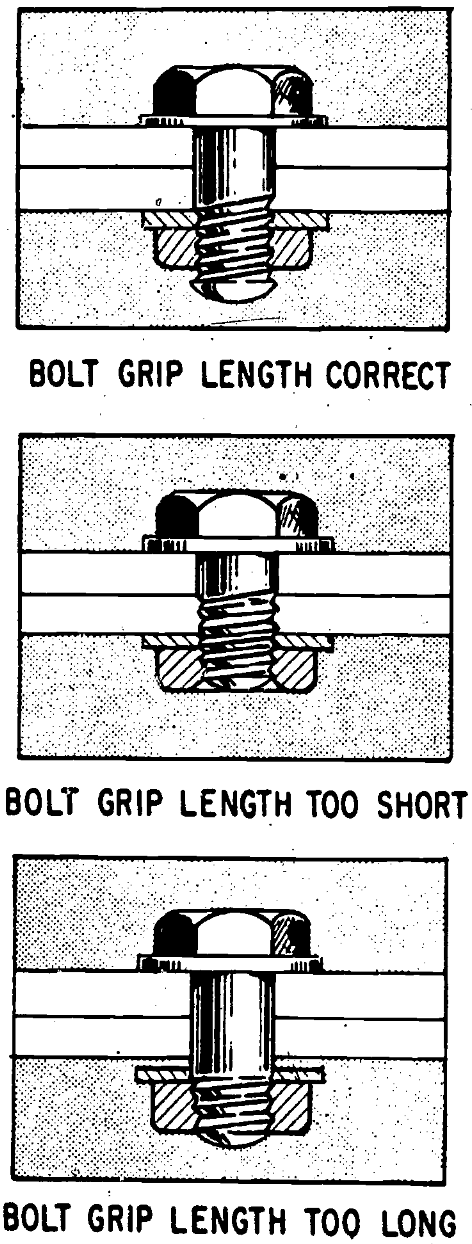


Figure 1-2. - Correct and incorrect grip lengths.

the diameter of the bolt is the thickness of its shaft. If this thickness is 1/4 inch or more, the bolt diameter is usually given in such fractions of an inch as 1/4, 5/16, 7/16, 1/2, and the like.

However, if the bolt is less than 1/4 inch thick, the diameter is usually expressed as a whole number. For instance, a bolt that is 0.190 inch in diameter is called a No. 10 bolt; a bolt that is 0.164 inch in diameter is called a No. 8.

The results of using a wrong-diameter bolt should be obvious. If the bolt is too big, it cannot, of course, enter the bolthole. If the diameter is too small, the bolt has too much play in the bolthole, and the chances are that the bolt is not as strong as the correct size of bolt.

The third and fourth bolt dimensions that should be considered are head thickness and width. If the head is too thin or too narrow, it may not be strong enough to bear the load imposed on it. If the head is too thick or too wide, it may extend so far that it interferes with the movement of adjacent aircraft parts.

BOLTHEADS

The most common type of head is the hex head, shown in figure 1-1. This type of head may be thick for greater strength or relatively thin to fit in places having limited clearances. In addition, the head may be common or drilled. A hex head bolt may have a single hole drilled through it between two of the sides of the hexagon and still be classed as a common head. The drilled head hex bolt has three holes drilled in the head, connecting opposite sides of the hex.

Four additional types of boltheads are shown in figure 1-3. Notice that panel A in that illustration shows an eyebolt, often used in flight control systems. Panel B shows a countersunk head, close tolerance bolt. Panel C shows an internal wrenching bolt. Both the countersunk head bolt and the internal wrenching bolt have hexagonal recesses (six-sided holes) in their heads. The bolts are tightened and loosened by using appropriate size Allen wrenches. Panel D shows a clevis bolt with its characteristic round head. This head may be slotted, as shown, to receive a common screwdriver or recessed to receive a Reed and Prince or a Phillips screwdriver.

BOLT THREADS

Another structural feature in which bolts may differ is threads. Threads usually come in one of the two types — coarse or fine, and the two are not interchangeable. For any given size of bolt, there are a different number of coarse and fine threads per inch. For instance, consider the 1/4-inch bolts. Some are called 1/4-28 bolts, because they have 28 fine threads per inch. Others have only 20 coarse threads per inch and are called 1/4-20 bolts. To force one size of threads into another size, even though both are 1/4 inch, will strip the finer threads or softer metal. The same thing is true concerning the other sizes of bolts; therefore, make certain that bolts selected have the correct type of threads.

BOLT MATERIAL

The type of metal used in an aircraft bolt helps to determine its strength and its resistance

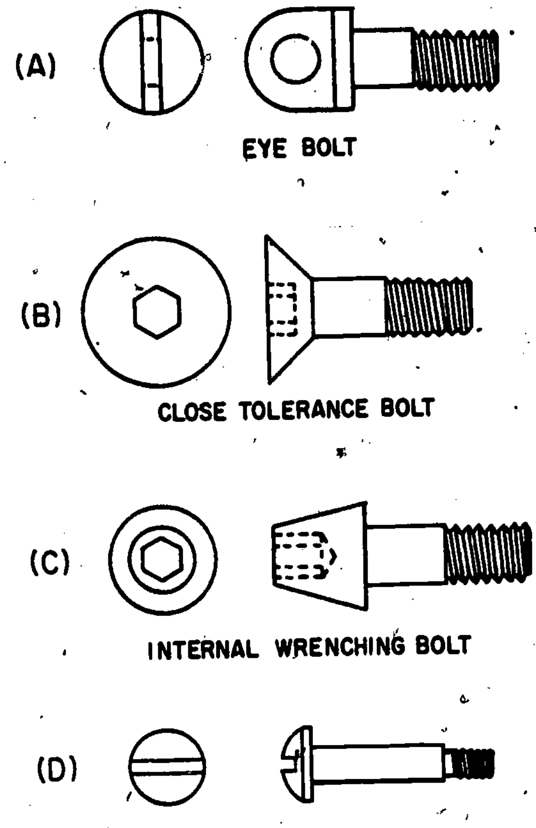


Figure 1-3. - Boltheads.

to corrosion. Therefore, make certain that material is considered in the selection of replacement bolts. Bolts have distinctive head markings that help to identify the material from which the bolts are manufactured. In certain cases, aircraft manufacturers are compelled to make bolts of different dimensions or greater strength than the standard types. Such bolts are made for a particular application, and it is extremely important that like bolts are used in replacement. Such special bolts are usually identified by the letter S stamped on the head. Figure 1-4 shows the tops of several hex-bolt heads, each marked to indicate the type of bolt material.

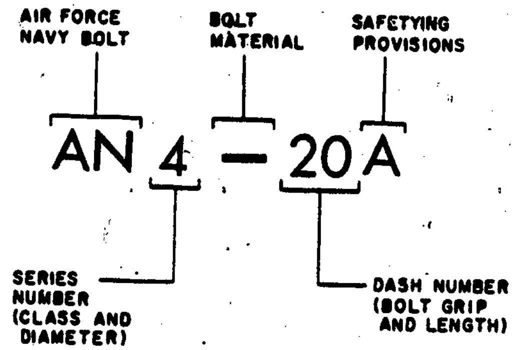


Figure 1-5. - AN bolt part number breakdown.

BOLT IDENTIFICATION

Unless current directives specify otherwise, every unserviceable bolt should be replaced with a bolt of the same type. Of course, substitute and interchangeable items are sometimes available, but the ideal fix is a bolt-for-bolt replacement. The part number of a needed bolt may be obtained by referring to the Illustrated Parts Breakdown (IPB) for the aircraft concerned. Exactly what this part number means depends upon whether the bolt is AN (Air Force-Navy), NAS (National Aircraft Standard), or MS (Military Standard).

AN Part Number.

There are several classes of AN bolts, and in some instances the bolt part numbers reveal slightly different types of information. However, most AN numbers contain the same type of information.

Figure 1-5 shows a breakdown of a typical AN bolt part number. The number starts with the letters AN discussed earlier. Next, notice that a series number follows the letters AN. This number consists of one or more digits representing the class of bolt and the bolt diameter in sixteenths of an inch. General-purpose hex-head bolts include all part numbers beginning with AN3, AN4, and so on through AN20. Other series numbers and the classes of bolts that the numbers represent are as follows:

AN21 through AN36 — clevis bolts.
AN42 through AN49 — eyebolts.

In figure 1-5 the last digit of the series number is 4, so this bolt is 4/16 inch (1/4 inch) in diameter. In the case of a series number ending in 0, for instance AN30, the 0 stands for 10, and the bolt has a diameter of 10/16 inch (5/8 inch).

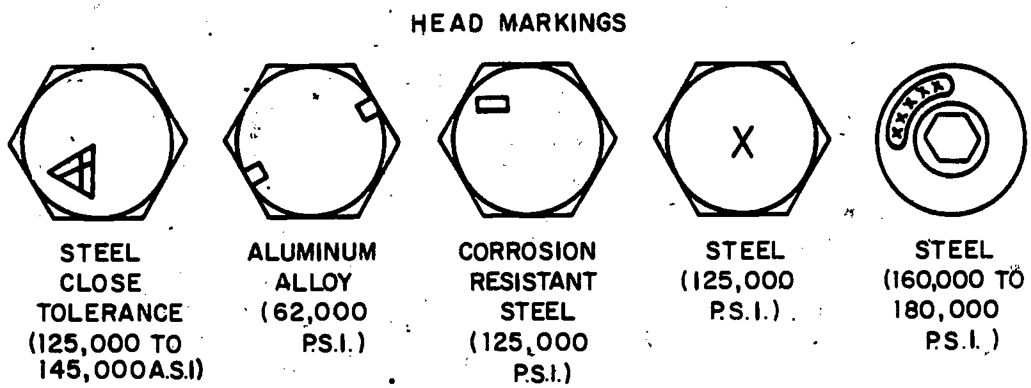


Figure 1-4. - Bolthead markings.

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Refer again to Figure 1-5 and notice that a dash follows the series number. When used in the part numbers for general-purpose AN bolts, clevis bolts, and eyebolts, this dash indicates that the bolt is made of carbon steel. With these types of bolts, the letter C, used in place of the dash, means corrosion-resistant steel; the letter D means 2017 aluminum alloy; and the letters DD stand for 2024 aluminum alloy. For some bolts of this type, a letter H is used with these letters or with the dash. If used, the H shows that the bolt has been drilled for safetying.

Next, notice the number 20 that follows the dash. This is called the dash number, and it represents the bolt's grip (as taken from special tables). In this instance the number 20 stands for a bolt that is 2 1/32 inches long.

The last character in the AN number illustrated in figure 1-5 is the letter A. This letter signifies that the bolt is not drilled for cotter pin safetying. If no letter were used after the dash number, the bolt shank would be drilled for safetying.

NAS Part Number

Another series of bolts used in aircraft construction is the National Aircraft Standard (NAS). (See figure 1-6.) In considering one of the NAS bolts, NAS144 (special internal wrenching type), notice that the bolt identification code starts with the letters NAS, which show, of course, that the code represents a National Aircraft Standard piece of hardware. Next, notice

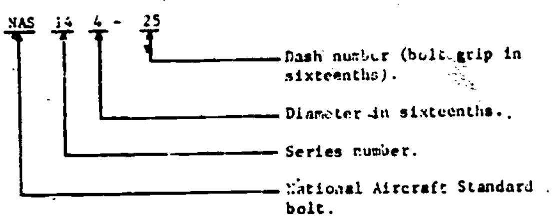


Figure 1-6. - NAS bolt part number breakdown.

that the series has a three-digit number, 144. The first two digits (14) show the class of the bolt. The next number (4) indicates the bolt diameter in sixteenths of an inch. The dash number (25) indicates bolt grip in sixteenths of an inch.

MS Part Number

Military Standard (MS) is another series of bolts used in aircraft construction. In the part number shown in figure 1-7, the MS indicates that the bolt is a Military Standard bolt. The series number (20004) indicates the bolt class and diameter in sixteenths of an inch (internal wrenching, 1/4-inch diameter). The letter H before the dash number indicates that the bolt has a drilled head for safetying. The dash number (9) indicates the bolt grip in sixteenths of an inch.

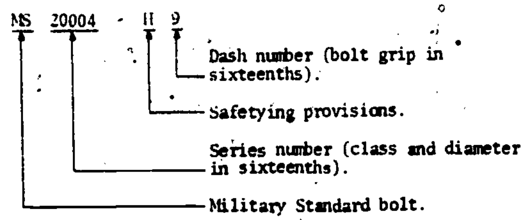


Figure 1-7. - MS bolt part number breakdown.

NUTS

Aircraft nuts differ in design and material just as bolts do, because nuts are designed to do a specific job with the bolts. For instance, some of the nuts are made of cadmium-plated carbon steel, stainless steel, brass, or aluminum alloy. The type of metal used is sometimes identified by markings on the nuts themselves; on others, the type of material must be recognized from the metallic luster of the metal. The anodized coating on aluminum nuts can be dyed in a number of colors, and these nuts are usually exceptionally light in weight. Cadmium plated steel nuts have a whitish color and bright luster when new. Corrosion resistant or stainless steel nuts may be coated with silver flashing which gives them a yellowish color and dull luster. In the case of the silver coated 1200 degree fahrenheit nut, it can only be identified by the number 12 stamped on one hex.

Nuts also differ greatly in size and shape. In spite of these many and varied differences, all nuts fall under one of two general groups - self-locking or nonself-locking. Nuts are also available in many various styles such as plain nuts, castle nuts, checknuts, plate nuts, channel nuts, barrel nuts, internal wrenching nuts, external wrenching nuts, shear nuts, sheet spring nuts, and wingnuts. These styles are discussed in subsequent paragraphs and sections.

NONSELF-LOCKING NUTS

Nonself-locking nuts require the use of a separate locking device for security of installation. Several types of these locking devices are mentioned in the following paragraphs in connection with the nuts on which the devices are used. Since no single locking device can be used with all types of nonself-locking nuts, you must select one suitable for the type of nut being used. Figure 1-8 illustrates four common styles of nonself-locking nuts.

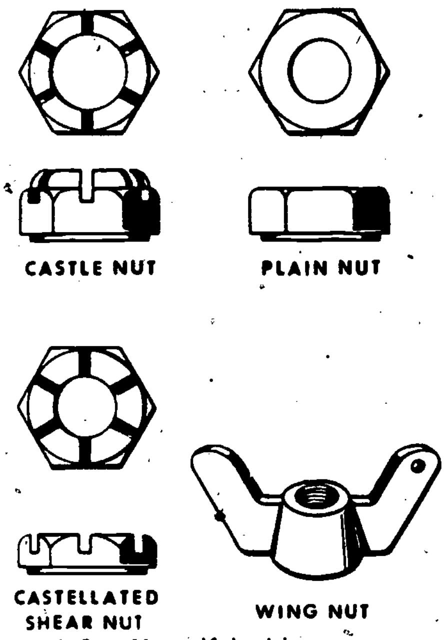


Figure 1-8.- Nonself-locking nuts.

SELF-LOCKING NUTS

Self-locking nuts provide tight connections which will not loosen under vibration. Self-locking nuts approved for use on aircraft meet critical specifications for strength, corrosion resistance, and temperatures. The two major types of self-locking nuts are the prevailing torque and the free-spinning types. The free-spinning type turns freely until seated where further tightening results in a locking action. The more widely used prevailing torque type requires wrenching throughout the entire cycle after the bolt or screw has engaged the frictional part of the nut.

You should remember, unless otherwise directed by applicable publications, that new self-locking nuts must be used each time components are installed in critical areas throughout the aircraft, including all flight, engine, and fuel control linkage and attachments.

Prevailing Torque Nuts

Prevailing torque nuts have either a non-metallic or all metal locking element. The non-metallic nuts have a nylon insert of smaller diameter than the bolt major diameter, which exerts a compressive locking force against the bolt. If these nuts are reused, they shall be checked to see if the locking insert has lost its locking friction or become brittle. All metal self-locking nuts have either a squeezed-in portion of the nut metal, or deformed or interrupted metal threads which provide a frictional force that locks the nut threads against the bolt threads. The Boots and the Flexloc are examples of the all-metal type; the Elastic Stop is an example of the non-metallic insert type. Figure 1-9 shows several types of self-locking nuts.

STYLES OF NONSELF-LOCKING AND PREVAILING TORQUE SELF-LOCKING NUTS

Plain Nut

This nut is of rugged construction. This makes the nut suitable for carrying large tensional loads. Plain hex nuts are available as self-locking or non-self-locking nuts; however, since the plain hex non-self-locking nuts require an auxiliary safetying device, such as a checknut or lockwasher, the nut's use on aircraft structures is somewhat limited.

Castle Nut

The castle nut is used in conjunction with drilled-shank bolts, hex-head bolts, clevis bolts, eyebolts, and drilled head studs. The nut is fairly rugged and can withstand large tensional loads. Slots (called castellations) in the nut are designed to accomodate a cotter pin or lock wire for safetying purposes.

Castellated Shear Nut

The castellated shear nut is designed for use with devices such as drilled clevis bolts and threaded taper pins which are normally subjected to shearing stress only. Like the the castle nut, the castellated shear nut is castellated for safetying, but is not as deep nor as strong as the castle nut.

Checknut

The checknut is used as a locking device for plain nuts, setscrews, threaded rod ends, and other devices.

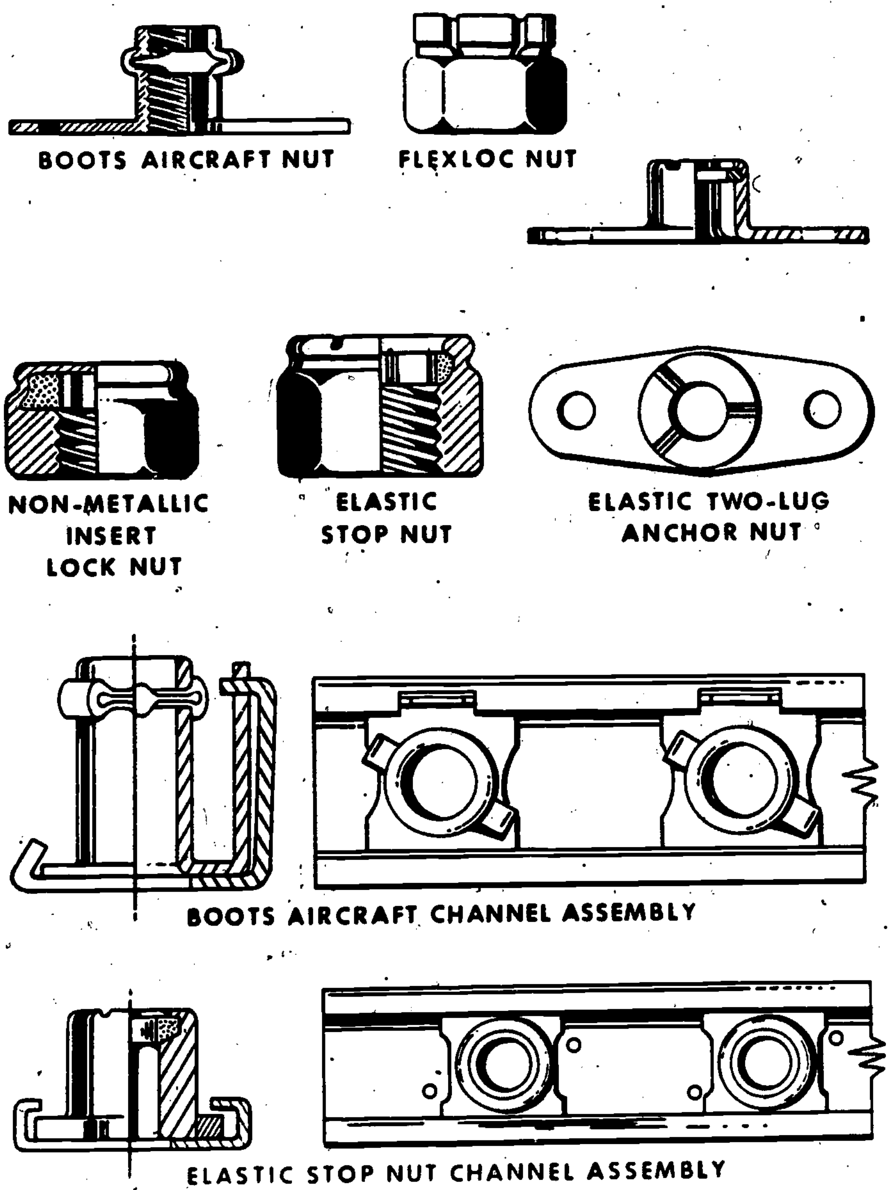


Figure 1-9. - Self-locking nuts.

Plate Nut

This nut is used for blind mounting in inaccessible locations and for easier maintenance. The nut is available in a wide range of sizes and shapes. One lug, two lug, and right-angle shapes are available to accomodate the physical requirements of the individual nut location. Floating type nuts provide a controlled amount of nut movement to compensate for sub-assembly misalignment. They can be either self-locking or plain.

Channel Nuts

These nuts are used in applications requiring anchored nuts equally spaced around openings such as access and inspection doors and removable leading edges. Straight or curved channel nut strips offer a wide range of nut spacings and provide a multiple nut unit that has all the advantages of float-type nuts. They are usually self-locking.

Barrel Nut

This nut is installed in a regular, drilled hole. The round portion of the nut fits in the drilled hole providing a self-wrenching effect. The nut is usually self-locking.

Internal Wrenching Nut

This nut is generally used where a nut with a high tensile strength is required or where space is limited and the use of external wrenching nuts would not facilitate the use of conventional wrenches for installation and removal. That is where a bearing surface is counterbored. This nut has a non-metallic insert which provides a locking action.

Point Wrenching Nut

This nut is usually self-locking and is generally used where a nut with a high tensile strength is required. This nut is installed with a smaller socket wrench than would normally be used for a hexagon nut.

Sheet Spring Nut (Figure 1-10)

This nut is used with standard and sheet metal self-tapping screws to support line clamps, conduit clamps, electrical equipment, access doors, etc. The most common types are the flat,

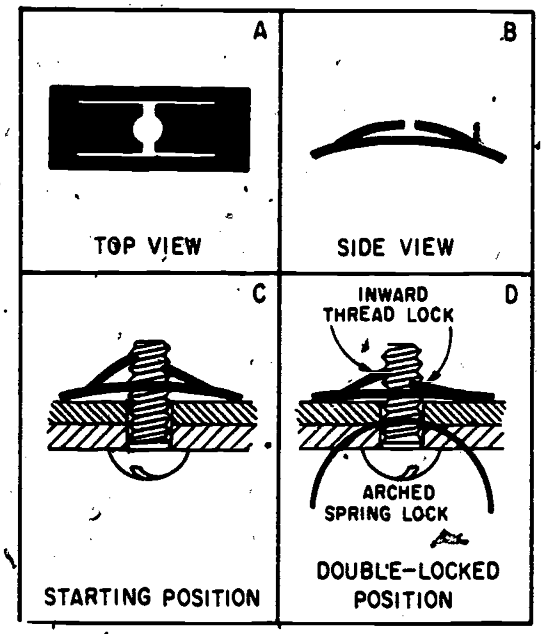


Figure 1-10. - Sheet spring nut.

the two-lug anchor, and the one-lug anchor type. The nut has an arched spring lock which prevents the screw from working loose. It should be used only where originally used in the fabrication of the aircraft.

Klincher Locknut

This locknut is used to ensure a permanent and vibration-proof, bolted connection that holds solidly and resists thread wear. It will withstand extremely high or low temperatures and exposure to lubricants, weather, and compounds without impairing the effectiveness of the locking element. The nut is installed with the end that looks like a double washer toward the metal being fastened. The end that looks like a double hexagon nut is positioned away from the metal being fastened.

Wingnut

Wingnuts are intended for places where the desired tightness can be obtained by use of the fingers and where the assembly is frequently removed, such as battery terminal connections. Usually one of the wings has a hole, for safetying the nut with wire.

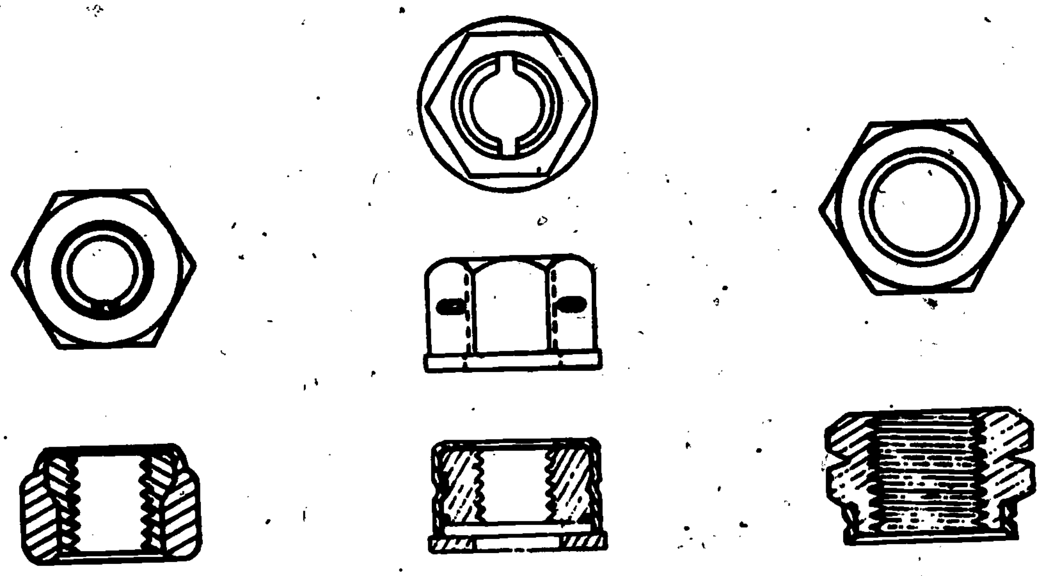


Figure 1-11. - Free-Spinning Nuts.

Free-Spinning Nuts (Figure 1-11)

The free-spinning nuts are available in three types: free-spinning on-off, free-spinning on residual torque off, and stressed nut. These nuts spin freely on and off as long as the nut is not in contact with the bearing surface. The locking action is provided by an internal core in the nut except for the stressed nut which uses a ground washer for its locking action.

Free-spinning nuts are designed for exhaust flange attachments and shall be used only as specified in the applicable technical orders of the equipment affected. These nuts are not considered suitable for general aircraft use. Any free-spinning nut which requires less than 10 inch-pounds of torque to break away when in the locked position shall be disposed of.

WASHERS

Washers used in aircraft structures may be grouped into three general classes - PLAIN washers, LOCKWASHERS, and SPECIAL washers. Figure 1-12 shows some of the most commonly used types.

Plain washers are widely used under nuts to provide a smooth bearing surface, to act as a shim in obtaining the correct relationship between the threads of the bolt and the nut, and to adjust the position of castellated nuts with respect to drilled cotter pin holes in bolts. Plain washers are also used under lockwashers to prevent damage to surfaces of soft materials.

Lockwashers are used with plain nuts when self-locking or castellated type nuts are not applicable. Sufficient friction is provided by the spring action of the washer to prevent loosening of the nut from vibration. Lockwashers are not to be used on primary structures, secondary structures, or accessories where failure might result in damage or danger to aircraft or personnel.

Special washers, such as ball-socket and seat, taper pin, and washers for internal-wrenching nuts and bolts, are designed for special applications.

Ball-socket and seat washers are used where the bolt is installed at an angle to the surface, or where perfect alignment with the surface is required. These washers are used together.

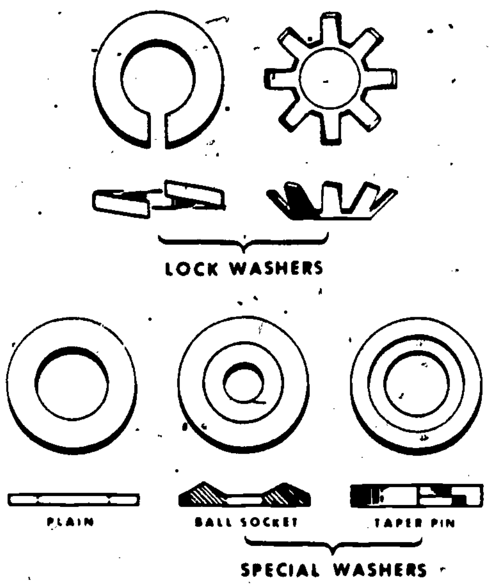


Figure 1-12. - Various types of washers.

Taper pin washers are used in conjunction with threaded taper pins and are installed under the nut to effect adjustment where a plain washer would distort.

Washers for internal-wrenching nuts and bolts are used in conjunction with NAS internal-wrenching bolts. The washer used under the head is countersunk to seat the bolthead/shank radius. A plain washer is used under the nut.

INSTALLATION OF NUTS, BOLTS, AND WASHERS

Be certain that each bolt is the correct material. Examine the marking on the head to determine whether a bolt is steel or aluminum alloy.

It is extremely important to use like bolts in replacement. In every case, refer to the applicable Maintenance Instructions Manual and Illustrated Parts Breakdown.

There are certain precautions which must be observed with all self-locking nuts. Bolts, studs, and screws with damaged threads and rough ends must not be used. Bolts, studs, and screws of 1/4 inch or less with cotter pin holes must not be used with self-locking nuts. Bolts, studs, and screws over 1/4 inch in diameter may be used with self-locking nuts, provided the cotter pin holes are free from burrs.

Nonmetallic-insert, self-locking nuts shall never be tapped nor subjected to temperatures in excess of 250 degrees fahrenheit. Cadmium plated nuts are limited to 450 degrees fahrenheit and corrosion resistant or stainless steel nuts are limited to 800 degrees fahrenheit.

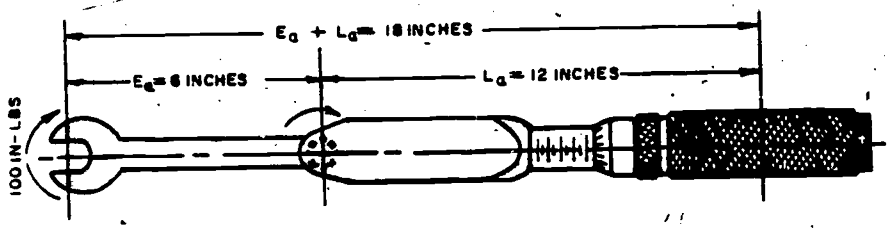
Used self-locking nuts are generally suitable for reuse in noncritical applications if the threads have not been damaged and are in a serviceable condition and if the locking material is not damaged or permanently distorted.

NOTE: If any doubt exists about the condition of the nut, replace it with a new one.

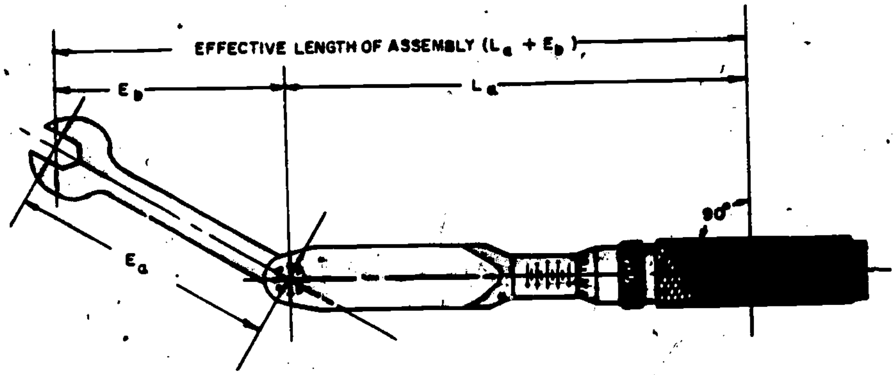
Be sure that washers are used under both the heads of bolts and nuts unless the omission of washers is specified. A washer guards against mechanical damage to the material being bolted and prevents corrosion of the components. An aluminum alloy washer should be used under the head and nut of a steel bolt securing aluminum alloy or magnesium parts. Use steel washers when joining steel parts with steel bolts.

Whenever possible the bolt should be placed with the head on top or in the forward position. This position tends to prevent the bolt from slipping out if the nut is accidentally lost.

In all installations, bolts or screws will protrude no less than two complete threads past the nut. This applies to both self-locking and plain nuts, and includes any chamfer at the bolt end. The nut should be properly tightened against the bearing surface. Fatigue failures account for over 75 percent of all fastener problems. Fatigue breaks are caused by insufficient tightening and lack of proper preload or clamping force. This results in movement between the parts of the assembly in use, and eventual failure. To avoid insufficient tightening and overstressing of bolts, the nuts should be properly torqued.



Typical torque wrench with extension
attached in line



Typical torque wrench with extension
attached at an angle

Figure 1-13. - Torque wrench with extension.

APPLICATION OF TORQUE

Standard torque charts have been established for average dry unplated conditions, but surface variations such as thread roughness, scale, paint, lubrication (oil, grease, etc.), hardening and plating may alter these values considerably. Also nuts that are reused will require higher torque readings. Torque values will also vary with manufacturers.

To obtain the correct recommended torque value on self-locking nuts, the nut must be run down until it is one turn from the beginning of seating. At this point, the prevailing torque should be noted. If the prevailing torque is less than one-third of the recommended torque, it should be disregarded and the nut tightened to the recommended torque value. If the prevailing torque is one-third or more than one-third of the recommended torque, it should be added to the recommended torque. Example: the recommended torque is 50 to 70 inch-pounds. The prevailing torque at one turn from the beginning of seating is 30 inch-pounds. The correct torque wrench reading would be 80 to 100 inch-pounds.

When adapters or extensions are used on torque wrenches, the difference in mechanical value must be considered in determining the dial setting to provide the specified torque at the nut being tightened. The following formula is used to determine dial reading or torque setting to achieve the desired torque: (See Figure 1-13.)

S equals Handle Setting

T equals Torque Applied at End of Adapter

L_a equals Length of Handle in Inches

E_a equals Length of Extension in Inches

For example, if it is desired to exert 100 inch-pounds at the end of the wrench and extension, when L_a equals 12 inches and E_a equals 6 inches, it is possible to determine the handle setting by making the following calculation:

$$S = \frac{T \times L_a}{L_a + E_a}$$

$$S = \frac{100 \times 12}{(12 + 6)}$$

$$S = \frac{1200}{18}$$

$$S = 66.6 \text{ inch-pounds}$$

Whenever possible, attach the extension in line with the torque wrench. When necessary to attach the extension at an angle to the torque wrench as shown in Figure 1-13, the effective length of the assembly will be $L_a + E_b$ as shown. In this instance, length E_b as shown. In this instance, length E_b must be substituted for length E_a in the formula.

NOTE

An extension shall not be used on the grip end of a torque handle.

Torque tools shall not be used to break loose previously tightened bolts.

A torque tool shall not be used to apply a greater amount of torque than the rated capacity of the tool.

Do not attempt to change setting when handle is in a locked position.

Do not attempt to use an extension on the end of a torque wrench at an angle less than 90 degrees.

SAFETYING OF NUTS

It is very important that all nuts, except the self-locking type, be safetied after installation. Safetying prevents nuts from loosening in flight due to vibration. Figure 1-14 illustrates the proper way to secure a nut using a cotter pin.

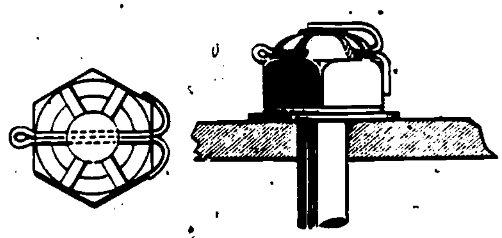


Figure 1-14. - Cotter pin installation.

SELF-QUIZ #1

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the stated course objectives. To pass the EOCT, you must study all the course material.

1. The unthreaded portion of a bolt shaft is the ________________.
2. A bolt should extend through the nut a MINIMUM of ____________ threads.
3. If a bolt is less than 1/4 inch thick, the diameter of the bolt is expressed as a ____________ number.
4. A bolt designed for use with a screwdriver is a ____________ bolt.
5. A single-dash bolthead marking indicates that the bolt is made of ____________.
6. In the part number for an AN bolt, the letter C following the series number means ____________.
7. Which nut is castellated for safetying, but is not as deep as a castle nut?
8. Elastic stop nuts must NOT be used in areas subjected to temperatures above ____________.
9. Washers used with internal wrenching bolts are ____________ washers.
10. When in doubt about a replacement bolt for an aircraft, you should refer to the applicable Maintenance Instructions Manual or ________________.
11. When installing a self-locking nut on a bolt, at what point should you note the prevailing torque?

(See page 1-14 for ANSWERS to Self Quiz questions)

ANSWERS TO SELF-QUIZ #1

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

1. grip (Page 1-1)
2. two (Page 1-2)
3. whole (Page 1-3)
4. clevis (Page 1-3)
5. corrosion-resistant steel (Page 1-4)
6. corrosion-resistant steel (Page 1-5)
7. Castellated shear nut (Page 1-6)
8. 250° F. (Page 1-10)
9. special (Page 1-9)
10. Illustrated Parts Breakdown (Page 1-10)
11. One turn before the nut seats (Page 1-12)

ERIC

MISCELLANEOUS HARDWARE, SAFETYING, AND TURNLOCK FASTENERS

Reading Assignment:
Pages 2-1 through 2-18

OBJECTIVES

After finishing this assignment, you should be able to:

1. State the four main groups of screws.
2. Describe situations requiring the use of taper or flathead pins.
3. Describe the different methods of safetying.
4. Explain the use of turnlock fasteners.
5. State the difference between heavy-duty and light-duty Dzus fastener installations.

SCREWS

Screws are the most common type of threaded fasteners used on aircraft. They are similar to other types of threaded fasteners such as bolts, but screws differ mainly in that they usually have a lower material strength, a looser thread fit, and shanks threaded along their entire length. However, several types of structural screws are available which differ from structural bolts only in the type of head. Their material is equivalent, and they have a definite grip. Screws may be divided into four main groups - structural, machine, self-tapping, and setscrews.

STRUCTURAL SCREWS

Structural screws are used for assembly of structural parts, as are structural bolts. The screws are made of alloy steel and are properly heat treated. Structural screws have a definite grip length (figure 2-1) and the same shear and tensile strengths as the equivalent size bolt. Structural screws differ from structural bolts only in the type of head. These screws are available in round-head, countersunk-head, and brazier-head types, either slotted or recessed for the various types of screwdrivers.

MACHINE SCREWS

The commonly used machine screws are the round-head, flat-head, fillister-head, pan-head, truss-head, and socket-head types (figure 2-2).

Flat-head Machine Screws

Flat-head machine screws are used in counter-sunk holes where a flush finish is desired. These screws are available in 82 and 100 degrees of head angle and have various types of recesses and slots for driving.

Round-head Machine Screws

Round-head machine screws are frequently used to assemble highly stressed aircraft components.

Fillister-head Machine Screws

Fillister-head machine screws are used as general-purpose screws and also may be used as cap-screws in light applications such as the attachment of cast aluminum gearbox cover plates.

Socket-head Machine Screws

Socket-head machine screws are designed to be screwed into tapped holes by internal wrenching. The screws are used in applications which require high strength precision products, compactness of the assembled parts, or sinking of heads below surfaces into holes.

Pan-head and Truss-head Machine Screws

Pan-head and truss-head screws are general-purpose screws used where head height is unimportant. These screws are available with cross-recessed heads only.

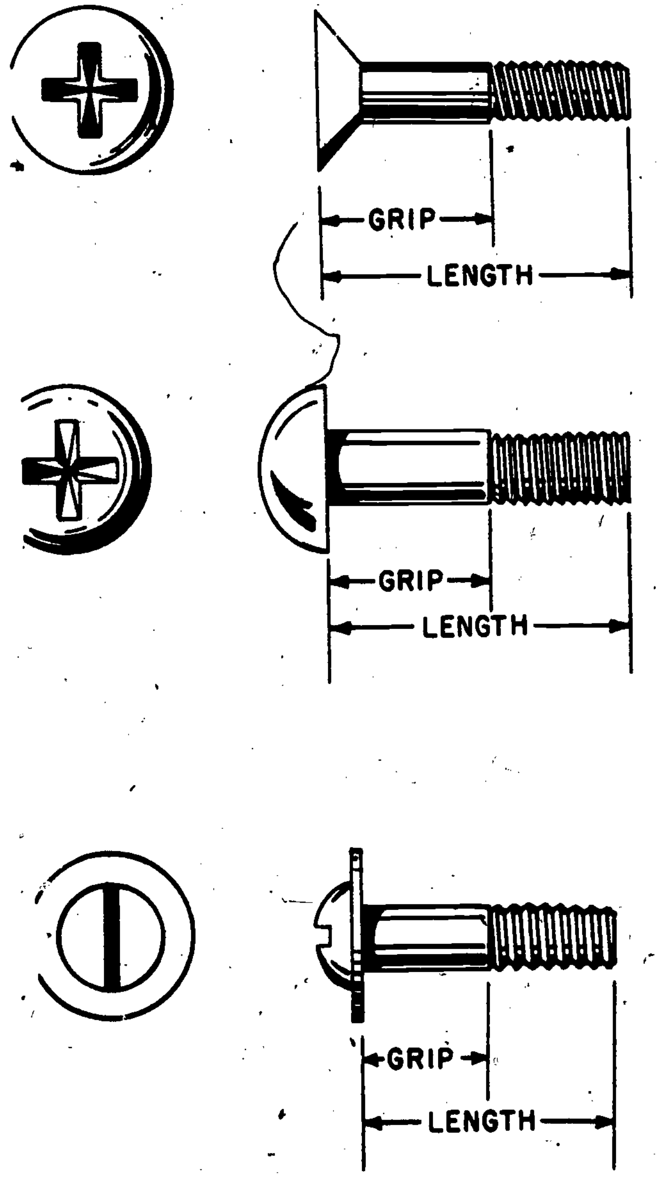


Figure 2-1. - Structural screws.

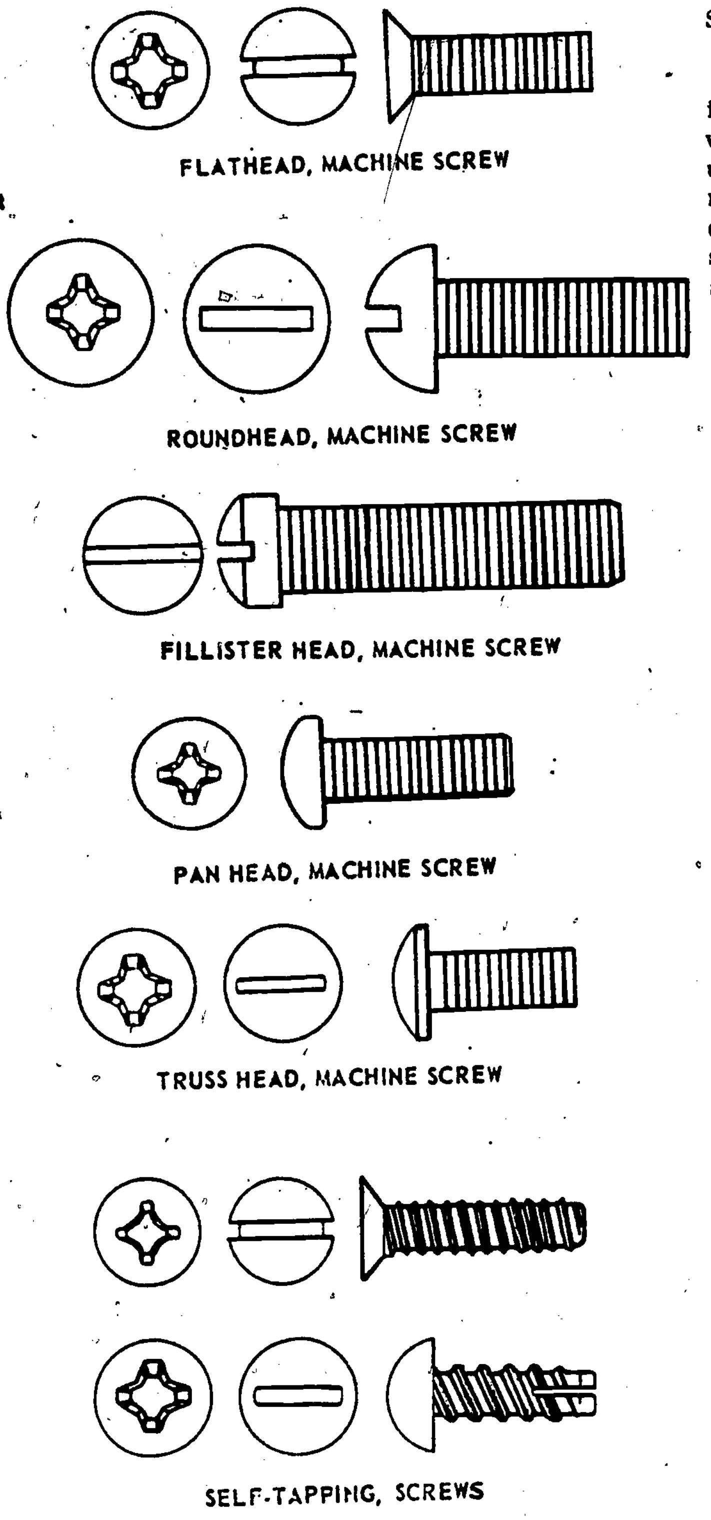


Figure 2-2. - Machine screws.

SELF-TAPPING SCREWS

A self-tapping screw is one that cuts its own internal threads as it is turned into the hole in which it is inserted. Self-tapping screws can be used only in comparatively soft metals and materials. Self-tapping screws may be further divided into two classes or groups — machine self-tapping screws and sheet-metal self-tapping screws.

Machine self-tapping screws are usually used to attach removable parts, such as nameplates to castings. The threads of the screw cut mating threads in the casting after the hole has been predrilled undersize. Sheet-metal self-tapping screws are used for temporarily attaching sheet metal in place for riveting and for permanent assembly of nonstructural assemblies, where screws must be inserted in blind applications.

CAUTION: Self-tapping screws should never be used to replace standard screws, nuts, or rivets in the original structure.

SETSCREWS

Setscrews are used to position and hold in place components such as gears on a shaft. Setscrews are available with many different point styles. These screws are classified as hexagon-socket and fluted-socket headless setscrews.

PINS

TAPER PINS

Taper pins are used in joints that carry shear loads and in areas where some clearance is required. (See figure 2-3 (A) and (B).) The threaded taper pin is used with a taper-pin washer and a shear nut if the taper pin is drilled, or with a self-locking nut if undrilled. When a shear nut is used with the threaded taper pin and washer, the nut is secured with a cotter pin.

FLATHEAD PINS

The flathead pin is used with tie rod terminals or secondary controls, which do not operate

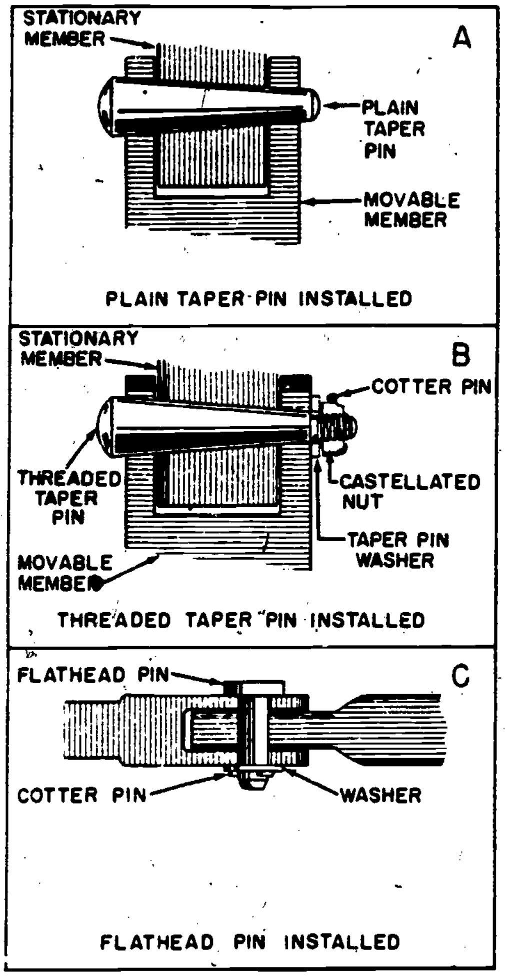


Figure 2-3. - Types of aircraft pins.

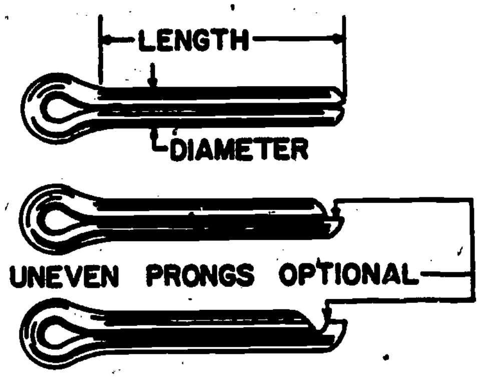


Figure 2-5. - Types of cotter pins.

continuously. This pin is used where little clearance is provided. The flathead pin should be secured with a cotterpin. The pin is normally installed with the head up (figure 2-3 (C)). This precaution is taken to maintain the flathead pin in the installed position in case of cotter pin failure.

HELI-COIL INSERTS

Heli-Coil thread inserts are primarily designed to be used in materials which are not suitable for threading because of their softness. The inserts are made of a diamond cross-sectioned stainless steel wire which is helically coiled. In its finished form, the wire is similar to a small spring which has been fully compressed. There are two types of Heli-Coil inserts. (See figure 2-4.) One is the plain insert, made with a tang that forms a portion of the bottom coil offset and is used to drive the insert. This tang is

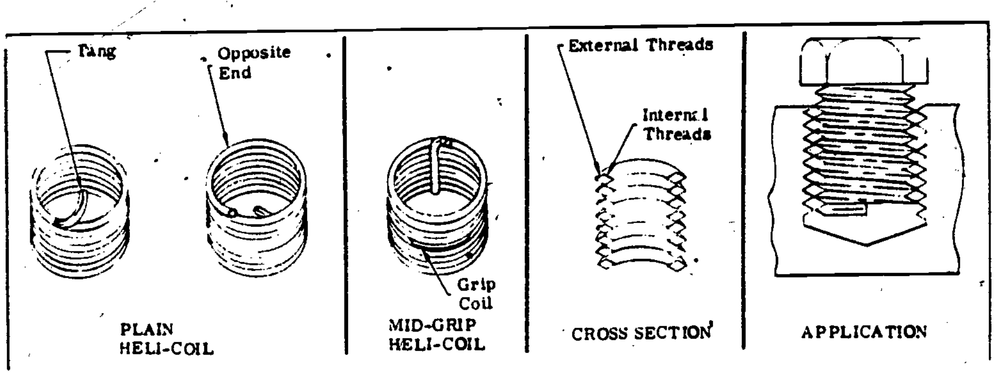


Figure 2-4. - Heli-Coil inserts.

left on the insert after installation, except when removal is necessary to provide clearance for the end of the bolt. The tang is notched to provide for the breakoff from the body of the insert, providing full penetration for the fastener.

The second type of insert is the self-locking mid-grip insert which has a specially formed grip coil midway of the insert. The grip coil produces a gripping effect on the engaging screw. For quick identification, the self-locking mid-grip inserts are dyed red.

SAFETYING MATERIAL

Maintenance personnel will come in contact with many different types of safetying materials. These materials are used to stop rotation and other movement of fasteners and to secure other equipment likely to come loose due to aircraft vibration during flight.

COTTER PINS

Cotter pins are used to secure bolts, screws, nuts, and pins. Some cotter pins are made of low-carbon steel; others consist of stainless steel and thus are more resistant to corrosion. In addition, stainless steel cotter pins may be used in locations where nonmagnetic material is required. Regardless of shape or material, all cotter pins are used for the same general purpose-safetying. Figure 2-5 shows three types of cotter pins and the method for determining their size.

NOTE: The length of uneven prong cotter pins is measured to the end of the shortest prong.

SAFETY WIRE

Safety wire comes in many types and sizes. You must first select the correct type and size of wire for the job. Annealed corrosion-resisting wire is used in high-temperature, electrical-equipment, and aircraft-instrument applications. All nuts except the self-locking types must be safetied; the method used depends upon the particular installation. Figure 2-6 illustrates the correct methods of installing safety wire. The following general rules apply to safety wiring:

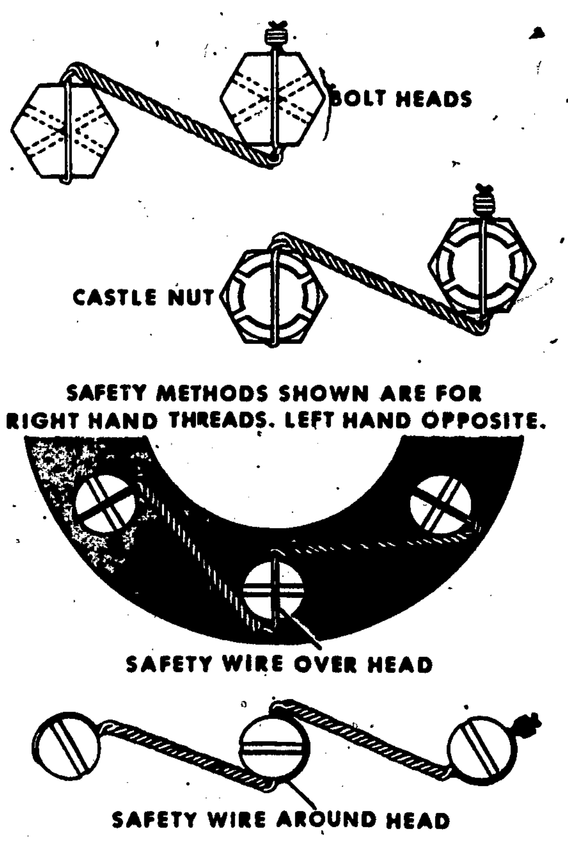


Figure 2-6. - Safety wire installation.

1. All safety wires must be tight after installation, but not under so much tension that normal handling or vibration will break the wire.

2. The wire must be applied so that all pull exerted by the wire tends to tighten the nut.

3. Twists should be tight and even and the wire between nuts as taut as possible without overtwisting. Wire between nuts should be twisted with the hands. The use of pliers will damage the wire. Pliers may be used only for final end twist prior to cutting off excess wire.

Annealed copper safety wire is used for sealing first aid kits, portable fire extinguishers, oxygen regulator emergency valves, and other valves and levers used for emergency operation of aircraft equipment. This wire can be broken by hand in case of an emergency.

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There are two methods of lockwiring, the doubletwist method that is most commonly used, and the singlewire method used on screws, bolts, and/or nuts in a closely spaced or closed geometrical pattern such as a triangle, square, rectangle, or circle. The single wire method may also be used on parts in electrical systems and in places that are difficult to reach.

Note

Safetywire shall not be used to secure nor shall it be dependent upon fracture as the basis for operation of emergency devices such as handles, switches, guards covering handles, etc., that operate emergency exits, fire extinguishers, emergency cabin pressure releases, emergency bomb releases, emergency landing gear door releases, and the like. However, where existing structural equipment or safety of flight emergency devices require copper safetywire (0.020-inch diameter only), or as identified in specific technical orders to secure equipment while not in use, but which are dependent upon shearing or breaking of the safetywire for successful emergency operation of equipment, particular care shall be exercised to assure that safetying under these circumstances shall not prevent emergency operation of these devices.

There are many combinations of lockwiring with certain basic rules common to all applications. These rules are as follows:

a. When drilled head bolts, screws, or other parts are closely grouped it is more convenient to safetywire them in series or to each other. The number of bolts, nuts, screws, etc., that may be wired together depends on the application. When securing widely spaced bolts by the double-twist method, the maximum number of bolts that can be wired in a series is three. When securing closely spaced bolts the number that can be secured by a 24-inch length of wire is the maximum number in a series. Widely spaced multiple groups shall not be safetied together when the fasteners are from 4 to 6 inches apart. Lockwiring shall not be used to secure fastenings or fittings which are spaced more than 6 inches apart, unless tie points are provided on adjacent parts to shorten the span of the lockwire to less than six inches.

b. Drilled head bolts and screws need not be safetywired if installed with self-locking nuts or lockwashers in accordance with applicable T.O.'s.

c. Lockwire must be tight when installed.

(1) To prevent failure due to rubbing or vibration, lockwire must be tight after installation.

d. Lockwire must tend to tighten.

(1) By installing lockwire in a manner that tends to tighten and keep a part locked in place, the natural tendency of the part to loosen is counteracted.

e. Lockwire must never be overstressed.

(1) Lockwire will break under vibrations if twisted too tightly. Lockwire shall be pulled taut when being twisted, but shall have a minimum of tension, if any, when secured.

f. Lockwire ends shall be bent into the part to avoid sharp or projecting ends which might present a safety hazard.

g. Internal wiring must not cross over or obstruct a flow passage when an alternate method can be used.

(1) Check the units to be lockwired to make sure that they have been correctly torqued and that the wiring holes are properly positioned in relation to each other. When there are two or more units, it is desirable that the holes in the units be in the same relationship to each other. Never overtorque or loosen units to obtain proper alignment of the holes. It should be possible to align the wiring holes when the units are torqued within the specified limits. However, if it is impossible to obtain a proper alignment of the holes without either over or under torquing, select another unit which will permit proper alignment within the specified torque limits.

(2) To prevent mutilations on the twisted section of the wire when using pliers, grasp the wire at the ends or at a point that will not be twisted. Lockwire must not be nicked, kinked

or mutilated. Never twist the wire ends off with pliers and, when cutting off ends, leave at least three to six complete turns (1/4 to 1/2 inch) after the loop. The strength of the lockwire holes is marginal. When removing a lockwire, never twist the wire off with pliers. Cut the lockwire close to the hole, exercising extreme care.

(3) Figure 2-7 illustrates typical lockwiring procedures. Although there are numerous lockwiring operations performed on aircraft hardware, practically all are derived from the basic examples shown in figure 2-7.

h. Lockwire should, where practicable be installed with the wire positioned around the head of the bolt, screw, or nut and twisted in such a manner that the loop of the wire fits closely to the contour of the unit being lockwired.

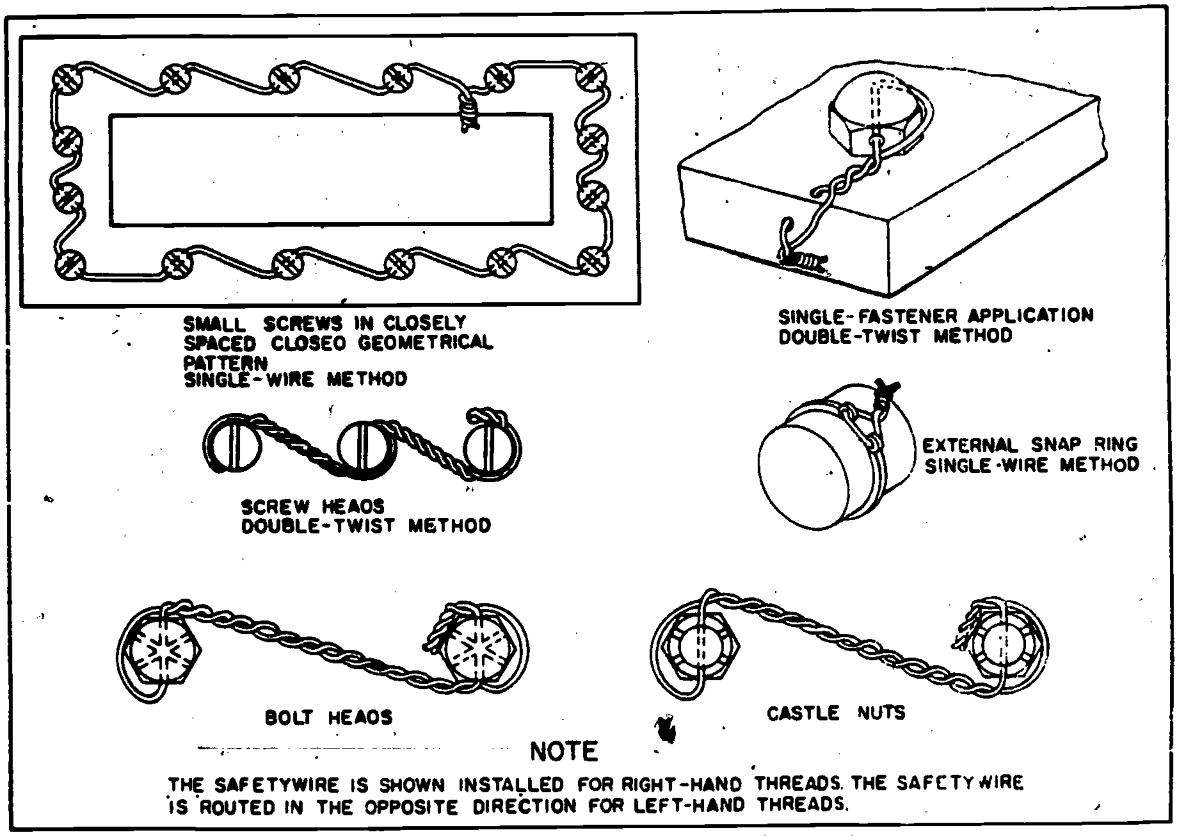

Figure 2-7. - Securing screws, nuts, bolts, and snap rings.

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CONNECTORS AND COUPLINGS

A variety of clamping devices are used to connect ducting sections to each other or to various components. Whenever ducting, lines or components are disconnected or removed for any reason, install suitable plugs, caps or coverings on the openings to prevent the entry of foreign materials. Tag the various parts to ensure correct reinstallation. Take care during handling and installation to ensure that flanges are not scratched, distorted, or deformed. Flange surfaces should be free of dirt, grease, and corrosion. The protective flange caps should be left on the ends of the ducting until the installation progresses to the point where removal is necessary to continue with the installation.

In most cases, seals and gaskets must be discarded and replaced. Ensure that seals and gaskets are properly seated and that flanges are mated and aligned so that excessive torque is not required to close the joint. Excessive torque may impose structural loads on the clamping device. Adjacent support clamps and brackets

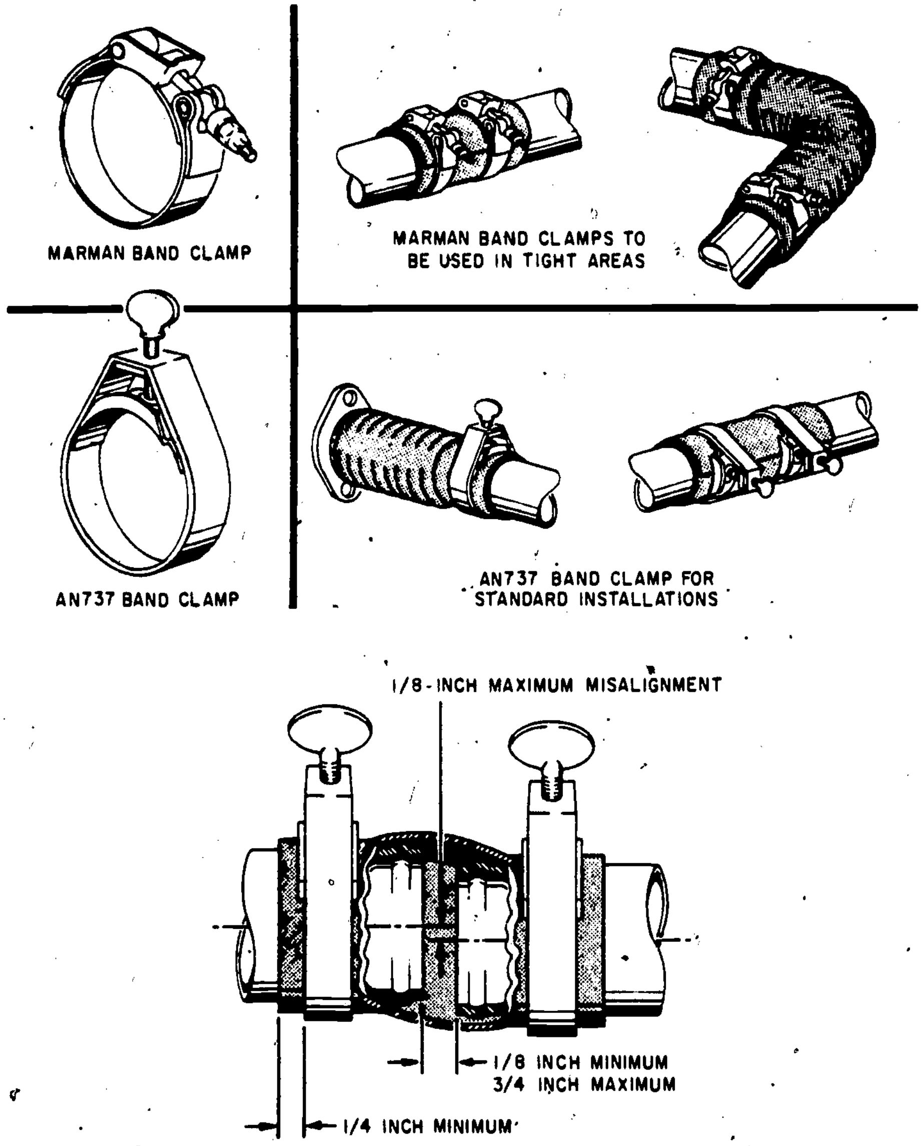

Figure 2-8. - Flexible line connectors.

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should remain loose until installation of the coupling has been completed.

FLEXIBLE CONNECTORS/COUPLING

Some of the most commonly used plain band couplings are illustrated in figure 2-8. When a hose is installed between two duct sections, as shown in figure 2-8, the gap between the duct ends should be 1/8 inch minimum to 3/4 inch maximum. When the clamps are installed on the connection, each clamp should be 1/4 inch minimum from each end of the connector. Misalignment between the ducting ends should not exceed 1/8 inch maximum.

Marman type clamps commonly used in ducting systems should be tightened to the torque value indicated on the coupling. Tighten all couplings in the manner and to the torque value specified on the clamp or in the applicable Maintenance Instructions Manual.

When flexible couplings are installed such as the one illustrated in figure 2-9 the following steps are recommended to assure proper security:

1. Fold back half of the sleeve seal and slip it onto the sleeve.

2. Slide the sleeve (with the sleeve seal partially installed) onto the line.

3. Position the split sleeves over the line beads.

4. Slide the sleeve over the split sleeves and fold over the sleeve seal so that it covers the entire sleeve.

5. Install the coupling over the sleeve seal and torque to correct value.

NOTE: To find torque values for the various sizes and types of couplings, refer to the applicable Maintenance Instructions Manual. Some couplings will have the correct torque value marked on the outside of the band.

RIGID COUPLINGS

The rigid line coupling illustrated in figure 2-10 is referred to as a V-band coupling. When this coupling is installed in restricted areas, some of the stiffness of the coupling can be overcome by tightening the coupling over a spare set of flanges and a gasket to the recommended torque value of the joint. Tap the coupling a few times with a plastic mallet before removing it.

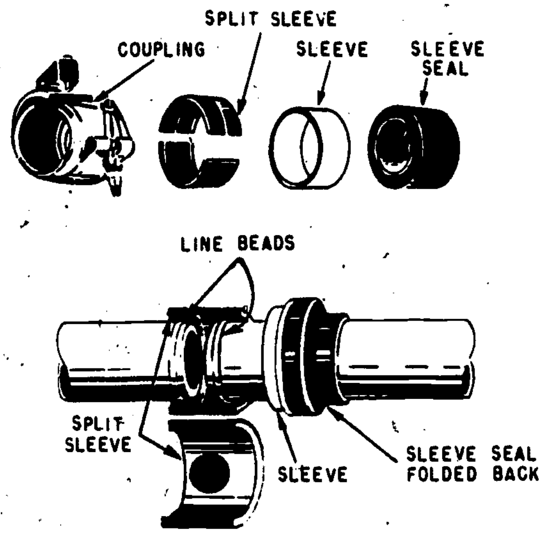

Figure 2-9.– Installation of flexible line couplings.

When installing rigid couplings, follow the steps listed below and illustrated in figure 2-10.

1. Slip the V-band coupling over the flanged tube.

2. Place a gasket into one flange. One quick rotary motion assures positive seating of the gasket.

3. Hold the gasket in place with one hand while the mating flanged tube is assembled into the gasket with a series of vertical and horizontal motions to assure the seating of the mating flange to the gasket.

NOTE: View B of figure 2-10 illustrates the proper fitting and connecting of a rigid coupling, using a metal gasket between the ducting flanges.

4. While holding the joint firmly with one hand, install the V-band coupling over the two flanges.

5. Press the coupling tightly around the flanges with one hand while engaging the latch.

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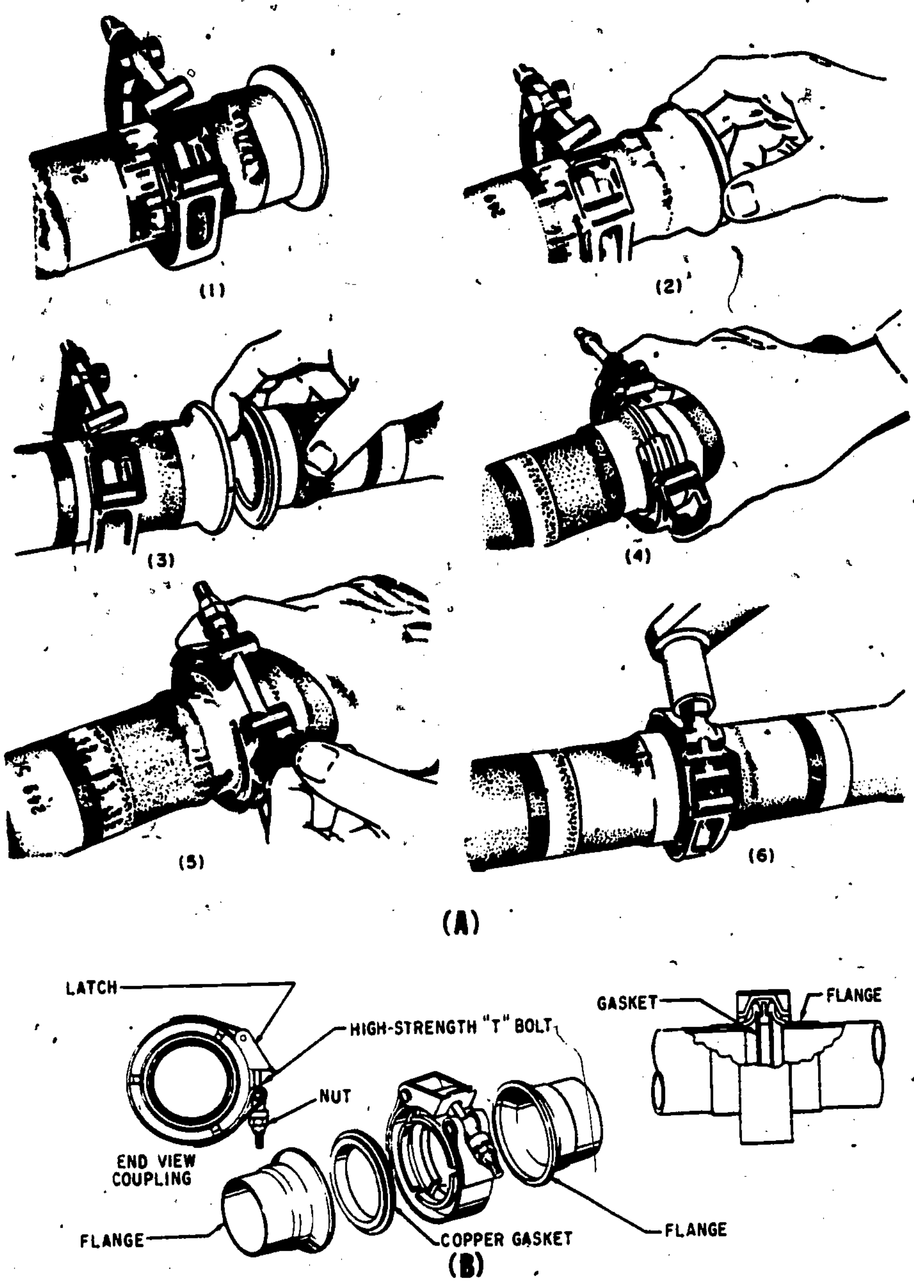


Figure 2-10. - Installation of rigid line couplings.

6. Tighten the coupling firmly with a ratchet wrench. Tap the outer periphery of the coupling with a plastic mallet to assure proper alignment of the flanges in the coupling. This action will seat the sealing edges of the flanges in the gasket. Tighten again, making sure the recommended torque is not exceeded.

7. Check the torque of the coupling with a torque wrench and tighten until the specified torque is obtained.

8. Safety wire the V-band coupling as illustrated in figure 2-11 as an extra measure of security in the event of T-bolt failure. If the nut

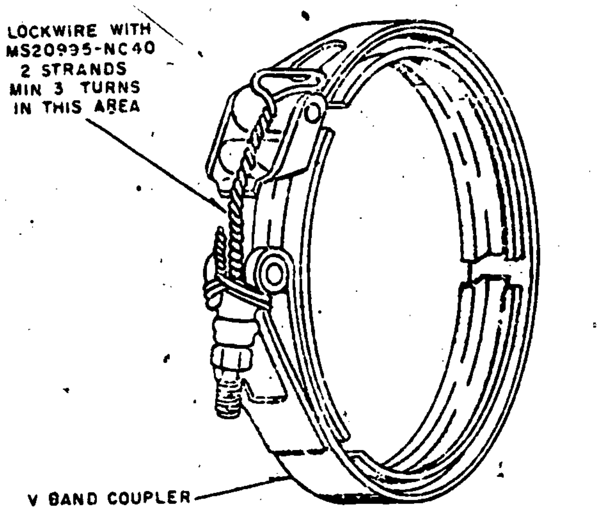


Figure 2-11. - Safetying a V-band coupling.

on the T-bolt is drilled for safetying, extend the safety wire to the nut so that the wire will pull on the nut in a clockwise (tightening) direction. Most V-band connectors use a T-bolt with some type of self-locking nut.

TURNLOCK FASTENERS

Turnlock fasteners are used to secure inspection plates, doors, and other removable panels on aircraft. Turnlock fasteners are also referred to by such terms as quick-opening, quick-action, and stressed-panel fasteners. The most desirable feature of these fasteners is that they permit quick and easy removal of access panels for inspection and servicing purposes. Although removal and replacement of damaged turnlock fasteners is usually one of the responsibilities of the AM, all maintenance personnel should be familiar with the different types of fasteners, their uses, and component parts. The removal and installation of fasteners is relatively simple, and any maintenance person may, at some time, have to replace one of them.

CAMLOC FASTENERS

The 4002 series Camloc fasteners consist of four principal parts — the receptacle, the grommet, the retaining ring, and the stud assembly. (See figure 2-12.) The receptable consists of an aluminum alloy forging mounted in a stamped sheet-metal base. The receptable assembly is riveted to the access door frame, which is attached to the structure of the aircraft. The grommet is a sheet-metal ring held in the access panel with the retaining ring. Grommets are furnished in two types, the flush type and the protruding type. In addition to serving as a grommet for the hole in the access panel, the grommet holds the stud assembly. The stud assembly consists of a stud, a cross pin, spring, and a spring cup. The assembly is so designed that it can be quickly inserted into the grommet by compressing the spring. Once installed in the grommet, the stud assembly cannot be removed unless the spring is again compressed.

Camloc Installation Tools

The following list of Camloc tools should be available to assure satisfactory Camloc installation. The list does not represent the minimum tools required for any particular installation.

Pliers, No. 4P3.
Snapring tool, No. T26.
Cutters, Nos. 4-G2C and 4-GC.
Hole saws, Nos. HS-471D and HS-500.
Flaring tools, Nos. T-55-1 and T-50-1.
Dimpling tools, Nos. 4-G200M, 4-G200F, 2-S200M, and 2-S200F.

Camloc Fastener Repair

Repair of Camloc fasteners includes removal of the damaged stud, grommet, or receptacle, and installation of the replacement part. In all cases, alignment of the stud, grommet, and receptacle must be maintained.

Grommet selection is determined as follows:

1. In the 4002 series, the grommet is used in combination with the stud assembly, but is dependent upon the type of hole required, the total thickness of the material, and the specified counterbore of the snapring.

2. In the 2700 series, the spring cup of the stud assembly eliminates the use of a grommet.

3. In the 40S51 series, the grommet is a nonremovable part of the stud assembly.

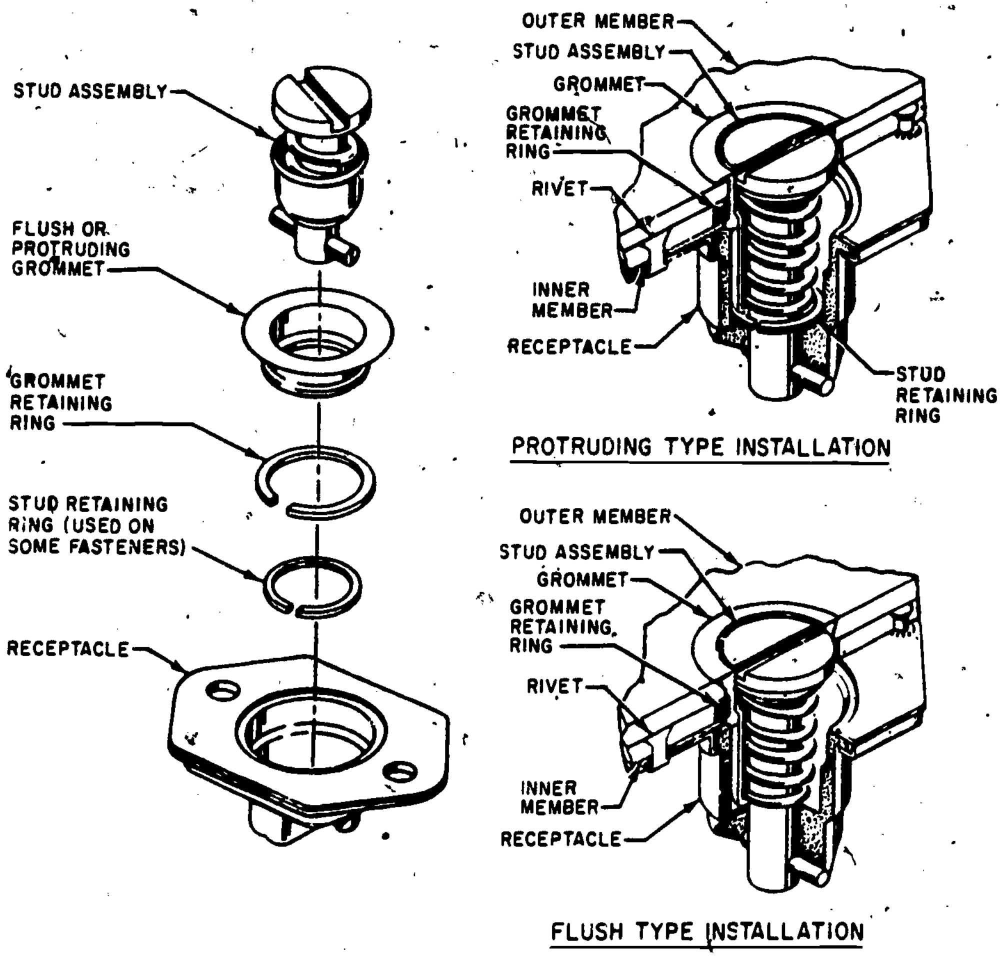


Figure 2-12. - Camloc 4002 series fastener.

NOTE: Lateral movement of the grommet must be held to a minimum. Vertical movement of the grommet, when the fastener is unlocked, should be held to a minimum to prevent possible loss or fallout of the grommet.

The following repair methods apply to the 4002 series Camloc fastener.

Stud Damage

Stud assemblies 4002-1 through -15 are removed by compressing the spring with Camloc pliers and lifting out the stud. To install a new stud, compress the spring and insert the stud into the grommet. (See figure 2-13.) When the spring is released, the stud assembly cannot fall out.

Stud assemblies -16 and longer are retained in the grommet by a split washer. No pliers are required for removal or installation of these studs. The stud is inserted in the grommet, and the split washer is placed on the stud shank between the cross pin and the spring cup. The stud cross pin should not be removed under any circumstances.

Grommet Damage

Remove the grommet by first prying off the snapring and slip the grommet out of the hole. Check for possible damage to the hole size, the dimple, or countersink. Remove all burrs and install a new grommet identical to the original. Install a new snapring, using snapring tool T26,

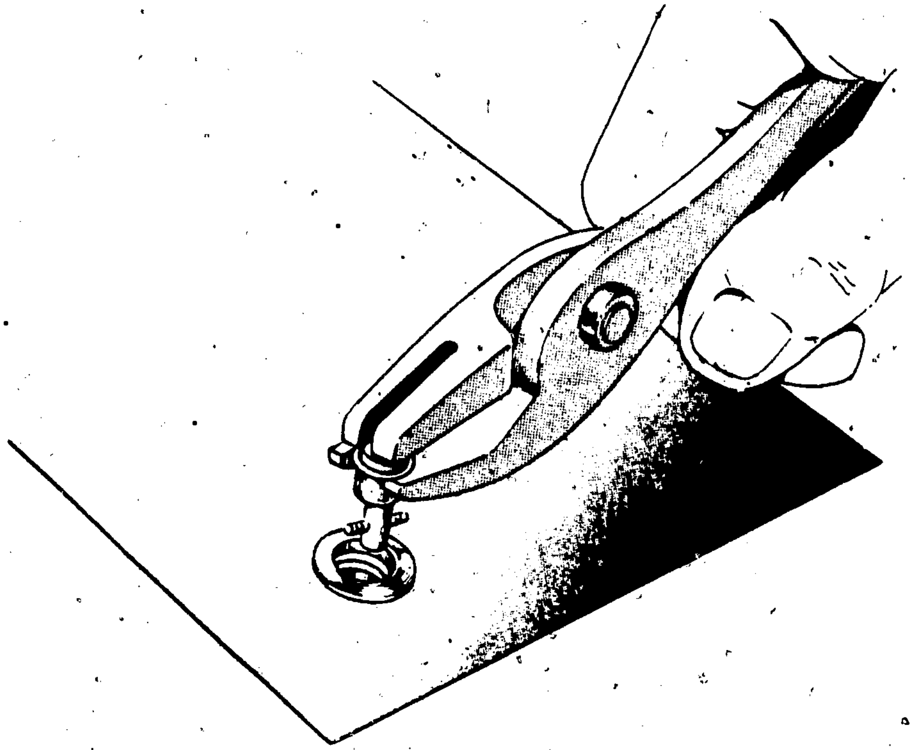


Figure 2-13. - Installing Camloc stud.

as shown in figure 2-14. The snapring must be fully seated behind the shoulder of the grommet.

Receptacle Damage

The AM will remove the attaching rivets, using standard removal procedures, when replacing the damaged receptacle. The new receptacle, which should be identical to the original, is then riveted into place.

Camloc High-stress Panel Fasteners

The Camloc high-stress panel fastener shown in figure 2-15 is a high-strength, quick release, rotary type fastener and may be used on flat or curved, inside or outside panels. The fastener may have either a flush or protruding stud. The studs are held in the panel with flat or cone-shaped washers. Cone-shaped washers are used with flush fasteners in dimpled holes. This fastener may be distinguished from screws by the deep No. 2 Phillips recess in the stud head and by the bushing in which the stud is installed.

A threaded insert in the receptacle provides an adjustable locking device. As the stud is inserted and turned counterclockwise 1/2 turn or more, it screws out the insert sufficiently to permit the stud key to engage the insert cam when the stud is turned clockwise. Rotating the stud clockwise 1/4 turn engages the insert, and continued rotation screws the insert in, tightening the fastener. Turning the stud 1/4 turn counterclockwise will release the stud, but will not screw the insert out far enough to permit reengagement on installation. The stud should be turned at least 1/2 turn counterclockwise to reset the insert.

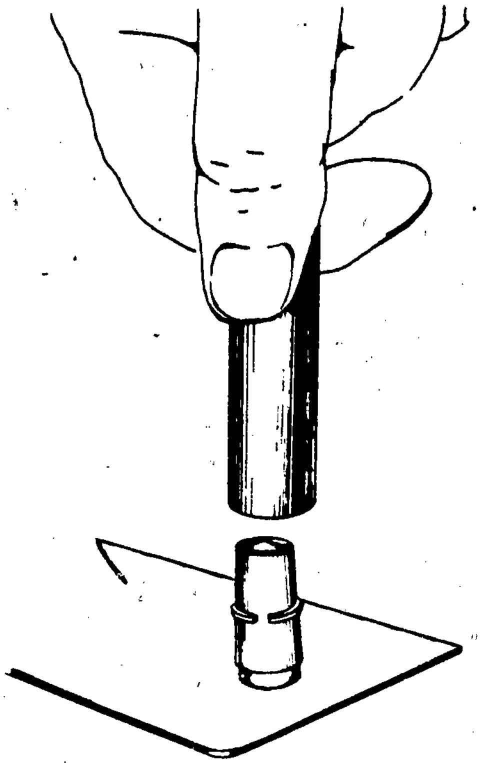


Figure 2-14. - Installing snapring behind shoulder of grommet

AIRLOC FASTENERS

Figure 2-16 illustrates the parts that make up an Airloc fastener. As with the Camloc fastener, the Airloc fastener also consists of a receptacle, a stud, and a cross pin. The stud is attached to the access panel and is held in place by the cross pin. The receptacle is riveted to the access panel frame.

Two types of Airloc receptacles are available — the fixed type (insert A) and the floating type (insert B). The floating type makes for easier alignment of the stud in the receptacle. Several types of studs are also available, but in each instance the stud and cross pin come as separate units so that the stud may be easily installed in the access panel.

The Airloc receptacle is fastened to the inner surface of the access panel frame by two rivets. Rivet heads must be flush with the outer surface of the panel frame. When replacing receptacles, the AM will drill out the two old rivets and attach the new receptacle by flush riveting, being careful not to mar the sheet. When inserting the stud and cross pin, insert the stud through the access panel and, by using a special handtool, insert the cross pin in the stud. Cross pins can be removed by means of special ejector pliers.

Airloc Fastener Repair

The Airloc assembly consists of the receptacle, stud, and cross pin as seen figure 2-16. The repair of this fastener is normally made by complete replacement of the damaged parts. The stud and cross pin should never be reused due to the press fit, which is necessary for cross pin retention.

Installation Procedures

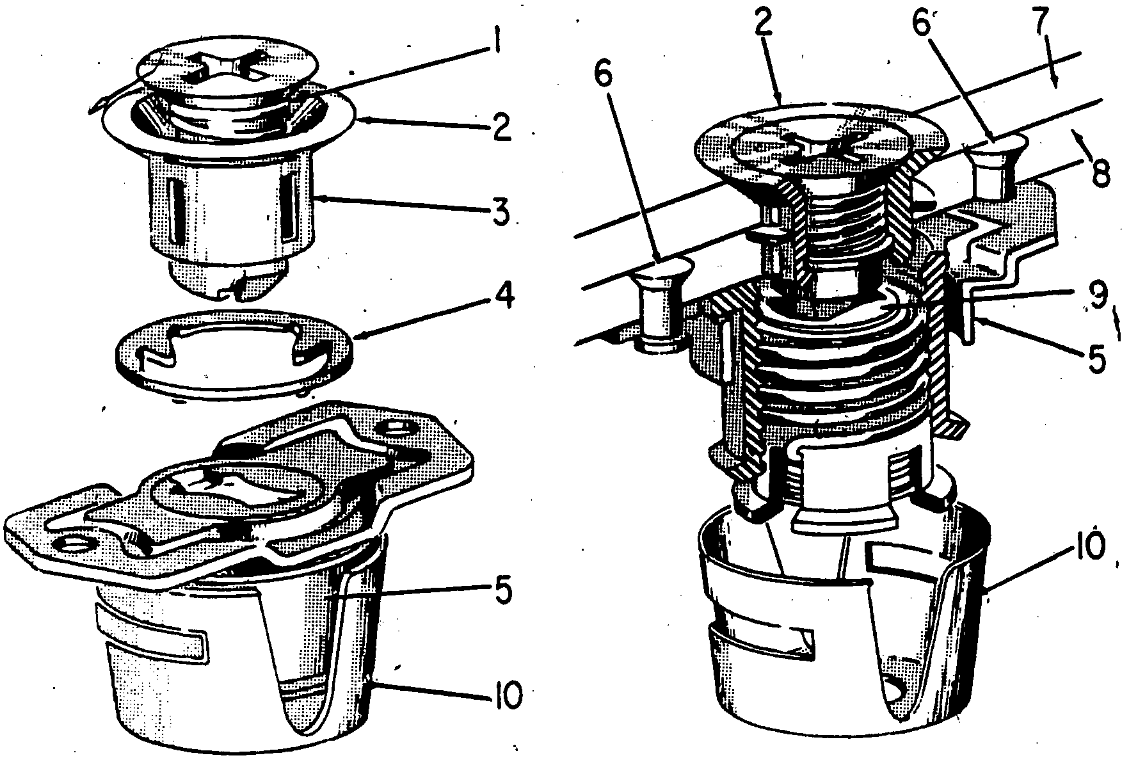
The stud normally comes in two head types, the countersunk and round head. (See figure 2-17). The head of the stud is stamped to indicate the total grip length. Studs are available in lengths that vary in increments of ten-thousandths of an inch.

After determining the correct length of stud, insert the new stud into the panel or sheet. Using the special Airloc tool, press the cross pin into the stud hole, as shown in figure 2-18.

When Airloc fasteners do not fasten properly and the studs are known to be the correct length, excess misalignment is normally the cause. This condition can often be corrected by removing the panel and fastening the studs in a different sequence. Fastening the difficult studs first or starting in the middle of the panel and working toward each end usually corrects this condition.

Removal

To remove damaged receptacles, remove the rivets, using standard removal procedures. The stud is removed by pressing out or clipping off the cross pin. Remove the cross pins for 1-inch and 1 3/8-inch studs by pressing out the pins, using special hand pliers. (See figure 2-19). The cross pin for 3/4-inch studs may be removed either by using the hand pliers or by clipping off the cross pin.



1. Tension spring.
2. Stud assembly.
3. Bushing.
4. Retaining ring.
5. Receptacle assembly.
6. Receptacle attaching rivets.
7. Outer skin.
8. Inner skin.
9. Insert.
10. Cover.

Figure 2-15. - Camloc high-stress panel fastener.

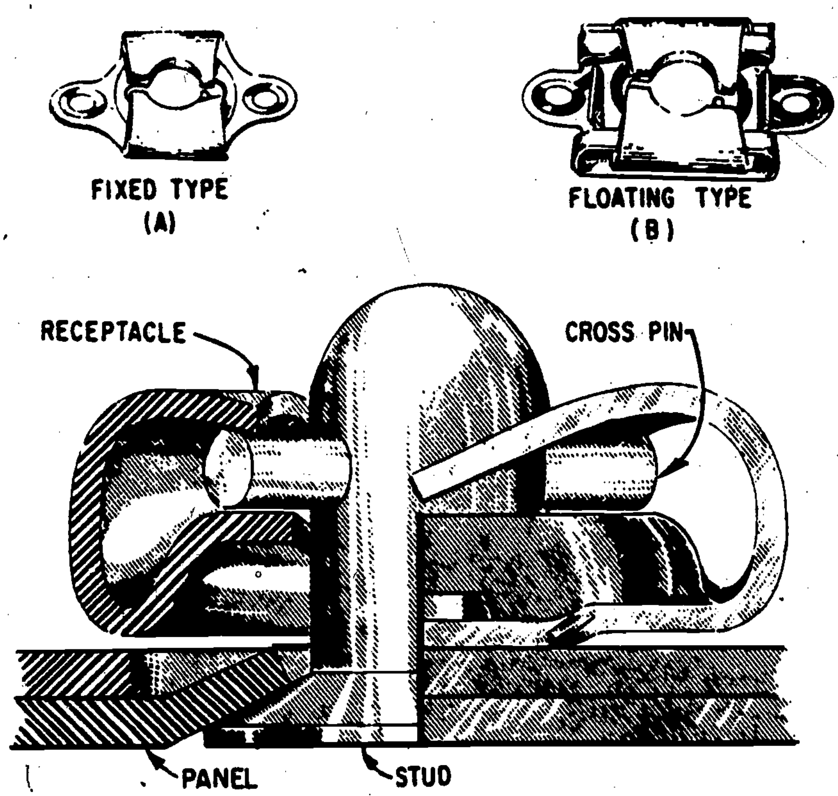


Figure 2-16. - Airloc fastener.

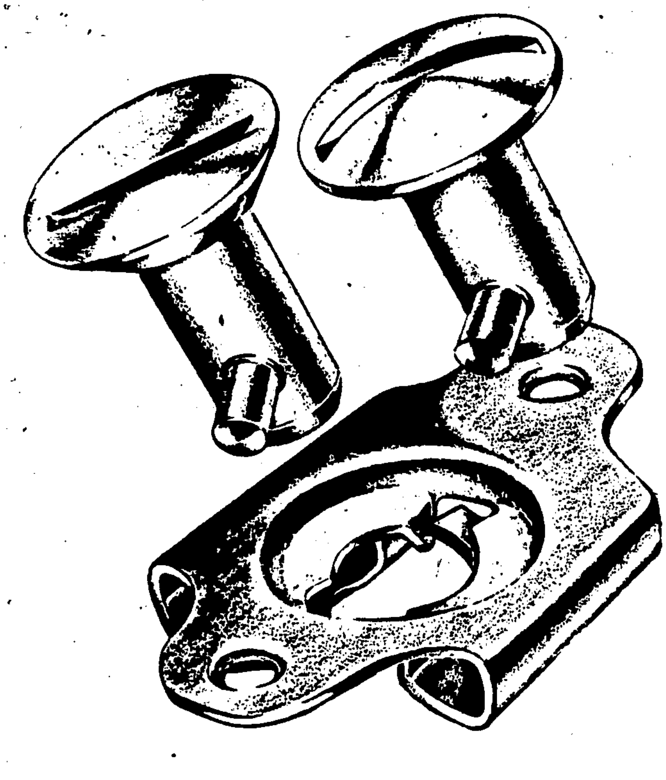


Figure 2-17. - Airloc stud head shapes, countersunk and round.

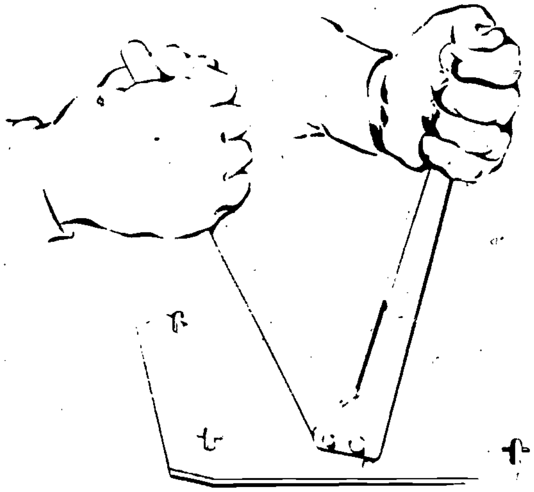


Figure 2-18. - Inserting cross pin, using special Airloc handtool.

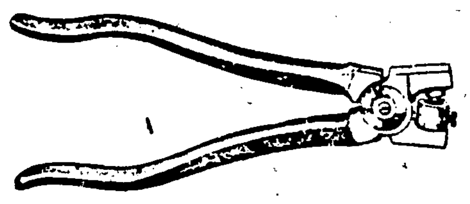


Figure 2-19. - Hand pliers for removing cross pins.

DZUS FASTENERS

Dzus fasteners are available in two types. One is the light-duty type, used on box covers, access hole covers, and lightweight fairing. The second is the heavy-duty type, used on cowling and heavy fairing. The main difference between the two types of Dzus fasteners is a grommet, used by heavy-duty but not by light-duty fasteners. Otherwise, the construction features are about the same.

Figure 2-20 shows the parts that make up a light-duty Dzus fastener. Notice that the parts include a spring and a stud. The spring is made of cadmium-plated steel music wire and is usually riveted to an aircraft structural member. The stud comes in a number of designs (as shown in insets A, B, and C) and mounts in a dimpled hole in the cover assembly.

When the panel or plate is being positioned on the aircraft preparatory to being secured in place, the spring riveted to the structural member enters the hollow center of the stud, which is retained in the plate or panel. Then, when the stud is turned about 1/4 turn, the curved jaws of the stud slip over the spring and compress it. The resulting tension locks the stud in place, securing the panel or plate.

Dzus Fastener Repair

The main difference in repairing the two types of Dzus fasteners is that the heavy-duty type requires an additional operation. The retaining grommet must also be removed and

66

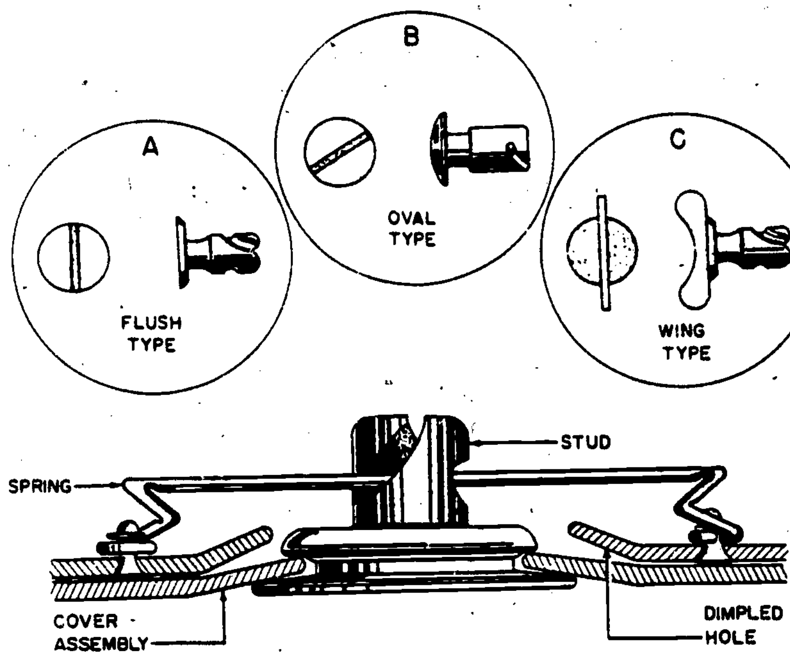


Figure 2-20. - Dzus fastener.

replaced. The S-shaped spring is replaced if damaged or broken.

Installation

The light-duty Dzus fastener is installed in three steps. (See (A) figure 2-21.) Using a special set of dies, dimple the hole. Then insert the correct size of stud in the dimpled hole. Using another set of dies, force the dimpled material into the undercut of the stud to lock the stud in place.

The heavy-duty Dzus fastener is installed in four steps. (See (B) figure 2-21.) Drill a hole to the proper size and insert the grommet. Then set the grommet (partially flared). Insert the correct size of fastener through the grommet. Using a set of dies, flare the grommet material, forcing the grommet to clinch the undercut part of the stud and the panel. This clinching action locks the stud in position.

Removal

The light-duty Dzus fastener may be removed by placing the stud over a hole in an anvil and striking the stud with a hammer and drift punch. After the broken stud is driven out, the hole will be too large and will be dimpled on the wrong side. This may be remedied by flattening the hole area with a hammer and redimpling with the proper size dimpling tool. Removal of the heavy-duty Dzus fastener requires a different procedure. A grommet is used in the hole and must be cut away before the damaged stud can be removed. A new grommet must be inserted before a new stud is installed.

The heavy-duty Dzus fastener may be removed by cutting away the grommet, using diagonal cutter type pliers. The old fastener is then free to fall out of the hole. Inpsect the hole area for damage, and repair as necessary.

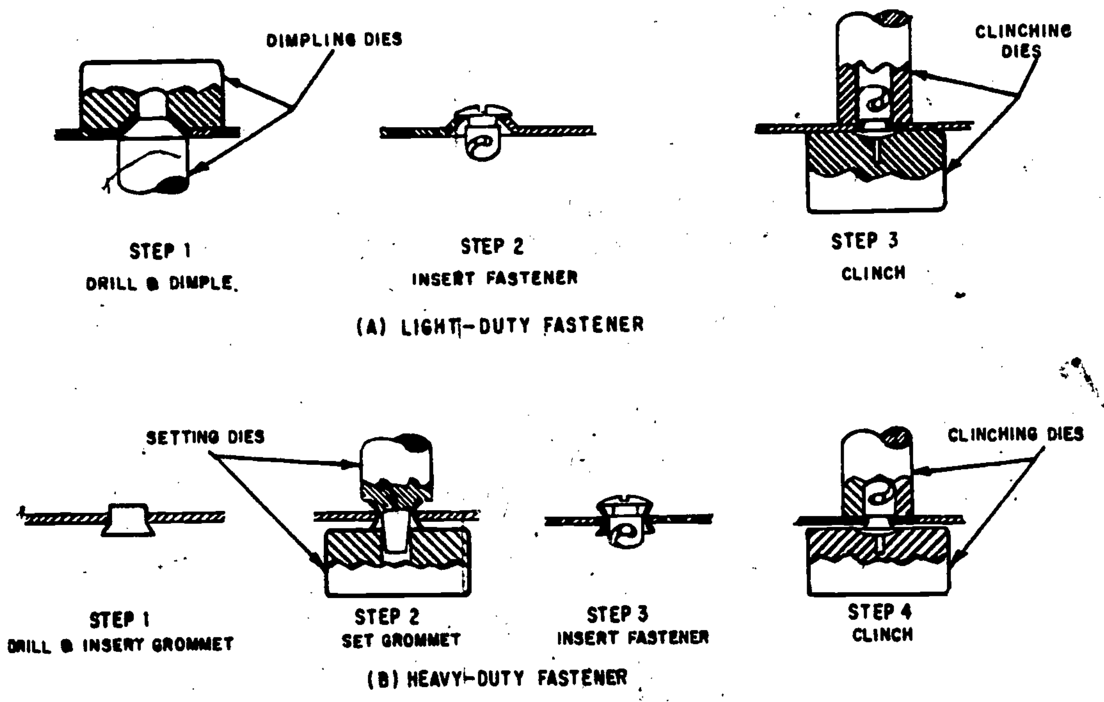


Figure 2-21. - Dzus fastener installation.

Then reinstall the new fastener and grommet in the original hole, as described earlier.

Repair of the Hole

When the hole is too badly worn to permit reinstallation of the same size heavy-duty fastener, it is recommended that a lap patch be installed over the old hole and a new hole cut in the lap patch. Then install the new fastener in the lap patch.

Repair of a Spring

When a spring is broken or damaged, replace with an identical spring. Different spring heights are available for each fastener. Special springs are used for installation in box corners and panels which would be subjected to either horizontal or vertical movements.

SELF-QUIZ #2

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the stated course objectives. To pass the EOCT, you must study all the course material.

1. Which screw has a definite grip and is made of equivalent bolt material?
2. Which nut should be used with a drilled taper pin?
3. Which component secures a flathead pin in position?
4. For quick identification, self-locking Heli-Coli inserts are dyed ________________.
5. What type of cotter pin is used in an area where nonmagnetic material is required?
6. During the safety wiring process, you should use pliers ONLY for ________________.
7. Why must a V-band coupling be safetywired?
8. Installed Camloc stud assemblies are held in position by either a split washer or a ________________.
9. Which turnlock fastener requires the removal of the cross pin before the stud can be removed?
10. To remove a heavy-duty Dzus fastener, you must cut away the ________________.

(See page 2-22 for ANSWERS to Self-Quiz questions)

69

ANSWERS TO SELF-QUIZ #2

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

1. Structural screw (Page 2-1)
2. Castellated shear (Page 2-3)
3. Cotter pin (Page 2-4)
4. red (Page 2-5)
5. Stainless steel (Page 2-5)
6. the final end twist (Page 2-5)
7. To provide an extra measure of security in the event of T-bolt failure. (Page 2-10)
8. grommet (Page 2-11)
9. Airloc (Page 2-14)
10. grommet (Page 2-18)

PAMPHLET REVIEW QUIZ

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the stated course objectives. To pass the EOCT, you must study all the course material.

1. What is the grip length of a bolt?

   A. Threaded portion of the bolt shaft
   B. Unthreaded portion of the bolt shaft
   C. Entire length of the bolt
   D. Entire length of the shaft

2. When determining bolt grip, how many threads, if any, may extend into the bolthole?

   A. Two
   B. Three
   C. Four
   D. None

3. If the bolt thickness is 1/4 inch or more, how is the bolt diameter expressed?

   A. Alphabetically
   B. Alphanumerically
   C. In fractions of an inch
   D. In whole numbers

4. You should use the appropriate size Allen wrench to tighter and loosen the countersunk head bolt and the ______________ bolt.

   A. clevis
   B. eye
   C. external wrenching
   D. internal wrenching

5. Two dashes on the head of a bolt indicate that the bolt material is ______________.

   A. steel
   B. corrosion-resistant steel
   C. aluminum alloy
   D. tungsten

6. Special bolts usually have a/an ______________ stamped on their heads.

   A. X
   B. S
   C. triangle
   D. single dash

7. A dash following an AN bolt series number indicates that the bolt is ______________.

   A. made of carbon steel
   B. made of corrosion-resistant steel
   C. close tolerance
   D. drilled for safetying

8. You can identify the type of material of an aircraft nut by the ______________.

   A. type of self-locking feature
   B. number of threads per inch
   C. diameter of the inside hole
   D. metallic luster of the metal

9. The two general groups of nuts are ______________.

   A. steel and aluminum
   B. plain and castellated
   C. self-locking and nonself-locking
   D. regular and aircraft

10. Which nut is designed for shear stress and is safetied with a cotter pin or safety wire?

   A. Castle
   B. Castellated shear
   C. Check
   D. Plain

11. How many times, if any, should you reuse self-locking nuts installed in critical areas on an aircraft unless technical publications specify otherwise?

   A. One time only
   B. Two times only
   C. As long as the locking device is good
   D. Cannot be reused

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12. During installation, how can you prevent a lockwasher from damaging the surface of a soft material?

- A. Use a plain washer under the lock-washer
- B. Decrease the fastener torque
- C. Lubricate the washer and the soft material surface
- D. Use checknuts with the lock-washer

13. Which washer should be used under the head of an internal wrenching bolt?

- A. Flat
- B. Countersunk
- C. Lock
- D. Ball-socket

14. When securing aluminum or magnesium parts with a steel bolt, you should use a/an ______ washer.

- A. steel
- B. copper
- C. magnesium
- D. aluminum

15. Why must all bolts in a particular installation be tightened (torqued) an equal amount?

- A. Prevent stripping the threads
- B. Prevent shearing the bolts while torquing
- C. Permit each bolt to carry its share of the load
- D. Ensure that all the washers are properly seated

16. How do structural screws differ from structural bolts?

- A. Heat treatment
- B. Type of head
- C. Major alloy
- D. Thread fit

17. Which machine screw is frequently used to assemble highly stressed aircraft components?

- A. Pan-head
- B. Truss-head
- C. Round-head
- D. Flat-head

18. Which machine screw is usually used to attach removable parts, such as nameplates, to castings?

- A. Self-tapping screw
- B. Setscrew
- C. Truss-head screw
- D. Flat-head screw

19. The portion of a Heli-coil used to drive the insert is the ______.

- A. keyway
- B. prong
- C. grip coil
- D. tang

20. Safety wire which can be broken by hand in case of an emergency is made of ______.

- A. stainless steel
- B. carbon steel
- C. aluminum alloy
- D. annealed copper

21. To find torque values for the various sizes and types of couplings, you should look in the applicable Maintenance Instructions Manual or ______.

- A. in the Accessory Manual
- B. in the Structural Repair Manual
- C. on the outside of the band
- D. on the ducting

22. When installing a V-band coupling over two tube flanges, you can assure proper alignment of the flanges by ______.

- A. applying and releasing the torque several times
- B. tapping the coupling with a plastic mallet
- C. holding the flanges in alignment as torque is applied
- D. applying a series of vertical and horizontal motions

ERIC

23. The MOST desirable feature of turn-lock fasteners is that they ________________.

A. permit quick and easy removal of access panels
B. provide a greater measure of security than threaded fasteners
C. are maintenance free
D. are not affected by high operating temperatures

24. In addition to serving as a grommet for a hole, a Camloc grommet holds the ________________.

A. receptacle
B. spring cup
C. stud retaining ring
D. stud assembly

25. To remove a damaged heavy-duty Dzus fastener stud, you must ________________.

A. cut away the grommet
B. tap the stud out with a drift punch
C. cut the head from the stud
D. remove the snap ring

PAMPHLET REVIEW QUIZ
ANSWER KEY

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure your understand the answers to those questions you missed, you should restudy the referenced portions of the text.

QUES.	ANS.	REF.	QUES.	ANS.	REF.
1	B	1-1	14	D	1-10
2	A	1-2	15	C	1-10
3	C	1-2	16	B	2-1
4	D	1-3	17	C	2-1
5	C	1-4	18	A	2-3
6	B	1-4	19	D	2-4
7	A	1-5	20	D	2-5
8	D	1-5	21	C	2-9
9	C	1-5	22	B	2-10
10	B	1-6	23	A	2-11
11	D	1-6	24	D	2-11
12	A	1-9	25	A	2-18
13	B	1-9			

71

AIRCRAFT METALS AND AIRCRAFT STRUCTURAL HARDWARE

DEPARTMENT OF TRANSPORTATION
U. S. Coast Guard (01/81) AM2-0207

U. S. Coast Guard Institute
PAMPHLET NO. 625

ERIC

75.

This pamphlet contains original material developed at the Coast Guard Institute and also excerpts from:

HC-130B and HC-130H Structural Repair Manual	T.O. 1C-130A-3
Aviation Structural Mechanic S 3 & 2	NAVTRA 10308-C

IMPORTANT NOTE: In January, 1981, the information contained in this pamphlet was current according to the latest updates of those Directives/Publications listed. This pamphlet was compiled for training **ONLY**. It should **NOT** be used in lieu of official Directives or publications. It is always **YOUR** responsibility to keep abreast of the latest professional information available for your rate.

The personnel responsible for the latest review and update of the material in this component during January 1981 are:

AMCM S. R. Carter	(Subject Matter Specialist)
Linda McCoy	(Education Specialist)
YN1 K. M. Baker	(Typographer)
YN2 D. J. Laase	(Typist)

Questions about the text should be addressed to your Subject Matter Specialist.

83

ERIC

76

NOTICE TO STUDENT

This pamphlet contains lesson quizzes and a pamphlet review quiz. Correct answers and text references are printed in the right-hand column of each quiz page. A 3 1/4 X 9-inch Answer Key Mask is provided with each course. Lay the mask over the answers in the right-hand column. After you answer the questions, remove the mask to check your answer with the printed answer. Try to answer the questions in each quiz before looking back at the text.

ERIC

INTRODUCTION

This pamphlet outlines the types and characteristics of metals used in aircraft construction and identifies the common types of aircraft hardware. To ensure the continued structural integrity of Coast Guard aircraft, all structural mechanics, must be thoroughly familiar with the information that will be presented here.

Two major topics will be discussed in this pamphlet:

(1) Aircraft metals

(2) Aircraft sturctural hardware

First, we will discuss the two types of aircraft metals (ferrous and non-ferrous), their characteristics, identification, and uses in aviation. We will also discuss the factors to be considered when substituting and interchanging metals in aircraft construction.

The second major topic provides information on the common types of structural hardware used on Coast Guard aircraft. The discussion will include the identification of various types of hardware, their uses, proper installation and removal procedures, and the special tools required for each type. You should refer to the specific T. O.'s for more details on the types of aircraft hardware, including the types not covered in this pamphlet.

This pamphlet is divided into two sections and a pamphlet review quiz. Each of the two sections has a list of objectives, text material, and a self-quiz with answers and reference page numbers. The multiple-choice review quiz at the end of the pamphlet also includes answers and reference page numbers. The quiz items are designed to test your mastery of the objectives, which emphasize the most important points of the text.

To get the most from this pamphlet, you should use the study tips provided in the INSTRUCTIONS sheet for this course.

ERIC

AIRCRAFT METALS
AND
AIRCRAFT STRUCTURAL HARDWARE

TABLE OF CONTENTS

AIRCRAFT METALS

OBJECTIVES

When you complete this section, you will be able to:

1. Define ferrous and nonferrous metals.
2. Describe the various methods of identifying the types of ferrous metals.
3. State the different metals aluminum is commonly alloyed with.
4. Explain the numbering system for designating the various aluminum alloys.
5. State the different temper designations for aluminum alloys.
6. Describe the advantages of using titanium, copper, nickel, and magnesium alloys in aircraft construction.
7. Explain the prerequisites to be considered for substituting materials in the repair of aircraft.

Metallurgists have been working for more than a half century improving metals for aircraft construction. Each metal has certain properties and characteristics which make it desirable for a particular application, but it may have other qualities that are undesirable. For example, some metals are hard, others comparatively soft; some are brittle, some tough; some can be formed and shaped without fracture; and some are so heavy that weight alone make them unfeasible for aircraft use. The metallurgist's objectives are to improve the desirable qualities and tone down or eliminate the undesirable ones. This is done by alloying (combining) metals and by various heat-treating processes.

One does not need to be a metallurgist to be a good repairman or mechanic, but he should possess a knowledge and understanding of the uses, strengths, limitations, and other characteristics of aircraft structural metals. Such knowledge and understanding is vital to properly construct and maintain any equipment, especially airframes. In aircraft maintenance and repair, even a slight deviation from design specifications or the substitution of inferior materials may result in the loss of both lives and equipment. The use of unsuitable materials can readily erase the finest craftsmanship. The selection of the specific material for a specific repair job demands familiarity with the most common properties of various metals.

FERROUS AIRCRAFT METALS

A wide variety of materials is required in the repair of aircraft. This is a result of the varying needs with respect to strength, weight, durability, and resistance to deterioration of specific structures of parts. In addition, the particular shape or form of the material plays an important role. In selecting materials for aircraft repair, you should consider these factors, plus many others, in relation to their mechanical and physical properties. Among the common materials used are ferrous metals. The term FERROUS applies to the group of metals having iron as their principal constituent.

Identification of Ferrous Metals

If carbon is added to iron, in percentages ranging up to approximately 1.00 percent, the product will be vastly superior to iron alone and is classified as carbon steel. Carbon steel forms the base of those alloy steels produced by combining carbon with other elements known to improve the properties of steel. A base metal such as iron, to which small quantities of other metals have been added, is called an ALLOY. The addition of other metals is to change or improve the chemical or physical properties of the base metal.

SAE NUMERICAL INDEX. - The steel classification of the Society of Automotive Engineers (SAE) is used in specifications for all high-grade steels used in automotive and aircraft construction. A numerical index system identifies the composition of SAE steels.

Each SAE number consists of a group of digits. The first digit represents the type of steel; the second, the percentage of the principal alloying element; and usually the last two or three digits the percentage, in hundredths of 1 percent, of carbon in the alloy. For example, the SAE number 4150 indicates a molybdenum steel containing 1 percent molybdenum and 50 hundredths of 1 percent of carbon. Refer to the SAE numerical index shown in figure 1-1 to see how the various types of steel are classified into four-digit classification numbers.

Type of steel	Classification
Carbon	1xxx
Nickel	2xxx
Nickel-chromium	3xxx
Molybdenum	4xxx
Chromium	5xxx
Chromium-vanadium	6xxx
Tungsten	7xxx
Silicon-manganese	9xxx

Figure 1-1 - SAE numerical index.

HARDNESS TESTING METHODS. - Hardness testing is a factor in determining the results of heat treatment as well as the condition of the metal before heat treatment. There are two commonly used methods of hardness testing, the BRINELL and the ROCKWELL tests. These tests require the use of specific machines. An additional somewhat indirect method (SPARK TESTING) is used in identifying ferrous metals. This method gives some indication of the hardness of the metal.

Spark testing is a common means of identifying ferrous metals which have become mixed. In this test the piece of iron or steel is held against a revolving stone and the metal is identified by the sparks thrown off. Each ferrous metal has its own peculiar spark characteristics. The spark streams vary from a few tiny shafts to a shower of sparks several feet in length. Few nonferrous metals give off sparks when touched to a grinding stone. Therefore, these metals cannot be successfully identified by the spark test.

Wrought iron produces long shafts that are dull red as they leave the stone and end up a white color. Cast iron sparks are red as they leave the stone and turn to a straw color. Low-carbon steels give off long straight shafts having a few white sprigs. As the carbon content of the steel increases, the number of sprigs along each shaft increases and the stream becomes whiter. Nickel steel causes the spark stream to contain small white blocks of light within the main burst.

Types, Characteristics, and Uses of Alloyed Steels

While the plain carbon steel type remains the principal product of the steel mills, so-called alloy or special steels are being turned out in ever increasing tonnage. Let us now consider those alloyed steels and their uses in aircraft.

CARBON STEELS. - Steel containing carbon in percentages ranging from 0.10 to 0.30 percent are classed as LOW-CARBON STEEL. The equivalent SAE numbers range from 1010 to 1030. Steels of this grade are used for making such items as safety wire, certain nuts, cable bushings, and threaded rod ends. Low-carbon steel in sheet form is used for secondary structural parts and clamps, and in tubular form for moderately stressed structural parts.

Steels containing carbon in percentages ranging from 0.30 to 0.50 percent are classed as MEDIUM-CARBON STEEL. This steel is especially adaptable for machining or forging and where surface hardness is desirable. Certain rod ends and light forgings are made from SAE 1035 steel.

Steel containing carbon in percentages ranging from 0.50 to 1.05 percent are classed as HIGH-CARBON STEEL. The addition of other elements in varying quantities adds to the hardness of this steel. In the fully heat-treated condition, this steel is very hard and will withstand high shear and wear and have little deformation. It has limited use in aircraft. SAE 1095 in sheet form is used for making flat springs, and in wire form for making coil springs.

NICKEL STEELS. - The various nickel steels are produced by combining nickel with carbon steel. Steels containing from 3 to 3.75 percent nickel are commonly used. Nickel increases the hardness, tensile strength, and elastic limit of steel without appreciably decreasing the ductility. It also intensifies the hardening effect of heat-treatment. SAE 2330 steel is used extensively for aircraft parts such as bolts, terminals, keys, clevises, and pins.

CHROMIUM STEELS. - Chromium steels are high in hardness, strength, and corrosion-resistant properties. SAE 51335 is particularly adaptable for heat-treated forgings which require greater toughness and strength than may be obtained in plain carbon steel. It is used for such articles as the balls and rollers of antifriction bearings.

CHROME-NICKEL OR STAINLESS STEELS.- These are corrosion-resisting metals. The anticorrosive degree is determined by the surface condition of the metal as well as by the composition, temperature, and concentration of the corrosive agent.

The principal part of stainless steel is chromium, to which nickel may or may not be added. The corrosion-resisting steel most often used in aircraft consturction is know as 18-8 steel because of its content of 18 percent chromium and 8 percent nickel. One of the distinctive features of 18-8 steel is that its strength may be increased by cold-working.

Stainless steel may be rolled, drawn, bent, or formed to any shape. Because these steels expand about 50 percent more than mild steel and conduct heat only about 40 percent as rapidly, they are more difficult to weld. Stainless steel, with but a slight variation in its chemical composition, can be used for almost any part of an aircraft. Some of its more common applications are in the fabrication of exhaust collectors, stacks and manifolds, structural and machined parts, springs, castings, and tie rods and cables.

CHROME-VANADIUM STEELS. - These are made of approximately 0.18 percent vanadium and about 1.00 percent chromium. When heat treated, they have strength, toughness, and resistance to wear and fatigue. A special grade of this steel in sheet form can be cold-formed into intricate shapes. It can be folded and flattened without signs of breaking or failure. SAE 6150 is used for making springs, and chrome-vanadium with high-carbon content, SAE 6195, is used for ball and roller bearings.

CHROME-MOLYBDENUM STEELS. - Molybdenum in small percentages is used in combination with chromium to form chrome-molybdenum steel which has various uses in aircraft. Molybdenum is a strong alloying element, since only 0.15 to 0.25 percent is used in the chrome-molybdenum steels; the chromium content varies from 0.80 to 1.10 percent. Molybdenum raises the ultimate strength of steel without affecting ductility or workability. Molybdenum steels are tough, wear-resistant, and harden throughout from heat treatment. They are especially adaptable for welding, and for this reason are used principally for welded structural parts and assemblies. SAE 4130 is used for parts such as engine mounts, nuts, bolts, gear structures, support brackets for accessories and other structural parts.

The progress of jet propulsion in the field of naval aviation has been aided by the continuous research in high-temperature metallurgy. This research has made alloys to withstand the high temperatures and velocities encountered in jet power units. These alloys are chemically similar to the previously mentioned steels, but may also contain cobalt, copper, and columbium in varied amounts as alloying elements.

NONFERROUS AIRCRAFT METALS

The term NONFERROUS refers to all metals which have elements other than iron as their principal constituent. This group includes aluminum, titanium, copper, and magnesium and their alloys; and in addition, such alloy metals as monel and babbitt.

Aluminum and Aluminum Alloys

Commercially pure aluminum is a white, lustrous metal, light in weight and corrosion resistant. Aluminum combined with various percentages of other metals (generally copper, manganese, magnesium, and chromium) form the alloys which are used in aircraft construction. Aluminum alloys in which the principal alloying ingredients are either manganese, magnesium, or chromium, or magnesium and silicon show little attack in corrosive environments. On the other hand, those alloys in which substantial percentages of copper are used are more susceptible to corrosive action. The total percentage of alloying elements is seldom more than 6 or 7 percent in the wrought aluminum alloys.

TYPES, CHARACTERISTICS, AND USES. - Aluminum is one of the most widely used metals in modern aircraft construction. It is vital to the aviation industry because of its high strength/weight ratio, its corrosion-resisting qualities, and its comparative ease of fabrication. The outstanding characteristic of aluminum is its light weight. In color, aluminum resembles silver although it possess a characteristic bluish tinge of its own. Commercially pure aluminum melts at the comparatively low temperature of 1,220°F. It is nonmagnetic and is an excellent conductor of electricity.

Commercially pure aluminum has a tensile strength of about 13,000 psi, but by rolling or other cold-working processes, its strength may be approximately doubled. By alloying with other metals, together with the use of heat-treating processes, the tensile strength of aluminum may be raised to as high as 96,000 psi, or to well within the strength range of structural steel.

Aluminum alloy material, although strong, is easily worked, for it is very malleable and ductile. It may be rolled into sheets as thin as 0.0017 inch or drawn into wire 0.004 inch in diameter. Most aluminum alloy sheet stock used in aircraft construction ranges from 0.016 to 0.096 inch in thickness; however, some of the larger aircraft use sheet stock which may be as thick as 0.356 inch.

One disadvantage of aluminum alloy is the difficulty of making reliable soldered joints. Oxidation of the surface of the heated metal prevents soft solder from adhering to the material; therefore, to produce good joints of aluminum alloy, a riveting process is used. Some aluminum alloys are also successfully welded.

The various types of aluminum may be divided into two classes - CASTING ALLOYS (those suitable for casting in sand, permanent mold, and die castings) and the WROUGHT ALLOYS (those which may be shaped by rolling, drawing, or forging). Of the two, the wrought alloys are the most widely used in aircraft constuction, since they are used for stringers, bulkheads, skin, rivets, and extruded sections. Casting alloys are not so extensively used in aircraft.

WROUGHT ALLOYS. - Wrought alloys are divided into two classes: nonheat treatable and heat treatable. In the nonheat-treatable class, strain hardening (cold-working) is the only means of increasing the tensile strength. Heat-treated alloys may be hardened by heat treatment, by cold-working, or by the application of both processes.

Aluminum products are identified by a universally used designation system. Under this arrangement, wrought aluminum and wrought aluminum alloys are designated by a four-digit index system.

The first digit of the designation indicates the major alloying element or alloy group, as shown in figure 1-2. Thus 1xxx indicates aluminum of 99.00 percent or greater, 2xxx indicates an aluminum alloy in which copper is the major alloying element, etc. Although most aluminum alloys contain several elements, only one group (6xxx) designates more than one alloying element.

Aluminum—99.00 percent minimum and greater	1xxx
Aluminum alloys, grouped by major alloying element:	
Copper	2xxx
Manganese	3xxx
Silicon	4xxx
Magnesium	5xxx
Magnesium and silicon	6xxx
Zinc	7xxx
Other elements	8xxx

Figure 1-2 - Designations for aluminum alloy groups

In the 1xxx group, the second digit in the designation indicates modifications in impurity limits. If the second digit is zero. it indicates that there is no special control on individual impurities. The last two of the four digits indicate the minimum aluminum percentage. Thus, alloy 1030 indicates 99.30 percent aluminum without special control on impurities. Alloys 1130, 1230, 1330, Alloys 1130, 1230, 1330, etc., indicate the same aluminum purity with special control on one or more impurities. Likewise, 1075, 1175, 1275, etc., indicate 99.75 percent aluminum.

In the 2xxx through 8xxx groups, the second digit indicates alloy modifications. If the second digit in the designation is zero, it indicates the original alloy, while numbers 1 through 9, assigned consecutively, indicate alloy modifications. The last two of the four digits have no special significance, but serve only to identify the different alloys in the group.

The temper designation follows the alloy designation and shows the actual condition of the metal. It is always separated from the alloy designation by a dash, as shown in figure 1-3.

The letter "F" following the alloy designation indicates the "as fabricated" condition, in which no effort has been made to control the mechanical properties of the metal.

The letter "O" indicates dead soft, or annealed, condition.

The letter "W" indicates solution heat treated. Solution heat treatment consists of heating the metal to a high temperature followed by a rapid quench in cold water. This is an unstable temper, applicable only to those alloys which spontaneously age at room temperature. Alloy 7075 may be ordered in the "W" condition.

The letter "H" indicates strain hardened; that is, cold-worked, hand-drawn, or rolled. Additional digits are added to the "H" to indicate the degree of strain hardening. (See figure 1-3.) Alloys in this group cannot be strengthened by heat treatment; hence, the term "nonheat treatable."

The letter "T" indicates fully heat treated. Digits are added to the "T" to indicate certain variations in treatment.

Greater strength is obtainable in the heat-treatable alloys. Therefore, they are used for structural purposes in aircraft in preference to the nonheat-treatable alloys. Heat-treatable alloys commonly used in aircraft construction (in order of increasing strength) are 6061, 6062, 6063, 2017, 2024, 7075, and 7178.

Alloys 6061, 6062, and 6063 are sometimes used for oxygen and hydraulic lines and in some application as extrusions and sheet metal.

Alloy 2017 is used for rivets, stressed-skin covering, and other structural members.

Alloy 2024 is used for airfoil covering and fittings. It may be used wherever 2017 is specified, since it is stronger.

Alloy 2014 is used for extruded shapes and forgings. This alloy is similar to 2017 and 2024 in that it contains a high percentage of copper. It is used where more strength is required than that obtainable from 2017 or 2024.

Alloy .7178 is used where highest strength is necessary. Alloy 7178 contains a small amount of chromium as a stabilizing agent as does alloy 7075.

Nonheat-treatable alloys used in aircraft construction are 1100, 3003, and 5052. These alloys do not respond to any heat treatment other than a softening, annealing effect. They may be hardened only by cold-working.

Alloy 1100 is used where strength is not an important factor but where weight, economy, and corrosion resistance are desirable. This alloy is used for fuel tanks, fairings, oil tanks, and for the repair of wingtips and tanks.

Alloy 3003 is similar to 1100 and is generally used for the same purposes. It contains a small percentage of manganese and is stronger and harder than 1100, but retains enough work ability that it is usually preferred over 1100 in most applications.

Alloy 5052 is used for fuel lines, hydraulic lines, fuel tanks, and wingtips. Substantially higher strengths without too much sacrifice of workability can be obtained in 5052. It is therefore preferred over 1100 and 3003 in many applications. Figure 1-4 shows the nominal chemical compositions for the wrought alloys.

Alclad is the name given to standard aluminum alloys which have been coated on both sides with a thin layer of pure aluminum. Alclad has very good corrosion-resisting qualities and is used exclusively for exterior surfaces of

ERIC

84

Designation	Condition indicated	Example
-F.	As fabricated.	3003-F
-O	Fully annealed	6061-O
-W	Unstable following solution heat treatment.	7075-W
-H	Strain hardened (cold worked)	
-H1, plus one or more digits.	Strain hardened only	3003-H12
-H2, plus one or more digits.	Strain hardened and then partially annealed.	3003-H24
-H3, plus one or more digits.	Strain hardened and then stabilized	5052-H36
-T	Heat treated	
-T3.	Solution heat treated and then cold worked.	2024-T3
-T4.	Solution heat treated	2024-T4
-T5.	Artificially aged only	6063-T5
-T6.	Solution heat treated and then artificially aged.	7075-T6
-T7.	Solution heat treated and then stabilized to control growth and distortion.	7075-T7
-T8.	Solution heat treated, cold worked, and then artificially aged.	2024-T86
-T9.	Solution heat treated, artificially aged, and then cold worked.	6061-T91
-T10	Artificially aged and then cold worked.	2014-T10

NOTE: The -T designations above may have one or more digits added to denote certain variations of the basic heat treatments described.

Figure 1-3 - Temper designations for aluminum alloys

Alloy	Alloying elements in percent. Aluminum and normal impurities constitute remainder.					
	Silicon	Copper	Manganese	Magnesium	Chromium	Zinc
3003	0.6	0.2	1.2	–	--	0.1
2014	0.8	4.5	0.8	0.4	0.1	0.25
2017	0.8	4.0	0.5	0.5	0.1	0.25
2117	–	2.5	–	0.3	--	--
2024	0.5	4.5	0.6	1.5	0.1	0.25
5052	0.45	0.1	0.1	2.5	0.25	0.1
5056	–	–	0.1	5.2	0.1	--
6061	0.6	0.25	0.15	1.0	0.25	0.25
6062	0.6	0.25	0.15	1.0	0.06	0.25
6063	0.4	0.1	0.1	0.7	0.1	0.25
7075	0.5	1.6	0.3	2.5	0.3	5.6
7178	–	2.0	0.3	2.7	0.3	6.8

Figure 1-4 - Chemical composition of aluminum alloys

aircraft. Alclad sheet is available in all tempers of 2014, 2017, 7075, and 7178.

CASTING ALLOYS. - Aluminum casting alloys, like wrought alloys, are divided into two groups. In one, the physical properties of the alloys are determined by the elements added and cannot be changed after the metal is cast. In the other, the elements added make it possible to heat treat the casting to produce desired physical properties.

The casting alloys are identified by a letter preceding the alloy number. This is exactly opposite from the case of wrought alloys in which the letters follow the number. When a letter precedes a number, the letter indicates a slight variation in the composition of the original alloy. This variation in composition is made simply to impart some desirable quality. In casting alloy 214, for example, the addition of zinc, to increase its pouring qualities, is designated by the letter "A" in front of the number, thus creating the designation A214.

When castings have been heat treated, the heat treatment and the composition of the casting are indicated by the letter "T" and an alloying number. An example of this is the sand casting alloy 355, which has several different compositions and tempers and is designated by 355-T6, 355-T51, and A355-T51.

Aluminum alloy castings are produced by one of three basic methods - sand mold, permanent mold, and die cast. In casting aluminum, you must remember that in most cases different types of alloys must be used for different types of castings. Sand castings and die castings require different types than those used in permanent molds.

SHOP CHARACTERISTICS OF ALUMINUM ALLOYS. - Aluminum is one of the most readily workable of all the common commercial metals. It can be fabricated readily into a variety of shapes by any conventional method; however, formability varies a great deal with the alloy and temper.

In general, the aircraft manufacturers form the heat-treatable alloys in the -0 or -T4 condition before they have reached their full strength. They are subsequently heat treated or aged to the maximum strength (-T6) condition before installation in aircraft. By this combination of processes, the advantage of forming in a soft condition is obtained without sacrificing the maximum obtainable strength/weight ratio.

Aluminum is one of the most readily weldable of all metals. The nonheat-treatable alloys can be welded by all methods, and the heat-

ERIC

treatable alloys can be successfully spot welded. The melting point for pure aluminum is 1,220°F, while various aluminum alloys melt at slightly lower temperatures. Aluminum products do not show any color changes on being heated, even up to the melting point. Riveting is the most reliable method of joining stress-carrying parts of heat treated aluminum alloy structures.

Titanium and Titanium Alloys

Titanium and titanium alloys are used chiefly for parts which require good corrosion resistance, moderate strength up to 600°F, and light weight.

TYPES, CHARACTERISTICS, AND USES. - Titanium alloys are being used in quantity for jet engine compressor wheels, compressor blades, spacer rings, housing compartments, and airframe parts such as engine pads, ducting, wing surfaces, firewalls, fuselage skin adjacent to the engine outlet, and armor plate.

In view of titanium's high melting temperature, approximately 3,300°F, its high-temperature properties are disappointing. The ultimate and yield strengths of titanium drop fast above 800°F. In applications where the declines might be tolerated, the absorption of oxygen and nitrogen from the air at temperatures above 1,000°F, makes the metal so brittle on long exposure that it soon becomes worthless. Titanium has some merit for short-time exposure up to 2,000°F where strength is not important, as in aircraft firewalls.

Sharp tools are essential in machining techniques as titanium has a tendency to resist or back away from the cutting edge of tools. It is readily welded, but the tendency of the metal to absorb oxygen, nitrogen, and hydrogen must never be ignored. Machine welding with an inert gas atmosphere has proven most successful.

Both commercially pure and alloy titanium can absorb large amounts of cold-work without cracking. Practically anything that can be deep drawn in low-carbon steel can be duplicated in commercially pure titanium, although the titanium may require more intermediate anneals.

IDENTIFICATION OF TITANIUM. - Titanium metal, pure or alloyed, is easily identified. When touched with a grinding wheel, titanium makes white spark traces which end in brilliant white bursts. When rubbed with a piece of glass, moistened titanium will leave a dark line similar in appearance to a pencil mark.

Copper and Copper Alloys

Most commercial copper is refined to a purity of 99.9 percent minimum copper plus silver. It is the only reddish colored metal and is second only to silver in electrical conductivity. Its use as a structural material is limited because of its great weight. However, some of its outstanding characteristics, such as its high electrical and heat conductivity, in many cases overbalance the weight factor.

Because it is very malleable and ductile, copper is ideal for making wire. In aircraft, copper is used primarily for the electrical system and for instrument tubing and bonding. It is corroded by salt water but is not affected by fresh water. The ultimate tensile strength of copper varies greatly. For cast copper, the tensile strength is about 25,000 psi. When cold-rolled or cold-drawn, copper's tensile strength increases, ranging from 40,000 to 67,000 psi.

BRASS. - Brass is a copper alloy containing zinc and small amounts of aluminum, iron, lead, manganese, magnesium, nickel, phosphorous, and tin. Brass with a zinc content of 30 to 35 percent is very ductile while that containing 45 percent has relatively high strength. MUNTZ METAL is a brass composed of 60 percent copper and 40 percent zinc. It has excellent corrosion-resistant qualities when in contact with salt water. Its strength can be increased by heat treatment. As cast, this metal has an ultimate tensile strength of 50,000 psi and can be elongated 18 percent. It is used in making bolts and nuts, as well as parts that come in contact with salt water. RED BRASS, sometimes termed bronze because of its tin content, is used in fuel and oil line fittings. This metal has good casting and finishing properties and machines freely.

BRONZES. - Bronzes are copper alloys containing tin. The true bronzes have up to 25 percent tin, but those below 11 percent are most useful, especially for such items as tube fittings in aircraft.

Among the copper alloys are the copper aluminum alloys, of which the aluminum bronzes rank very high in aircraft usage. They would find greater usefulness in structures if it were not for their strength/weight ratio as compared with alloy steels. Wrought aluminum bronzes are almost as strong and ductile as medium-carbon steel and possess a high degree of resistance to corrosion by air, salt water, and chemicals. They are readily forged, hot- or cold-rolled, and many react to heat treatment.

These copper-base alloys contain up to 16 percent of aluminum (usually 5 to 11 percent) to which other metals such as ~~iron,~~ nickel, or manganese may be added. Aluminum bronzes have good tearing qualities, great strength, hardness, and resistance to both shock and fatigue. Because of these properties, they are used for diaphragms and gears, air pumps, condenser bolts, and slide liners. Aluminum bronzes are available in rods, bars, plates, sheets, strips, and forgings.

Cast aluminum bronzes, using about 89 percent copper, 9 percent aluminum, and 2 percent of other elements, have high strength combined with ductility, and are resistant to corrosion, shock, and fatigue. Because of these properties, cast aluminum bronze is used in gun mounts, bearings, and pump parts. These alloys are useful in areas exposed to salt water and corrosive gases.

Manganese bronze is an exceptionally high-strength, tough, corrosion-resistant copper zinc alloy containing aluminum, manganese, iron, and occasionally nickel or tin. This metal can be formed, extruded, drawn, or rolled to any desired shape. In rod form, it is generally used for machined parts. Otherwise, it is used in catapults, landing gears, and brackets.

Silicon bronze is composed of about 95 percent copper, 3 percent silicon, and 2 percent manganese, zinc, iron, tin, and aluminum. Although not a bronze in the true sense of the word because of its small tin content, silicon bronze has high strength and great corrosion resistance and is used variably.

BERYLLIUM COPPER. - Beryllium copper is one of the most successful of all the copper-base alloys. It is a recently developed alloy containing about 97 percent copper, 2 percent beryllium, and sufficient nickel to increase the percentage of elongation. The most valuable feature of this metal is that the physical properties can be greatly stepped up by heat treatment-the tensile strength rising from 70,000 psi in the annealed state to 200,000 psi in the heat-treated state. The resistance of beryllium copper to fatigue and wear makes it suitable for diaphrams, precision bearings and bushings, ball cages, springwashers, and nonsparking tools.

Monel

Monel, the leading high-nickel alloy, combines the properties of high strength and excellent corrosion resistance. This metal consists of 67 percent nickel, 30 percent copper, 1.4 percent iron, 1 percent manganese, and 0.15 percent carbon. It cannot be hardened by heat treatment-responding only to cold-working.

Monel, adaptable to castings and hot- or cold-working, can be successfully welded and has working properties similar to those of steel. It has a tensile strength of 65,000 psi which, by means of cold-working, may be increased to 160,000 psi, thus entitling this metal to classification among the tough alloys. Monel has been successfully used for gears and chains, for operating retractable landing gears, and for structural parts subject to corrosion. In aircraft, monel has long been used for parts demanding both strength and high resistance to corrosion, such as exhaust manifolds and carburetor needle valves and sleeves.

K-Monel

K-monel is a nonferrous alloy containing mainly nickel, copper, and aluminum. It is produced by adding a small amount of aluminum to the monel formula. It is corrosion resistant and capable of hardening by heat treatment. K-monel has been successfully used for gears, chains, and structural members in aircraft which are subjected to corrosive attacks. This alloy is nonmagnetic at all temperatures. K-monel can be successfully welded.

Magnesium and Magnesium Alloys

Magnesium, the world's lightest structural metal, is a silvery-white material weighing only two-thirds as much as aluminum. Magnesium does not possess sufficient strength in its pure state for structural uses; but when alloyed with zinc, aluminum, and manganese, magnesium produces an alloy having the highest strength/weight ratio.

TYPES, CHARACTERISTICS, AND USES. - Magnesium is probably more widely distributed in nature than any other metal. It can be obtained from such ores as dolomite and magnesite, from underground brines, from waste liquors of potash, and from sea water. With about 10 million pounds of magnesium in 1 cubic mile of sea water, there is no danger of a dwindling supply.

The machining characteristics of magnesium alloys are excellent. Usually the maximum speeds of machine tools can be used with heavy cuts and high feed rates. Power requirements for magnesium alloys are about one-sixth of those for mild steel. An excellent surface finish can be produced, and in most cases grinding is not essential. Standard machine operations can be performed to tolerances of a few ten-thousandths of an inch. There is no tendency of the metal to tear or drag.

Magnesium alloy sheets can be worked in much the same manner as other sheet metal with one exception-the metal must be worked while hot. The structure of magnesium is such that the alloys work-harden rapidly at room temperatures. The work is usually done at temperatures ranging from 450° to 650°F, which is a disadvantage. However, in the ranges used, magnesium is more easily formed than other materials. Sheets can be sheared in much the same way as other metals, except that a rough flaky fracture is produced on sheets thicker than about 0.064 inch. A better edge will result on a sheet over 0.064 inch thick if it is sheared hot.

Magnesium embodies fire hazards of an unpredictable nature. When in large sections, its high thermal conductivity makes it difficult to ignite, and prevents its burning. It will not burn until the melting point is reached, which is approximately 1,200°F. However, magnesium dust and fine chips are ignited easily. Precautions must be taken to avoid this if possible and to extingush them immediately. An extinguishing powder, such as powdered soapstone, clean, dry, unrusted cast iron chips, or graphite powder, should be used.

CAUTION: Water or any standard liquid or foam extinguisher causes magnesium to burn more rapidly and may cause small explosions.

SUBSTITUTION AND INTERCHANGEABILITY OF AIRCRAFT METALS

In selecting interchangeable or substitute materials for the repair and maintenance of Coast Guard aircraft, it is of the utmost importance to check the appropriate aeronautic technical publications when specified materials are not in stock nor obtainable from another source. It is impossible to determine that another material is as strong as the original by mere observation. There are four requirements that you must keep clearly in mind in this selection. The first and most important of these is maintaining the original strength of the structure. The other three are maintaining contour or aerodynamic smoothness, maintaining original weight if possible or keeping added weight to a minimum, and maintaining the original corrosive-resistance properties of the metal.

You can appreciate the importance of checking the specific technical publication by understanding that different manufacturers design structural members to meet various load requirements for specific aircraft. Structural repair of these members, apparently similar in construction, will thus vary in their load carrying design with different aircraft.

The contractor normally prepares structural repair instructions, including tables of interchangeability and substitution for ferrous and nonferrous metals and their specifications for all types of aircraft used by the Coast Guard. Such instructions are usually promulgated in the -3 manual covering structural repair instructions for specific model of aircraft. Similar information is also contained in T.O. 1-1A-1, General Manual for Structural Repair.

T.O. 1-1A-1, section III, table IV, presents the substitution and conversion information for aluminum alloy sheet metal. In section IV, table IV, steel specifications are given; table V, in section IV, covers aluminum specifications.

T.O. 1-1A-9, Aerospace Metals-General Data and Usage Factors, provides precise data on specific metals to assist in selection, usage, and processing for fabrication and repair.

Always consult these publications and the -3 aircraft manual for the specific-type aircraft when you are confronted with a problem concerning maintenance and repair involving substitution and interchangeability of aircraft structural metals. BE SURE YOU HAVE THE AERONAUTIC TECHNICAL PUBLICATION OF THE MOST RECENT ISSUE.

90

LESSON QUIZ

Directions: Cover the answers to the questions with the enclosed Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any questions incorrectly, refer to the text material.

Questions	Answers
1. In a ferrous metal, what is the principal alloying element?	1. Iron (Page 1-1)
2. How much carbon does SAE No. 4150 steel contain?	2. 0.50 percent (Page 1-2)
3. In a metal spark test, long straight spark shafts having a few white sprigs identify the metal as ________.	3. low-carbon steel (Page 1-2)
4. Steel containing 0.50 to 1.05 percent carbon is classed as ________ carbon steel.	4. high (Page 1-2)
5. A steel especially adaptable for welding and for use as engine mounts is ________ steel.	5. chrome-molybdenum (Page 1-3)
6. Aluminum alloys are more susceptible to corrosion when alloyed with substantial percentages of ________.	6. copper (Page 1-4)
7. The letter "H" following an aluminum alloy designation number indicates the alloy has been ________.	7. strain hardened (Page 1-5)
8. Aluminum alloys which can be hardened ONLY by cold-working are ________.	8. 1100, 3003, 5052 (Page 1-5)
9. For short-time exposures up to 2,000 degrees F. where strength is NOT required, firewalls may be made of ________.	9. titanium (Page 1-8)
10. K-monel is produced by adding ________ to the monel formula.	10. aluminum (Page 1-9)
11. You should NOT use water or standard liquid or foam fire extinguishers on magnesium fires because ________.	11. they cause magnesium to burn more rapidly and may cause small explosions (Page 1-10)
12. When you are concerned with substituting or interchanging materials for an aircraft repair, you can find precise data on specific metals in ________.	12. T.O. 1-1A-9 (Page 1-11)

AIRCRAFT STRUCTURAL HARDWARE

OBJECTIVES

When you complete this section, you will be able to:

1. Explain the meaning of the various components of a rivet identification code.
2. State the types of rivet materials and how the materials are identified.
3. Describe solid rivet installation and removal procedures.
4. State the types of blind rivets and explain the installation and removal procedures for the various types.
5. State the tools necessary for the installation of Rivnuts.
6. Describe the various special fasteners available for aircraft structural work.

An aircraft, even though made of the best materials and strongest parts, would be useless unless those parts were firmly held together. Several methods are used to hold metal parts together; they include riveting, bolting, and welding. The process that is used must produce a union that will be as strong as, or stronger than, the parts that are joined. In this pamphlet we will discuss rivets and special fasteners. Welding will be discussed in another pamphlet.

RIVETS

Every AM should be a skilled riveter. The fact that there are hundreds of thousands of rivets in the airframe of some of our late model aircraft is an indication of how important riveting is in the work of the AM. A glance at any aircraft will disclose the thousands of rivets in the outer skin alone. In addition to the riveted skin, rivets are also used for joining spar sections, for holding rib sections in place, for securing fittings to various parts of the aircraft, and for fastening innumerable bracing members and other parts together. Rivets that are satisfactory for one part of the aircraft are often unsatisfactory for another part. It is therefore important that the AM know the strength and driving properties of the various types of rivets and how to identify them as well as how to drive or otherwise install them.

SOLID RIVETS

Solid rivets are classified by their head shape, by the material from which they are manufactured, and by their size. Rivet head shapes and their identifying code numbers are shown in figure 2-1. The prefix "MS" identifies hardware under the cognizance of the Department of Defense, and the item conforms to written military standards. The prefix "AN" identifies specifications which are developed and issued under joint authority of the Air Force-Navy.

Countersunk-head Rivets

Countersunk-head rivets, often referred to as FLUSH RIVETS, are used where streamlining is important. On modern high speed aircraft, practically all external surfaces are flush riveted. Countersunk-head rivets are obtainable with heads having an included angle of 78 and 100 degrees. The 100-degree is the most commonly used type.

Universal-head Rivets

Universal-head rivets offer only slight resistance to airflow and are, therefore, frequently used on external surfaces, especially on helicopters, transports, and other low-speed aircraft where aerodynamic smoothness is not of prime importance.

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92

Rivet Identfication Code

The rivet codes shown in figure 2-1 are sufficient to identify rivets only as to head shape. To be meaningful and precisely identify a rivet, certain other information is encoded and added to the basic code.

A letter or letters following the head-shape code identify the material or alloy from which the rivet was made. (Figure 2-3 includes a listing of the most common of these codes.) The alloy code is followed by two numbers separated by a dash. The first number is the numerator of a fraction which specifies the shank diameter in thirty-seconds of an inch. The second number is the numerator of a fraction in sixteenths of an inch and identifies the length of the rivet. The rivet code is illustrated in figure 2-2.

Rivet Composition

Most of the rivets used in aircraft construction are made of aluminum alloy. A few types, used for special purposes, are made of mild steel, monel, titanium, and copper. Of the aluminum alloy rivets, those made of 1100, 2117, 2017, 2024, and 5056 are considered standard.

Alloy 1100 Rivets

Alloy 1100 rivets are supplied in the "as fabricated" (F) temper and are driven in this

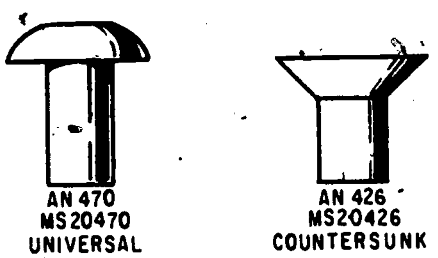


Figure 2-1-Rivet head shapes and code numbers

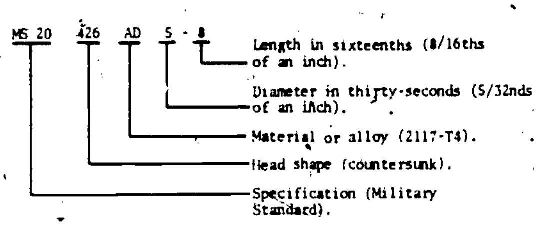


Figure 2-2 - Rivet coding example

condition. No further treatment is required and the rivet properties do not change w prolonged periods of storage. They are re tively soft and easy to drive. The cold wor resulting from driving increases their strength slightly. The 1100-F rivets are used only for riveting nonstructural parts. These rivets are identified by their plain head. (See figure 2-3.)

Alloy 2117 Rivets

Like the 1100-F rivets, alloy 2117 rivets need no further treatment when received from the manufacturer, and can be stored indefinitely. They are furnished in the solution-heat-treated (T4) temper, but will change to the solution-heat-treated-and-cold-worked (T3) temper after driving. The 2117-T4 rivet is in general use throughout aircraft structures and is by far the most widely used rivet, especially in repair work. In most cases the 2117-T4 rivet may be substituted for 2017-T4 and 2024-T4 rivets for repair work by using the next larger diameter of rivet. This is desirable since both the 2017-T4 and 2024-T4 rivets must be heat treated prior to using, or kept in cold storage. The 2117-T4 rivets are identified by a dimple in the head.

Alloy 2017 and 2024 Rivets

As mentioned in the preceding paragra both alloy 2017 and 2024 rivets are supplied in the T4 temper and must be heat treated. These rivets must be driven within 20 minutes after quenching or refrigerated at 32°F or lower, which will delay the aging time 24 hours. If either time is exceeded, reheat treatment is required. These rivets may be reheated as many times as desirable provided the proper solution heat-treatment temperature is not exceeded. The 2024-T4 rivets are stronger than the 2017-T4 and are therefore harder to drive. The 2017-T4 rivet is identified by the raised teat on the head, while the 2024-T4 has two raised dashes on the head.

Alloy 5056 Rivets

Alloy 5056 rivets are used primarily for joining magnesium alloy structures because of their corrosion resistant qualities when used with magnesium. They are supplied in the H32 temper (strain-hardened and then stablized). These rivets are identified by a raised cross on the

Material or alloy	Code letters	Head marking on rivet
1100-F	A	Plain
2117-T4	AD	Indented dimple
2017-T4	D	Raised teat
2024-T4	DD	Raised double dash
5056-H32	B	Raised cross

Figure 2-3 - Rivet material identification

head. 5056-H32 rivets may be stored indefinitely with no change in driving characteristics.

RIVET DRIVING PROCEDURE

Before driving any rivets, make sure all holes line up perfectly, all shavings and burrs have been removed, and the parts to be riveted are fastened securely together. It is important that you hold the sheets firmly together in the immediate area of the rivet being driven.

To adjust the speed of the gun, place it against a block of wood. Never operate a rivet gun without resistance against the set, as the vibrating action may cause the retaining spring to break, allowing the set to fly out.

CAUTION: A rivet set can be a deadly weapon. If a rivet set is placed in a rivet gun without a set retainer and the throttle of the gun is opened, the rivet set may be projected like a bullet. This may cause either severe injury to a person or the destruction of equipment.

The gun should be adjusted so that the rivet may be driven in the shortest possible time, but the riveter must take care not to drive the rivet so hard or in such a manner as to dimple the metal. Practice will enable one to properly adjust a gun for any type of work.

When the rivet has been pushed into proper position and held there firmly with the set of the rivet gun resting squarely against the rivet head, the bucking bar is held firmly and squarely against the protruding rivet shank. (In most instances, the bucking bar must be manipulated by another man, called the bucker.) The gunner then exerts pressure on the trigger and starts driving. The gun must be held tightly against the rivet head and must not be removed until the trigger has been released.

The bucker removes the bucking bar and checks the upset head after the gunner has stopped driving. A signal system is usually employed to develop the necessary teamwork and consists of tapping lightly against the work. One tap may mean "not fully driven, hit it again"; two taps may mean "good rivet"; three taps may mean "bad rivet, remove and drive another"; and so on.

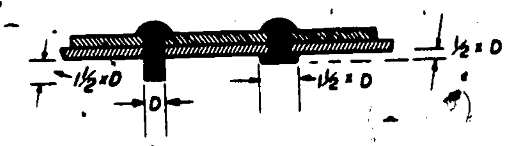


Figure 2-4 - Rivet dimensions before and after bucking

The upset head, often referred to as the bucktail, should be 1 1/2 times the original diameter of the original shank in width and 1/2 times the original diameter in height as shown in figure 2-4. If the head thus formed is narrower and higher than the dimensions given, more driving is necessary. If the head is wider and shallower, the rivet must be removed and replaced.

RIVET REMOVAL

Rivets must be removed and replaced if they show even the slightest deformity or lack of alignment. Among the reasons for replacing rivets are the following:

1. Rivet marred by bucking bar or rivet set.
2. Rivet driven at slant, or shank bent over.
3. Rivet too short, causing head to be shallow.
4. Rivet pancaked too flat from overdriving.
5. Sheets spread apart and rivet flashed between sheets.
6. Rivet driven too lightly, causing sheets to buckle.
7. Two rivet heads not in alignment.
8. Head of countersunk rivet not flush with outside surface or driven below surface.

Examples of these incorrectly driven rivets are shown in figure 2-5.

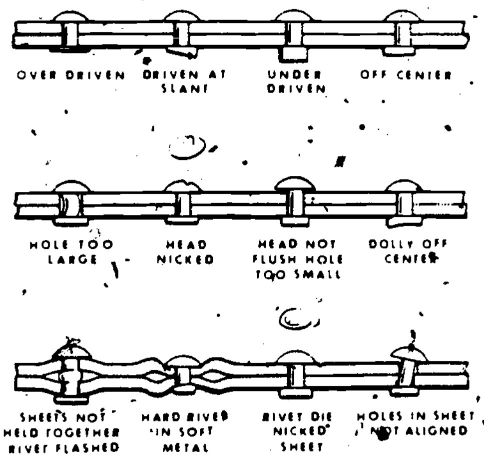


Figure 2-5 - Incorrectly driven rivets.

When removing rivets, you should take care not to enlarge the rivet hole, as this would necessitate the use of a larger size rivet for replacement. To remove a rivet, file a flat surface on the manufactured head if accessible. It is always preferable to work on the manufactured head rather than on the one that is bucked, since the former will always be more symmetrical about the shank. Indent the center of the filed surface with a center punch and use a drill of slightly less than shank diameter to drill through the rivet head. Remove the drill and, with the other rivet end supported, shear the head off with a sharp chisel. Always cut along the direction of the plate edge. If the shank is unduly tight after the removal of the head, the shank should be drilled out. However, if the sheet is firmly supported from the opposite side, the shank may be punched out with a drift punch. (See figure 2- 6).

The removal of flush rivets requires slightly more skill. If the formed head on the interior is accessible and has been formed over heavy material such as an extruded member, the formed head can be drilled through and sheared off, as mentioned above. If the material is thin, it may be necessary to drill completely through the shank of the rivet and then cut the formed head with diagonal cutting pliers. The remainder of the rivet may then be drifted out from the inside.

BLIND RIVETS

There are many places on an aircraft where access to both sides of a riveted structural part is impossible, or where limited space does not permit the use of a bucking bar. Furthermore, in the attachment of many nonstructural parts, such as aircraft interior furnishings, flooring, deicing boots, flotation equipment, and the like, the full strength of solid shank rivets is not necessary and their application whould add extra weight to the aircraft. The extra weight would reduce the payload.

For use in such places, rivets have been designed which can be formed from the outside. They are lighter than solid shank rivets, yet amply strong. These rivets are manufactured by various corporations and have characteristic peculiarities. One of the chief differences is they require special installation

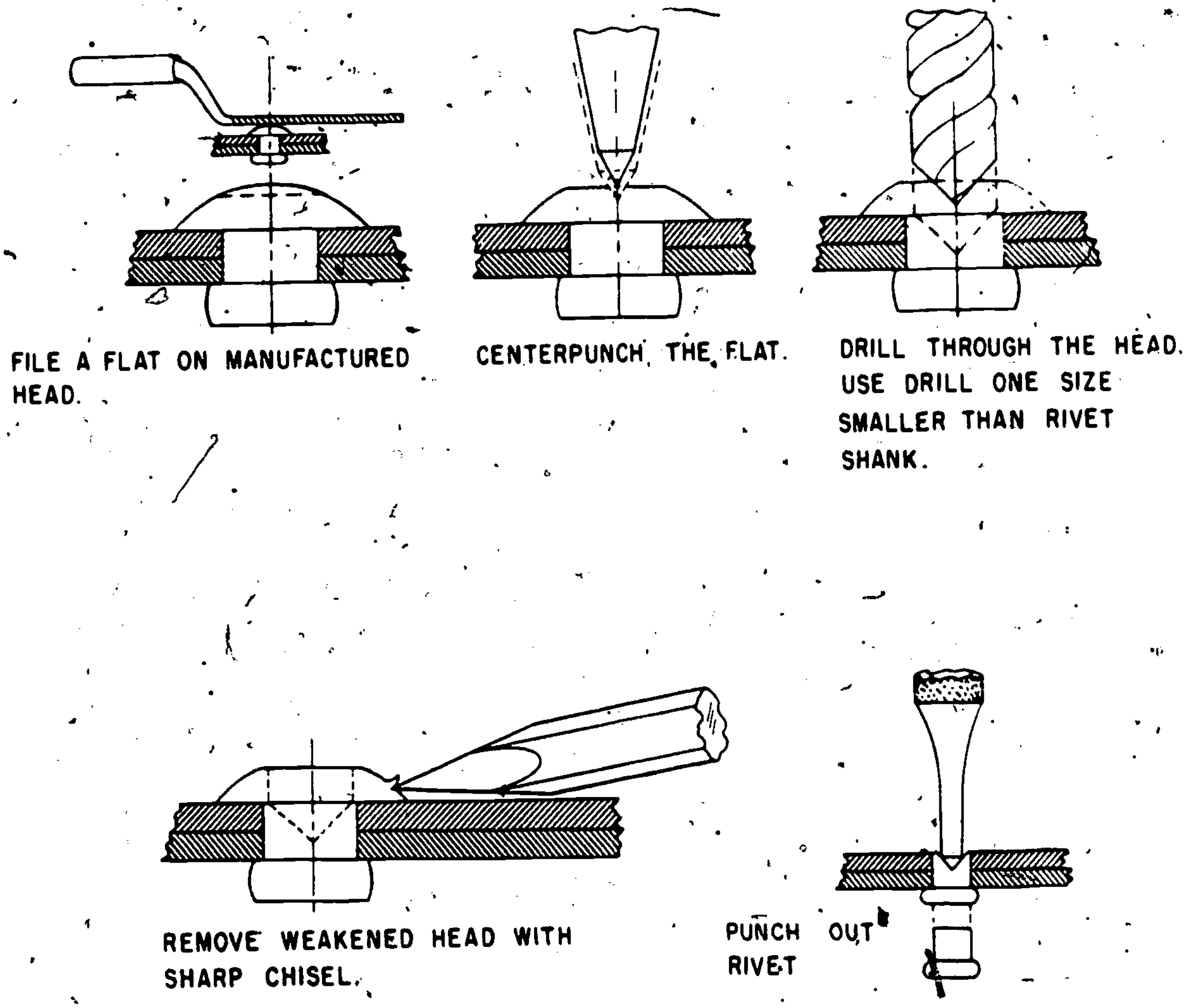


Figure 2-6 - Removal of rivets

tools. Rivets in this category are commonly referred to as BLIND RIVETS because of the self-heading feature.

Self-Plugging Rivet (friction lock)

The self-plugging rivet (friction lock) retains the stem in position by friction. The stem is drawn up into the rivet shank and the mandrel portion of the stem upsets the shank on the blind side, forming a plug in the hollow center of the rivet. The excess portion of the stem breaks off at a groove due to the continued pulling action of the rivet gun or tool. The two styles of rivet heads are the universal and the 100-degree countersunk. These correspond to the MS20470 and MS20426 solid rivets, respectively. Materials used are 2117-T4 and 5056-F aluminum alloys, and monel for special application. The shank diameter and grip lengths are designated by dash numbers after the basic number. The first dash number indicates the shank diameter in thirty-seconds of an inch and the second number indicates the grip length in sixteenths of an inch. The material code is the same as for solid rivets.

Pull-Through Rivets

Pull-through rivets are essentially the same as the self-plugging rivets, except that when the mandrel pulls on the stem, the stem forms the head on the rivet shank, then pulls all the way through the shank, leaving a hole in the rivet.

The same installation tools are used for the self-plugging (friction lock) and pull-through rivets. Figure 2-8 shows the self-plugging and pull-through rivet types with basic numbers. Figure 2-7 illustrates the installation of both types of rivets.

Self-Plugging Rivets (mechanical lock)

Figure 2-7 illustrates a blind rivet that operates on the same principle as the friction lock rivets. Both types employ a mandrel stem and a hollow shank. The main difference between the friction lock and mechanical lock rivets is in the method of pin retention; the friction lock relies on friction alone for pin retention, while the mechanical lock rivet employs a mechanical lock between the head of the rivet and the pull stem. Note in view B that the collar, shown clearly in view A attached to the head, has been driven into the head and has assumed a wedge or cone shape around the groove in the pin. This holds the shank firmly in place from the head side.

The self-plugging rivet is made of 5056-H14 aluminum alloy and includes the conical recess and locking collar in the rivet head. The stem is made of 2024-T36 aluminum alloy. Pull grooves which fit into the jaws of the rivet gun are provided on the stem end that protrudes above the rivet head. The blind end portion of the stem incorporates a head and a land with an extruding angle which expands the rivet shank.

Applied loads permissible for self-plugging rivets are comparable to those for solid shank rivets of the same shear strength, regardless of sheet thickness. The composite ultimate shear strength of the 5056-H14 shank and the 2024-T36 pin exceeds 38,000 psi on standard

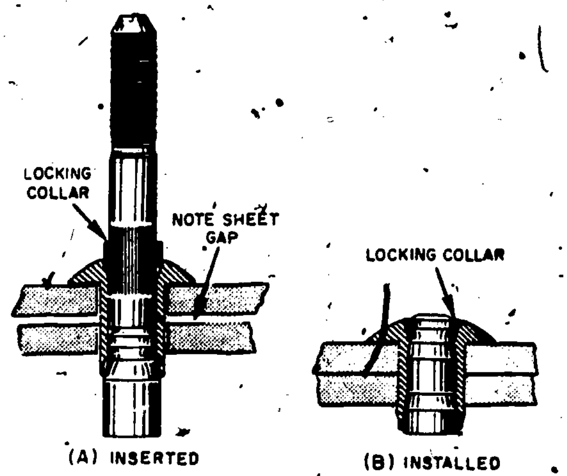


Figure 2-7 - Self-plugging rivet (mechanical lock)

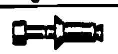
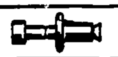
TYPE	CONFIGURATION	HEAD IDENTIFICATION	BASIC NUMBER
SELF PLUGGING		100 DEGREE COUNTERSUNK	MS20601
		UNIVERSAL HEAD	MS20600
		LARGE FLAT HEAD	CR198C
HOLLOW PULL THRU		100 DEGREE COUNTERSUNK	MS20605
		LARGE FLAT HEAD	CR148

Figure 2-8 - Rivet types with basic numbers

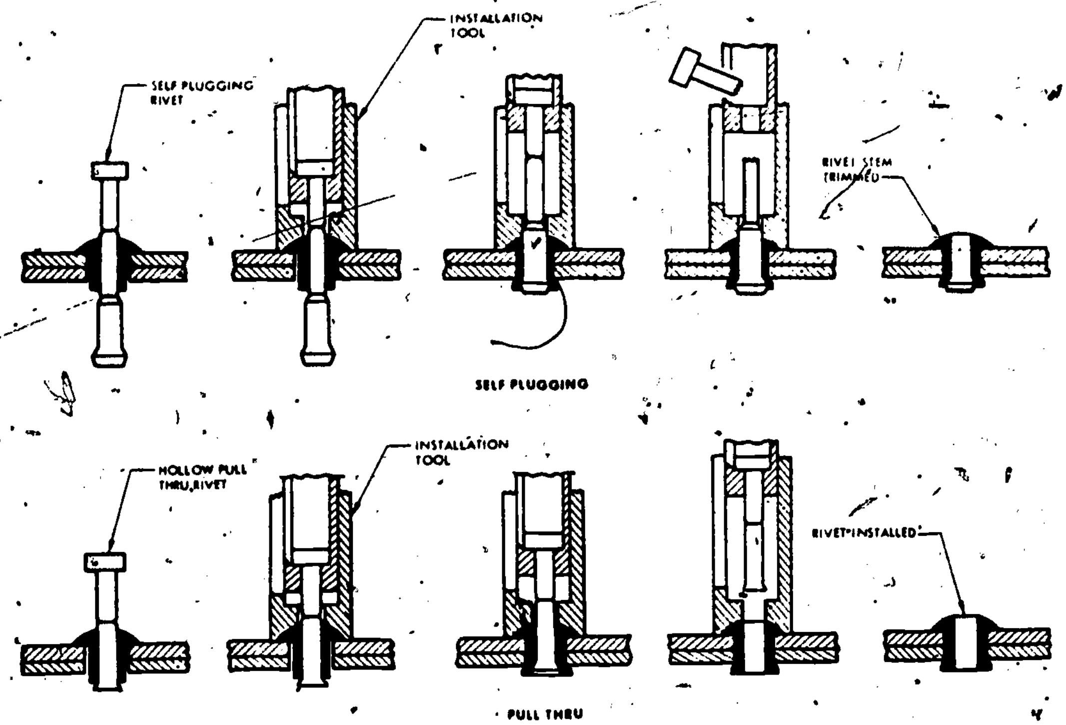


Figure 2-9 - Self-plugging (friction lock) and pull-through rivet installation

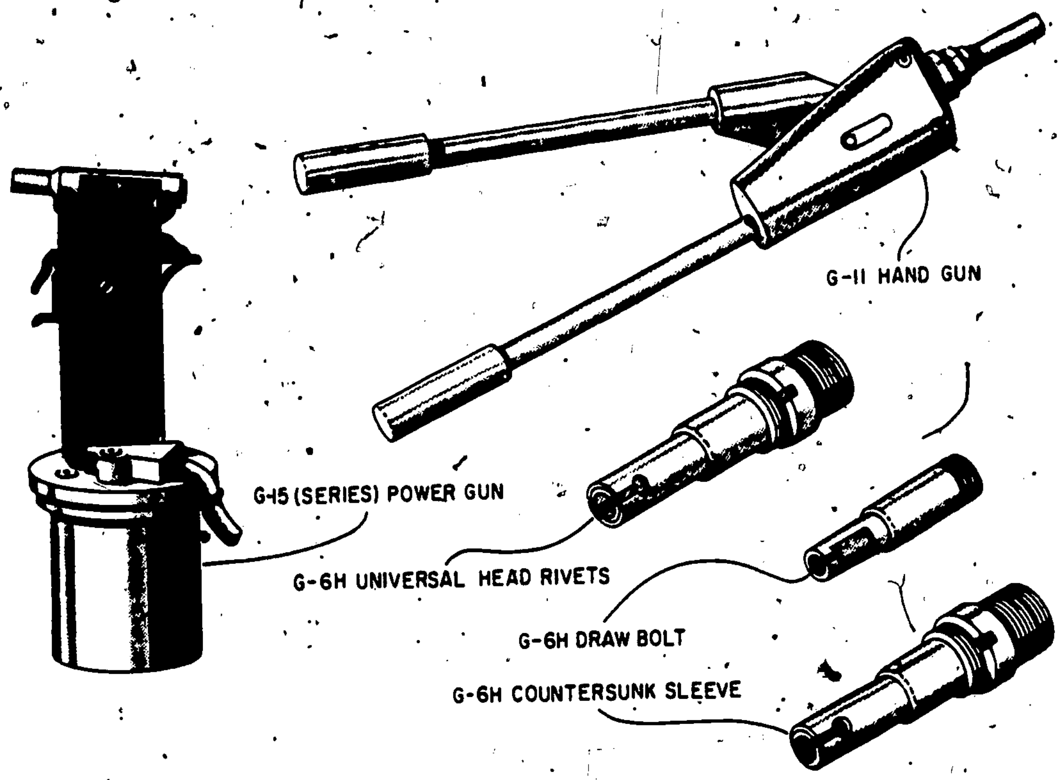


Figure 2-10 - Self-plugging rivet (friction lock) installation tools rivet hole diameter; their tensile strength is in excess of 28,000 psi. Pin-retention characteristics are excellent in these rivets and the possibility of the pin working out is minimized by the lock formed in the rivet head.

BLIND RIVET INSTALLATION AND REMOVAL

The special tools, installation procedures, and removal methods for blind rivets are covered in the following paragraphs. Selection of the proper equipment depends on a number of variables; space available for equipment, type of rivets to be driven, availability of air pressure, etc.

Installation Tools for Friction Lock Rivets

The guns used for installing the friction lock type of self-plugging rivet are the G-11 hand gun and the G-15 (series) and G-40 (series) power guns. The G-15 power gun uses G-6H pulling heads as does the G-11 hand gun. The G-40 power gun uses the H-40 pulling heads primarily; however, through the use of a 226 adapter, G-6H heads may be used. Extensions are available for all guns using G-6H heads. Figure 2-10 shows the G-11 and G-15 rivet guns with the G-6H pulling heads.

The heads are manufactured in three different sizes to accommodate the different rivet diameters. For ease of selection, the sizes are stamped on the parts of the pulling head.

Installation Procedures (Friction Lock)

It is important that the proper drawbolt and sleeve be used for the rivet being installed. The drawbolt should correspond to the diameter of the rivet, and the sleeve should correspond to the rivet diameter and head style. Speed of installation may be increased by inserting a number of rivets in the work and then applying the gun. In other instances, such as overhead work, it is apparent that this method would be impractical and the rivet should be loaded into the slot in the drawbolt, because improper seating of the rivet may permit the head to break off before the rivet is properly set. (See figure 2-11.) When using a hand gun, hold the rigid handle of the gun parallel to the rivet axis. Open the movable handle as far as it will go, then partially close. Repeat this operation until the rivet stem breaks, then release the gun by completely closing the movable handle. When using the power gun, hold the head of the gun parallel to the axis of the rivet. Push the gun against the work with enough force to seat the head of the rivet firmly, and to insure contact between the parts being riveted. Pull the trigger until the stem breaks. The stem will be ejected through the rubber tube at the back of the gun head. It is important that this tube be in place in order to prevent stems from getting into the gun mechanisms.

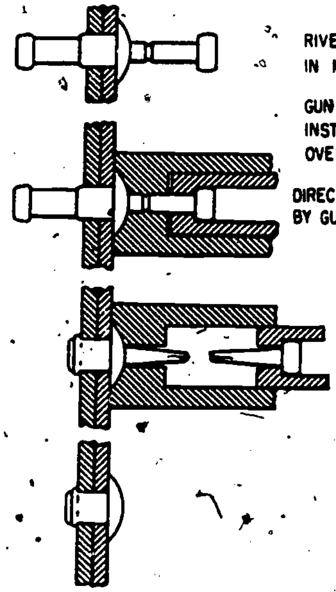


Figure 2-11 - Self-plugging rivet/(friction lock) installation

Inspection (Friction Lock)

The rivet is satisfactory if the pin is firm and the head is seated tightly on the face of the material. Occasionally, the head will rise slightly in the area which was under the slot of the pulling head. This condition is acceptable if the head is not too badly deformed and the tension characteristics of the joint are not made critical by the deformation of the head. Figure 2-12 illustrates satisfactory and unsatisfactory self-plugging rivets.

Removal (Friction Lock)

These rivets are removed in much the same manner as the common, solid shank rivets, except for the preliminary step of driving out the rivet stem. (See figure 2-13.)

1. Punch out the rivet stem with a pin punch.

2. Drill out the rivet head, using a drill slightly smaller than the rivet shank.

3. Pry off the weakened rivet head with a pin punch.

4. Push out the remainder of the rivet shank with a pin punch. If the shank will not punch out, drill the shank, taking care not to enlarge the hole in the material. If the hole should be enlarged, finish-drill for an oversize rivet.

Installation Tools for Mechanical Lock Rivets.

One of the tools used for driving these rivets is the CP350 blind rivet pull tool. (See figure 2-14.) The nose of the tool includes a set of chuck jaws which fit the pull grooves in the rivet pin and pull it through the rivet shank to drive the rivet; an outer anvil which bears against the outer part of the manufactured head during the driving operation; and an inner anvil which advances automatically to drive the locking collar home after the blind head is formed. A short nose assembly, interchangeable with the standard assembly, is available for use in areas where there is not sufficient clearance for the standard nose.

A change in rivet diameter requires a change in chuck jaws, outer anvil, inner anvil, inner anvil thrust bearing, and an adjustment of the shift valve operating pressure as described below. A change in the rivet head type from universal head to countersunk head, or vice versa, requires a change of the outer anvil only, if there is no change in the rivet diameter.

A special chuck jaws assembly tool is furnished with the tool. To ease insertion of the chuck jaws into the chuck sleeve, mount the three jaws on this assembly to form a cone, and lower the inverted chuck sleeve over the jaws.

Always be sure that the pull tool is equipped with the correct size chuck jaws, outer and inner anvils to fit the rivets being driven, and that the relief valve operation pressure is properly adjusted for the size rivets being driven. Also make sure that the rivets are the proper

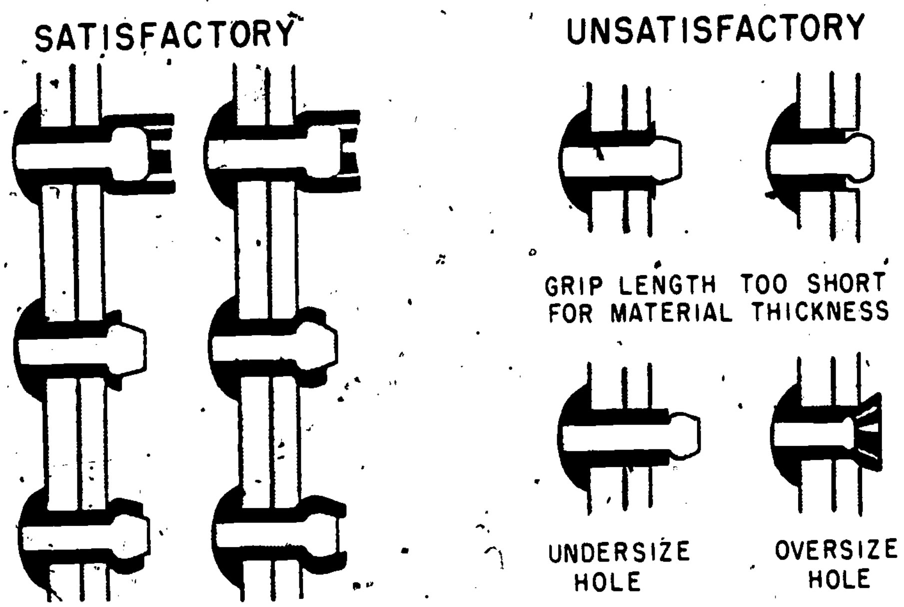


Figure 2-12 - Inspection of self-plugging rivets (friction lock) length. The tool has only one operating adjustment. This adjustment is used to control the pull on the pin at which the inner anvil advances. The desired amount of the pull depends on the diameter of the rivets to be installed. You may vary the pull by changing the pressure at which the adjustable shift valve operates. To adjust, proceed as follows:

1. Remove pipe plug from tool cylinder and connect a pressure gage to the tool.

2. Press trigger and release it the instant a puff of exhaust indicates that the shift valve controlling the inner anvil has shifted. The gage will then indicate the shift pressure. See figure 2-15 for the approximate pressures.

NOTE: The trigger must be released immediately as the valve shifts. Otherwise the gage will record the higher pressure, which builds up as soon as the valve has shifted.

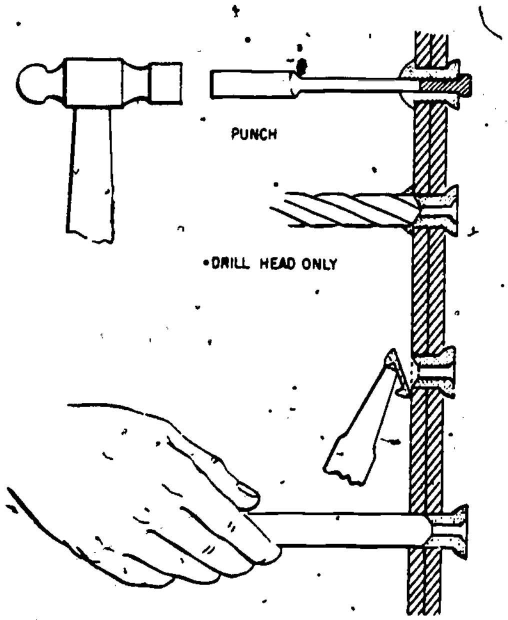


Figure 2-13 - Removal of self-plugging rivets (friction lock)

3. To adjust the pressure, loosed the valve-adjusting screw locknut and turn the valve-adjusting screw clockwise to increase pressure, or counterclockwise to decrease pressure, until you obtain the desired pressure. Check the pressure after tightening the valve-adjusting screw locknut. When rivets of extremely long grip length are to be driven, you should an adjustment to the high pressure limit. efficient operation of the tool, the MINI desired line pressure should be not less 90 psi and the MAXIMUM not more tha proximately 110 psi. When you are us CP350 A or B rivet pull tool, it may be nece to increase the inside diameter of the air bushing, part number 81479, from 0.05 0.065 inch when driving 3/16-inch dia rivets if the line pressure is below 90 psi. you are driving 1/8-inch diameter rive may be necessary to use air inlet bushing, number 82642, having a 0.040-inch inside meter. If the tool "flutters", cut down th pressure to 60 psi with an air regulator, number 900-102, attached to the air inlet ing. When using a CP350C rivet pull to drive 1/16- and 5/32-inch diameter rivets air inlet bushing, part number 81479, and valve stop, part number 83731. When dr 1/8-inch diameter rivets, use air inlet bus number 83642, and cut down the line pres to 60 psi with air regulator, part number 900 attached to the air inlet bushing.

Installation Procedures (Mechanical Lock)

Proper driving procedures are vital to tain a firm joint. The recommended proced are as follows:

1. Hold the head of the gun steady at right angles to the work.

2. Press on the head of the gun hard en to hold the rivet firmly against the work. not use a great amount of pressure un necessary to bring the part being riveted contact.

3. Squeeze the gun trigger and hold the rivet pin breaks, then release the trig Do not drive the next rivet until the re action has caused the gun to latch. You hear a distinct click, indicating that the is ready for the next installation cycle.

Figure 2-16 shows the complete installa of a self-plugging (mechanical lock) rivet.

The rivet is actually cold-squeezed by action of the pin head drawing against the ho shank end. Shank expansion through the ac of the extruding angle, blind head format and setting of the mechanical lock in the r

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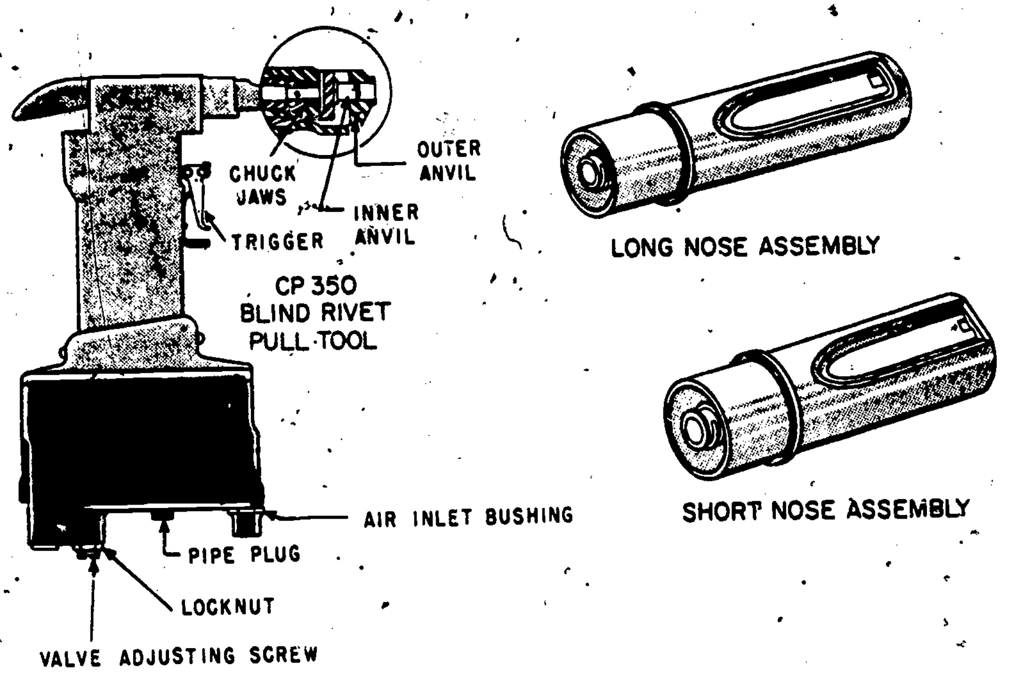


Figure 2-14 - Self-plugging rivet (mechanical lock) pull tool

Rivet diameter	Shift valve operating pressure
1/8	30 to 31 psi
5/32	46 to 47 psi
3/16	66 to 67 psi

Figure 2-15 - Adjustments for CP350 blind rivet pull tool

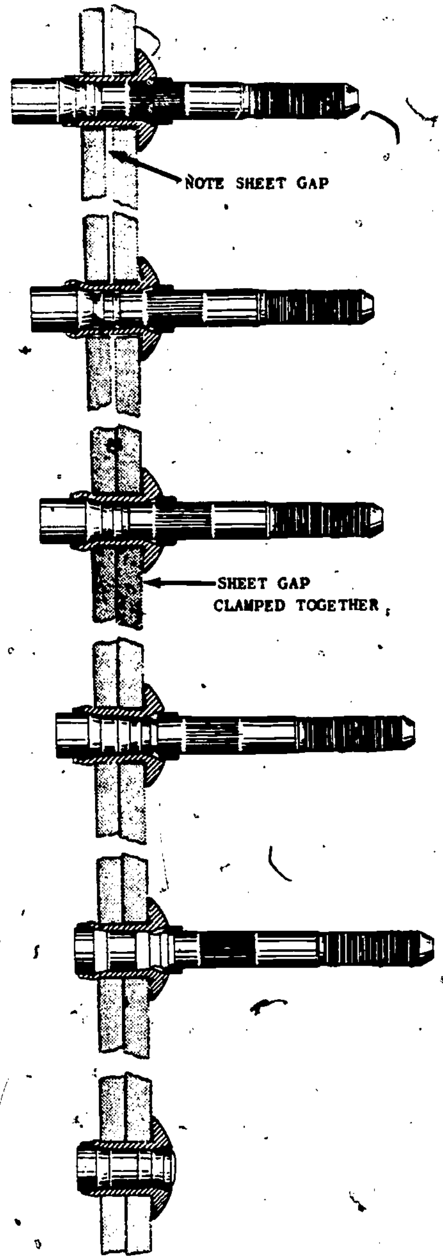
head all follow in automatic sequence and require but a fraction of a second. In some places such as near the trailing edge of a control surface, there may not be sufficient space between the two surfaces to insert the rivet.

In such cases, you may force the pin into the hollow shank until the head of the pin just touches the end of the shank. Since no further shank expansion will result, the drill hole should not be enlarged to provide a free fit of the already expanded rivet. To insert the rivet, use a hollow drift pin which will accommodate the rivet pin and locking collar. (See figure 2-17.) This hollow drift pin allows a driving force to be exerted on the head of the rivet. Drive the head into firm contact with the sheet and then apply the rivet pull tool in the usual manner to upset the rivet.

Due to the mechanical lock feature of the pin and sleeve, the driven rivet is substantially the mechanical equivalent of a one-piece solid rivet. The mechanical lock feature increases the load-carrying capacity in a single shear from about 10.3 percent in the case of thick sheets where joint strength is considered critical in rivet shear, to as much as 63.3 percent in thin sheets where sheet bearing is considered critical.

Inspection (Mechanical Lock)

Visual inspection of the seating of the pin in the manufactured head is the most reliable and simple means of inspection. If the proper grip length has been used and the locking collar and broken end of the pin are approximately flush with the manufactured head, the rivet has been properly upset and the lock formed. Insufficient grip length would be indicated by the pin breaking below the surface of the



(1) Mechanical-lock rivet before installation. Note shorter stem on blind side providing marked improvement for limited blind clearance applications.

(2) As the stem is pulled into the rivet sleeve, it immediately forms the blind head. The mechanical-lock always forms the blind head firmly against the blind sheet.

(3) Continued movement of the stem pushes the blind sheet ahead of the blind head until the sheets are firmly clamped together and the rivet is firmly seated.

(4) The plugging portion of the stem expands the rivet sleeve to fill the hole and reduces in diameter as it passes through the rivet sleeve, providing excellent hole fill—even in oversize holes.

(5) The movement of the stem is stopped by the pulling head at a point where the groove in the stem and the chamfer in the rivet line up to make a receptacle for the locking ring.

(6) The pulling head shifts automatically, inserts the positive mechanical locking ring, and fractures the stem flush with the rivet head.

Figure 2-16 - Self-plugging rivet (mechanical lock) manufactured head, and excessive grip length would be indicated by the pin breaking off well above the manufactured head. In either case, the locking collar might not be properly seated, thus forming an unsatisfactory lock. Figure 2-18 gives limits for proper pin seating.

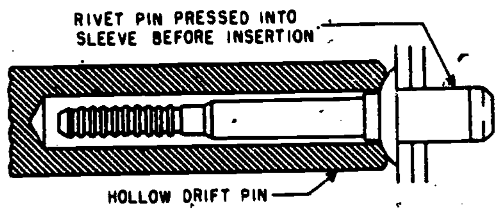


Figure 2-17 - Inserting self-plugging rivet (mechanical lock)

Rivet diameter	A	B	C
1/8 inch	0.012	0.016	0.008
5/32 inch	.015	.020	.010
3/16 inch	.018	.024	.012

A. Maximum allowable distance of locking collar above or below rivet head.
B. Maximum allowable distance of top of land on pin above rivet head.
C. Maximum allowable distance of top of land on pin below rivet head.

Figure 2-18 - Inspection criteria for self-plugging rivets (mechanical lock)

Removal (Mechanical Lock)

Removal of this rivet is accomplished easily without damage to the work by use of the following procedure: (See also figure 2-19.)

1. Shear the lock by driving out the pin, using a tapered steel drift pin not over 3/32-inch diameter at the small end. If working on thin material, back up the material while driving out the pin. If inaccessibility prohibits this, partially remove the rivet head by filing, or with a rivet shaver. An alternative would be to file the pin flat, center punch the flat, and carefully drill out the tapered part of the pin forming the lock.

2. Pry the remainder of the locking collar out with a drift pin.

3. Use the proper size drill to drill nearly through the rivet head. For a 1/8-inch diameter rivet, use a number 31 drill; for a 5/32, use a number 24; and, for a 3/16, use a number 15.

4. Break off the drilled head, using a drift pin as a pry.

5. Drive out the remainder of the rivet with a pin having a diameter equal to, or slightly less than, the rivet diameter.

RIVNUTS

The Rivnut is a hollow rivet made of 6063 aluminum alloy, counterbored, and threaded on the inside. Installation is done with the aid of a special tool, which heads the rivet on the blind side of the work. Rivnuts are primarily used as a nut plate, as in the attachment of deicer boots; however, they may be used as rivets in secondary structures, or for the attachment of accessories such as instruments, brackets, and soundproofing materials. After a suitable group of Rivnuts has been installed, accessories can be fastened in place with screws.

Rivnuts are manufactured in two head styles, flat and countersunk, and in two shank designs, open and closed ends, as shown in Figure 2-20. Each of these rivets is available in three sizes-Nos. 6-32, 8-32, and 10-32. These numbers indicate the nominal diameter and the actual number of threads per inch of the machine screw that fits into the Rivnut. Rivnuts are available with or without small projections, called keys, attached to the underside of the head to keep the Rivnut from turning. Keyed Rivnuts are used when the Rivnut serves as a nut plate, while Rivnuts without keys are used for straight blind riveting jobs where no torque loads are imposed.

Open-end Rivnuts are the most widely used and are recommended in preference to the closed-end type, except in sealed flotation or pressurized compartments, in which the closed-end Rivnut must be used.

Installation Tools for Rivnuts

Tools used for installing Rivnuts include the heading tool and the keyway cutter. The

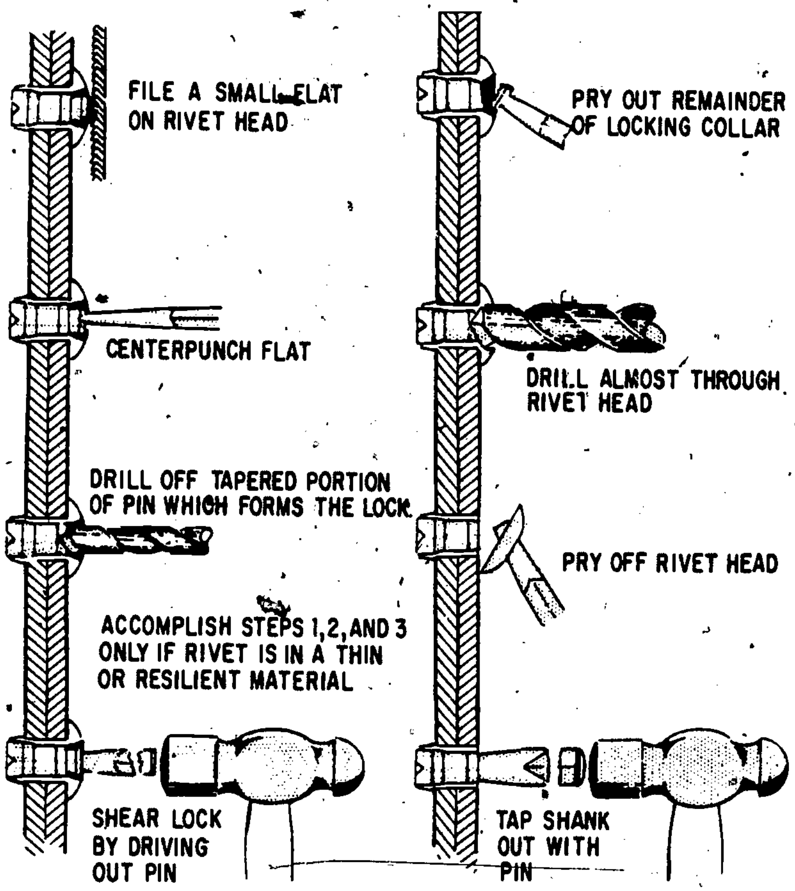


Figure 2-19 - Removing self-plugging rivets (mechanical lock)

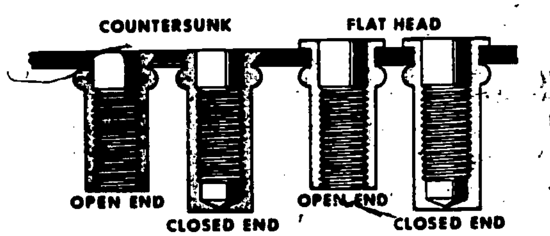


Figure 2-20 - Sectional view of Rivnut showing head and end designs heading tool, as shown in figure 2-21, has a threaded mandrel on which the Rivnut is threaded until the head of the Rivnut is against the anvil of the heading tool. This tool normally comes in three different sizes. They are identical, except for the size of their threaded mandrel. The heading tool comes in sizes 6-32, 8-32, and 10-32, which correspond with the thread sizes of the standard Rivnuts. The keyway cutter is used for cutting a notch in the Rivnut hole for the Rivnut keyway. In some instances the keyway cutter cannot be used because the material is too thick. In this case, use a small round file to form the keyway.

Installation Procedures (Rivnuts)

The drilling of holes for Rivnuts requires the same precision as that required for solid shank rivets. The shank of the Rivnut must fit snugly in the hole. To obtain the best results for a flathead installation, first drill a pilot hole smaller than the shank diameter of the Rivnut, then ream to the correct size. Pilot and ream drill sizes for Rivnuts are given in figure 2-22.

This application of flush Rivnuts is subject to certain limitations. For metal which has a thickness greater than the minimum grip length of the first Rivnut in a series, use the machine countersink; and for metal thinner than the minimum grip length of the first Rivnut in a series, use the dimpling process. The countersunk Rivnut should not be used unless the metal is thick enough for machine countersinking, or unless the underside is accessible for the dimpling operation. Aside from the countersinking operation, the procedure for installing a flush Rivnut is the same as that for the flathead Rivnut.

When installing Rivnuts, always check the threaded mandrel of the heading tool to see that it is free from burrs and chips from the previous installation. Then screw the Rivnut onto the mandrel until the head touches the anvil. Insert the Rivnut in the hole (with the key positioned in the keyway, if a key is used) and hold the heading tool at right angles to the work. Press the head of the Rivnut tightly against the sheet while slowly squeezing the handles of the heading tool together, until the Rivnut starts to head over. Then release the handle and screw the stud farther into the Rivnut. This prevents stripping the threads of the Rivnut before it is properly headed. Again squeeze the handles together until the Rivnut heading is complete. Now remove the stud of the heading tool from the Rivnut by turning the crank counterclockwise.

The action of the heading tool draws the Rivnut against the anvil, causing a bulge to form in the counterbored portion of the Rivnut on the inaccessible side of the work. This bulge is comparable to the upset head on an ordinary solid shank rivet. Practice is the best way to determine the amount of squeeze required to head the Rivnut properly.

When keyed Rivnuts are used, cut the keyway after the hole has been reamed. Operate the keyway cutter by inserting it in the hole and squeezing the handles. Always cut the keyway on the side of the hole away from the edge of the sheet.

Inspection (Rivnuts)

After the installation of Rivnuts, as well as other fasteners, the AM must inspect the completed installation. He will check the Rivnuts for the following:

1. Inspect the manufactured head for correct installation of the Rivnut keyway in its keyway slot, insuring it is flush with the surface in which it is installed.

2. Inspect the threaded portion of the Rivnut shank for cracks, stripped threads, and general condition. Stripped threads may have an improperly upset head. The stripped threads would also prevent the installation of screws.

3. When possible, in open skin areas, inspect the shank for a properly upset head.

NOTE: Rivnuts which are not to be used at the time of installation, or not used for any other reason, should be plugged with a screw designed specifically for that purpose. This will eliminate pockets, which could hold moisture and cause corrosion if left open.

Removal (Rivnuts)

Defective Rivnuts should be replaced with the same size Rivnuts whenever possible. When the hole has been enlarged by removal, substitution of the next larger size can be made.

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106

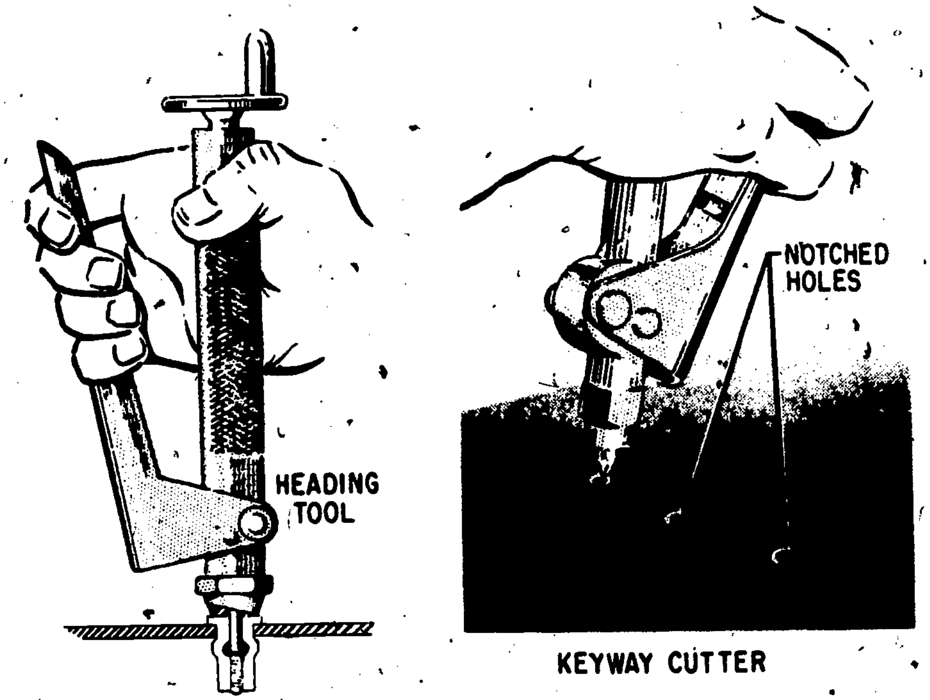


Figure 2-21 - Hand-operated Rivnut heading and keyway cutter tools

Rivnut size	6-32	8-32	10-32
Pilot drill size	19 (0.166)	8 (0.199)	1 (0.228)
Ream drill size	12 (0.189)	2 (0.221)	1/4" (0.250)

Figure 2-22 - Drill sizes for Rivnuts

To remove a Rivnut, select a drill the same size as the original hole. Drill out the Rivnut head, using light pressure and the hollow Rivnut shank as a guide. The Rivnut shank should fall out of the hole behind the sheet, or it may be drifted out, using a pin punch.

HI-SHEAR RIVETS

Hi-shear (pin) rivets are essentially threadless bolts. The pin is headed at one end and is grooved about the circumference at the other.

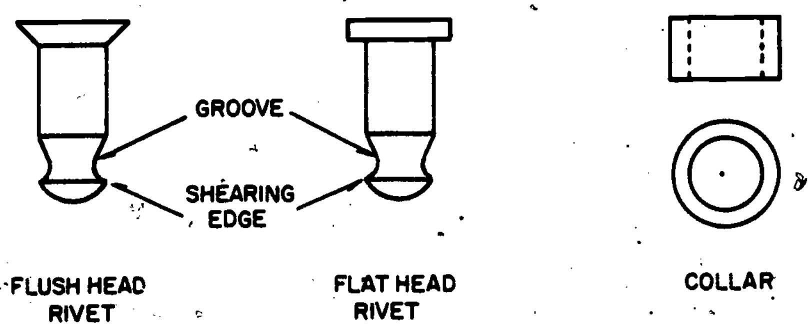


Figure 2-23 - Hi-Shear rivet installation

A metal collar is swaged onto the grooved end, effecting a firm tight fit. They are available in two head styles, the flat protruding head and the flush 100-degree countersunk head. Hi-Shear rivets are made in a variety of materials and are used only in shear application. Due to the shear strength being greater than either the shear or bearing strength of aluminum alloys, they are used to greater advantage only in the thicker gage sheets. They are never used where the grip length is less than the shank diameter. Hi-Shear rivets are illustrated in figure 2-23.

Rivet Identification (Hi-Shear)

Hi-Shear rivets are identified by code numbers similar to the solid rivets. The size of the rivet is measured in increments of thirty-seconds of an inch for the diameter and sixteenths of an inch for the rivet grip length. Thus an NAS1055-5-7 rivet would be a Hi-Shear rivet with a countersunk head, its diameter would be 5/32-inch, and its maximum grip length would be 7/16-inch.

The collars are identified by a basic code number and a dash number which corresponds to the dash number for the diameter of the rivet. An "A" before the dash number indicates an aluminum alloy collar. An NAS528-A5 collar would be used on a 5/32-inch diameter rivet pin. Repair procedures involving the installation or replacement of Hi-Shear rivets generally specify the collar to be used.

Installation Tools for Hi-Shear Rivets

The special tools required for use with Hi-Shear rivets differ from conventional sets only in the design of the collar swaging and trimming features and the discharge port through which excess collar material is ejected. (See figure 2-24.) Various tools and combinations of tools are available for installing rivets in limited access areas.

Installation Procedures (Hi-Shear)

Figure 2-24 illustrates four steps in the installation of the pin and collar to form the rivet. In step 1, the pin is inserted into the work. A bucking bar is placed against the head of the pin. In step 2, the collar is slipped over the grooved end of the pin. A gun or squeezer set is placed over the collar. As driving pressure is applied in step 3, the collar begins to form into the grooved end of the pin. Step 4 shows the collar formed or swaged completely into the grooved end of the pin. Excess material is trimmed off the collar automatically by the tool during driving.

Removal (Hi-Shear)

Hi-Shear rivets may be removed by various methods. However, only some of these methods are recommended as the others may increase the possibility of damaging the parts. Cutting the collar off with a chisel or other sharp tool should be done only where other methods are not practical and the structure is fairly rigid. (See (A) figure 2-25.) You must take special care to prevent damage to the part or to the hole. The use of a drill guide is recommended in drilling out a Hi-Shear rivet. (See (B) figure 2-25.) The base of the guide has a conical surface which fits over the driven collar. Use a drill with a diameter approximately equal to the rivet diameter to drill the shank end of the rivet down to the locking groove. The rivet is then driven out with a small punch. When absolutely necessary, the head of the rivet may be drilled out, but you should use a guide on protruding head rivets.

A collar removal tool, consisting of a hollow end mill, may also be used to remove the collar. (See (C) figure 2-25.) The rotating cutter is applied to the collar until a sufficient amount of collar material has been removed to permit a sharp tap of a hammer to drive out the pin. A stop prevents the cutter teeth from contacting and damaging the work surface.

LOCKBOLT FASTENERS

Lockbolt fasteners are designed to meet high-strength requirements. Used in many structural applications, their shear and tensile strengths equal or exceed the requirements of AN and NAS bolts.

Lockbolt Pins (tension pull type)

The lockbolt shown in figure 2-26 (A) consists of a pin and collar. They are available

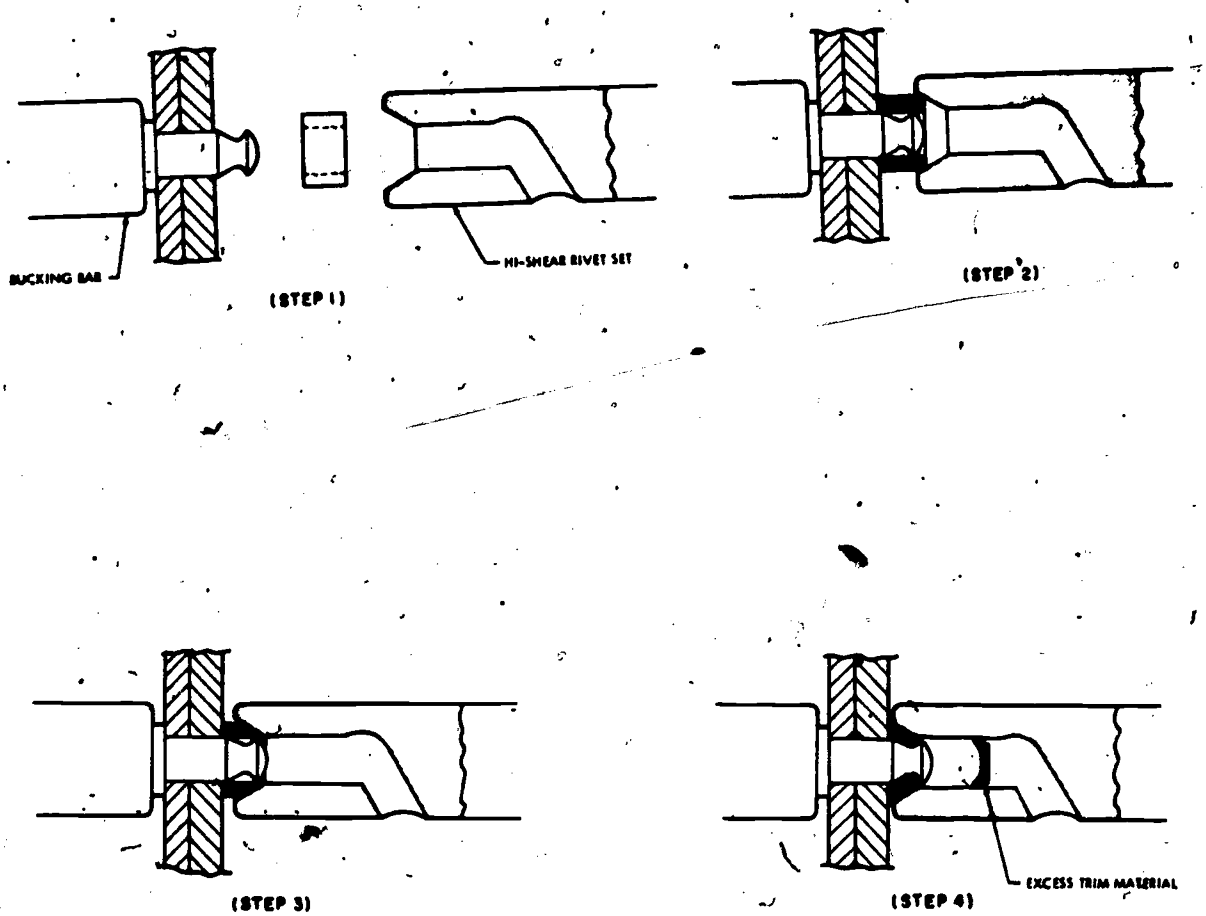


Figure 2-24 - Hi-Shear rivet installation

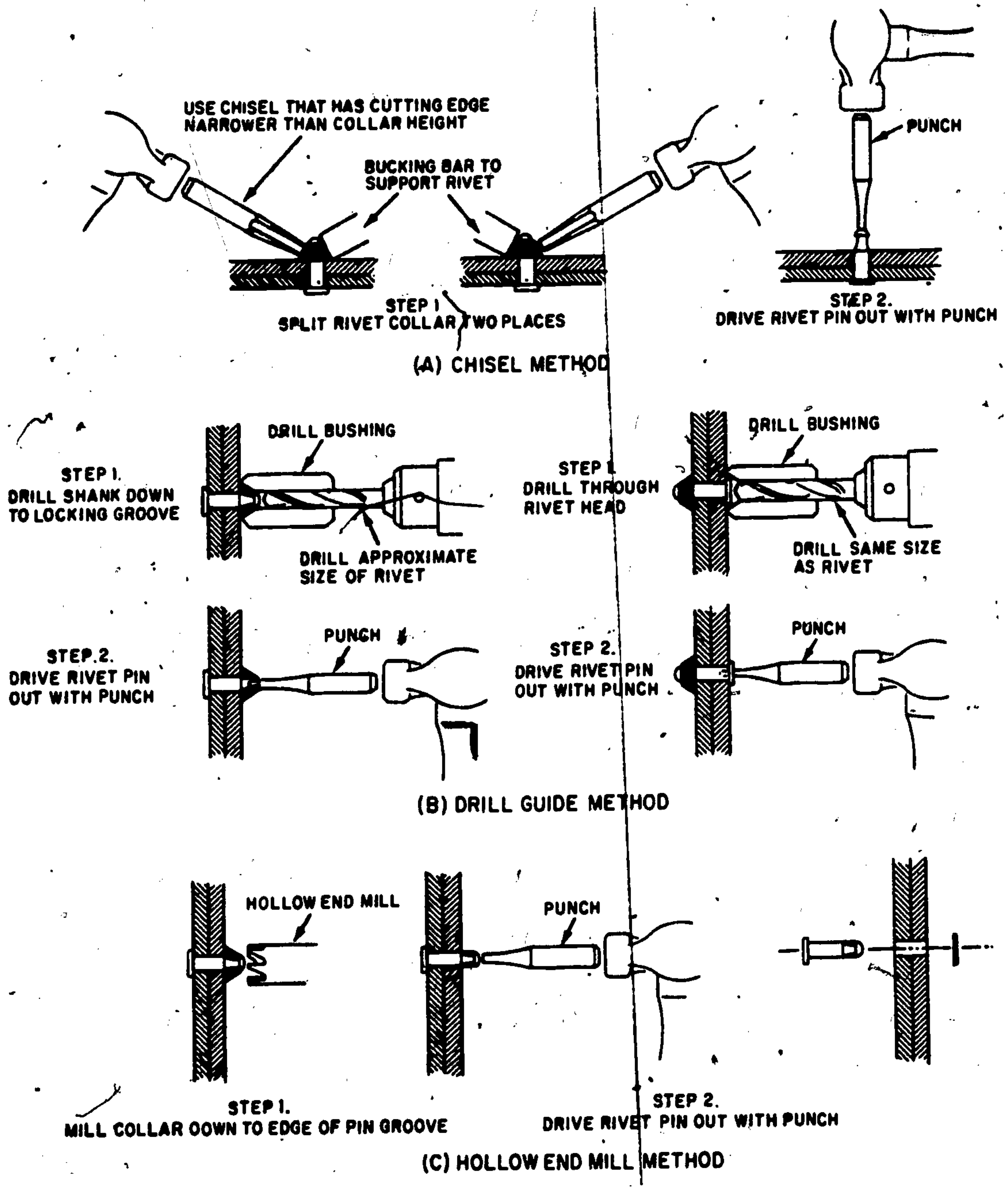


Figure 2-25 - Hi-Shear rivet removal

in two head styles, protruding and countersunk. Pin retention is accomplished by swaging the collar into the locking grooves on the pin.

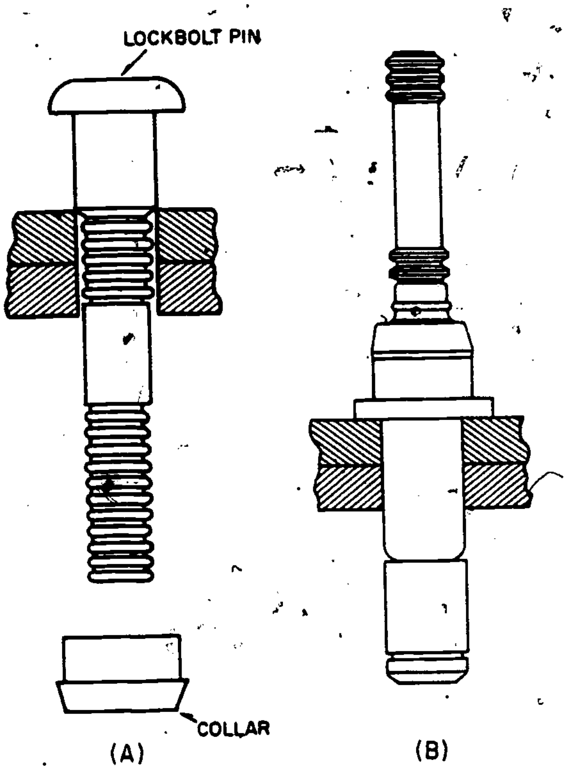


Figure 2-26 - Lockbolts

Blind Lockbolt

The blind lockbolt shown in figure 2-26 (B) is similar to the self-plugging rivet shown in figure 2-7. It features a positive mechanical lock for pin retention.

Installation Procedures for Lockbolt Fasteners

Figure 2-27 illustrates four steps in the installation of the lockbolt fastener. This fastener is installed using the CP352 pneumatic driving tool (similar to the CP350 blind rivet pull tool illustrated in figure 2-14).

Removal (Lockbolt).

Lockbolt collars may be removed by various methods. In general the procedure is the same as for removing Hi-Shear rivets. (See figure 2-25.) Cutting the collar off with a chisel should be done only where the structure is fairly rigid.

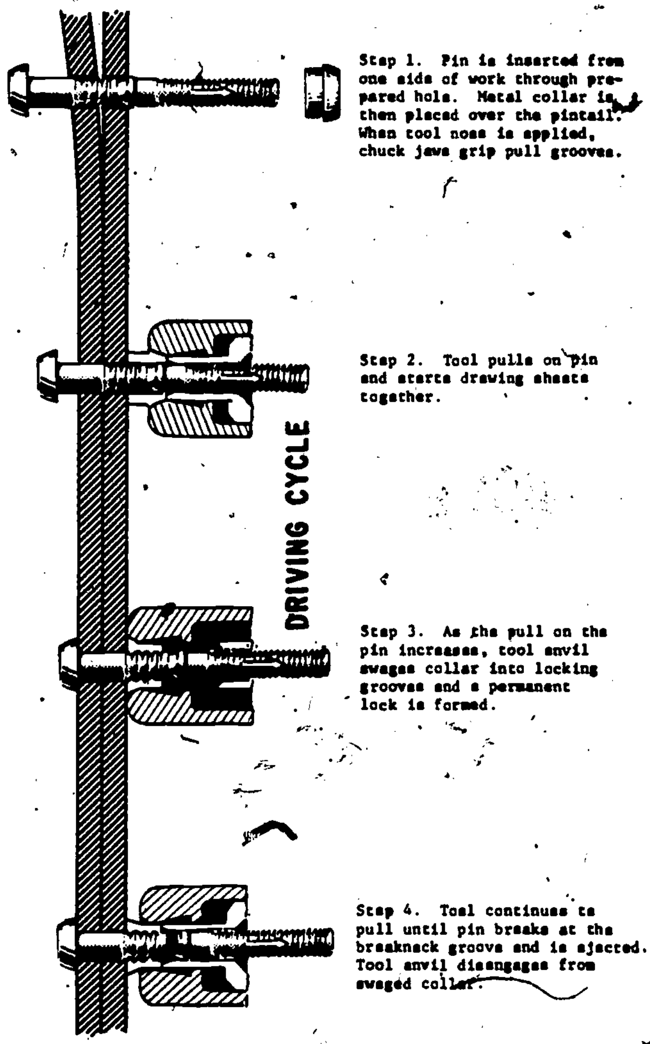


Figure 2-27 - Lockbolt installation

You must take special care to prevent damage to the structure or to the hole. The most acceptable method of removal is to cut the collar off, using a hollow end mill in a drill motor. After removal of the collar, the pin may be driven out with a punch.

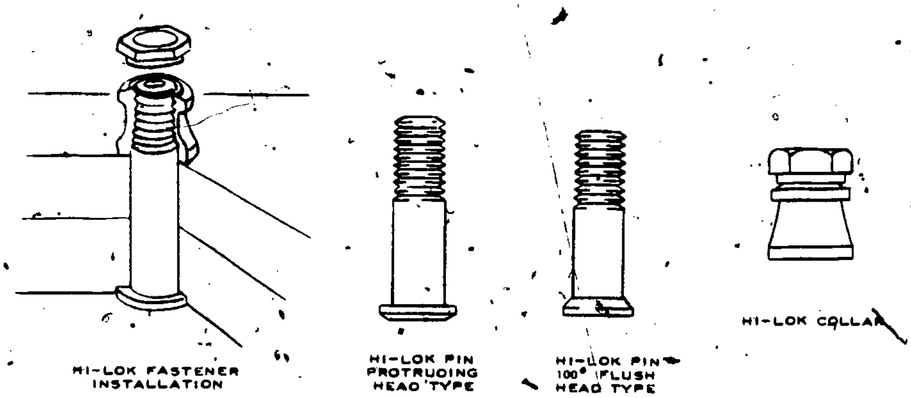


Figure 2-28 - Hi-Lok fastener

HI-LOK FASTENERS

The Hi-Lok fastener, shown in figure 2-28, combines the features of a rivet and a bolt and is used for high-strength, interference fit of primary structures. The Hi-Lok fastener consists of a threaded pin and threaded locking collar. The pins are made of cadmium-plated alloy steel with protruding or 100-degree flush heads. Collars for the pins are made of anodized 2024-T6 aluminum or stainless steel. The threaded end of the pin is recessed with a hexagon socket to allow installation from one side. The major diameter of the threaded part of the pin has been truncated (cut undersize) to accomodate a 0.004-inch maximum interference fit. One end of the collar is internally recessed with a 1/16-inch, built-in variation which automatically provides for variable material thickness without the use of washers and without preload changes. The other end of the collar has a torque-off wrenching device which controls a predetermined residual tension of preload (± 10%) in the fastener.

Installation Procedures for Hi-Lok Fasteners

Hi-Lok fasteners may be installed by one person working from one side of the work, using standard power or hand tools and Hi-Lok adapter tools. Hi-Lok adapter tools can be fitted to high-speed power drivers in straight, 90-degree, offset, and extension configurations. View (A) figure 2-29 illustrates steps in the installation of Hi-Lok fasteners using power tools.

Hi-Lok fasteners may be installed using the following hand tools: Allen hex key (Allen wrench) and open-end or ratchet-type wrenches. (See (B) figure 2-29.) To install the fastener, insert the pin into the prepared hole and manually screw the collar onto the pin a minimum of two turns. Insert the proper size Allen wrench into the hex recess of the pin and, using a ratchet or open-end wrench, rotate the collar clockwise until the wrenching device of the collar has been torqued off. The fastener is installed with the correct torque value as the collars are designed to break off (torque off) at pre-established torque levels.

Removal (Hi-Lok)

Hi-Lok fasteners are easily removed with standard hand tools in a manner similar to removing a nut from a bolt. To remove a Hi-Lok fastener, insert an Allen wrench in the hex recess of the pin. Hold the Allen wrench firm and, using a pair of channel-lock or vise-grip pliers, rotate the collar counterclockwise until removed. (See (C) figure 2-29.) Hi-Lok pins are reusable if no thread damage is incurred during removal. AN or NAS nuts may be substituted for Hi-Lok collars.

TAPER-LOK FASTENERS

The Taper-Lok fastener is a headed pin with a slightly tapered shank. The taper (0.021

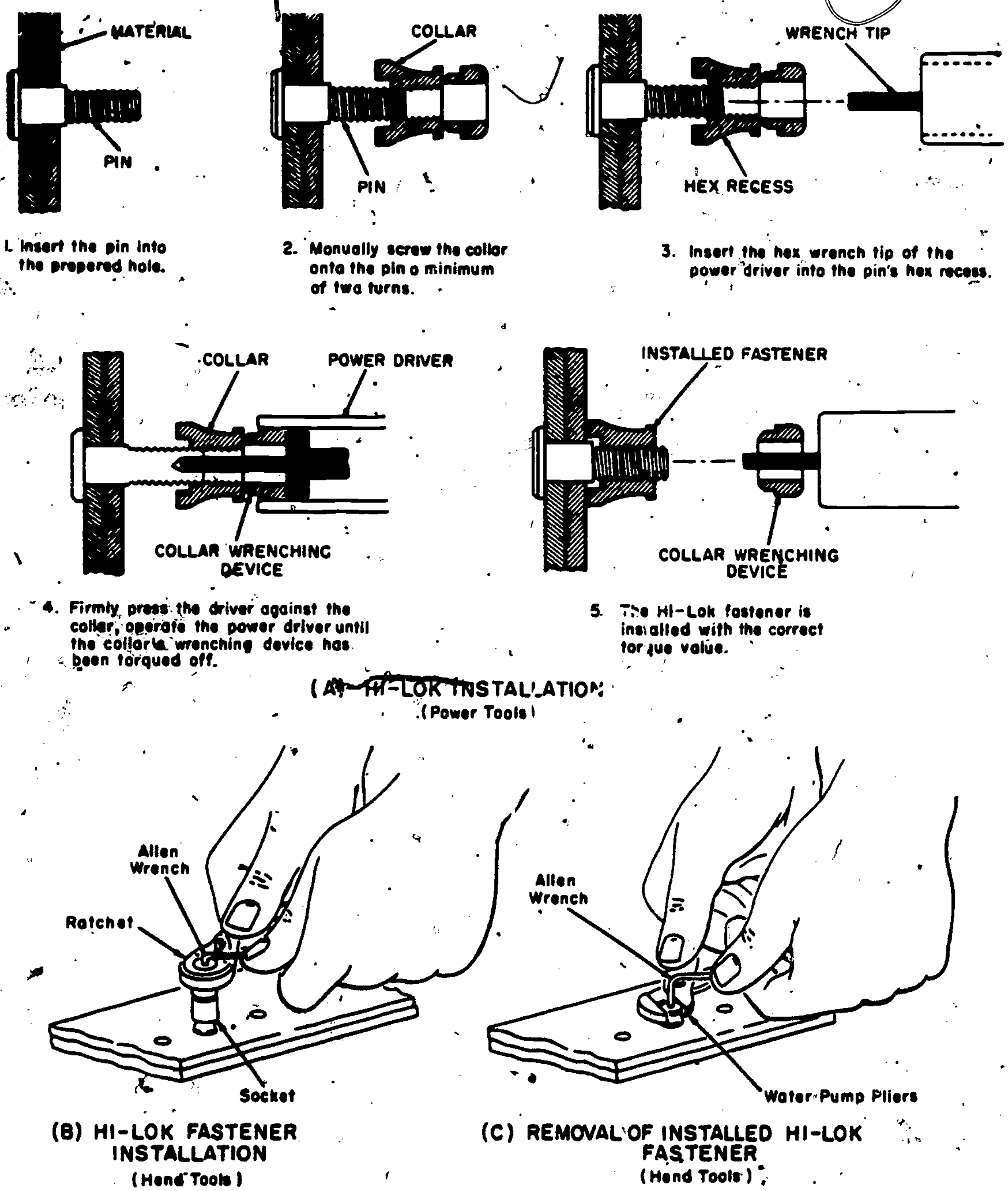


Figure 2-29 - Hi-Lok fastener installation and removal inch per inch) of the shank and mating hole provides the interference feature of the fastener. The fastener is secured by a washernut assembly. The washernut consists of a self-locking nut and captive washer. The counterbore design of the nut will absorb a 1/16-inch pin grip protruding through the material to be attached.

Installation Procedures for Taper-Lok Fasteners (Figure 2-30)

Press the Taper-Lok into its hole, using finger pressure. Seat the fastener with 10 to 30 pounds of finger pressure. Under no circumstances should heavy pounding of fasteners be used to drive the fastener to a nearly or fully seated position. If a sealant-coated fastener will not sufficiently engage the hole taper with finger pressure and the nut does not engage the threads, it is permissible to lightly tap the fastener head with a plastic-tipped mallet weighing no more than 12 ounces. Install the nut on the fastener, and apply the proper amount of torque to the nut. Refer to the applicable torque table. Torques are different for low-interference and high interference fits.

You must also check the heads of flush Taper-Loks installed on interior surfaces of the airplane. Any gap between the head and its countersink should not exceed 0.003 inch and this 0.003-inch gap must not exceed one-third of the fastener's periphery.

Check the heads for signs of distortion. The appearance of a distinct ring on the head of the fastener is evidence of distortion.

Next, check the gaps under the heads of protruding headed Taper-Loks. The gap should not exceed 0.004 inch. This gap is permissible for only one-half of the fastener's periphery. Furthermore, no two adjacent fasteners and no more than 10 percent of the total pattern of fasteners can have the maximum allowable gap.

Finally, check the amount the threaded end of the Taper-Lok shank protrudes above the fastened surfaces. Thread protrusion must not exceed prescribed values.

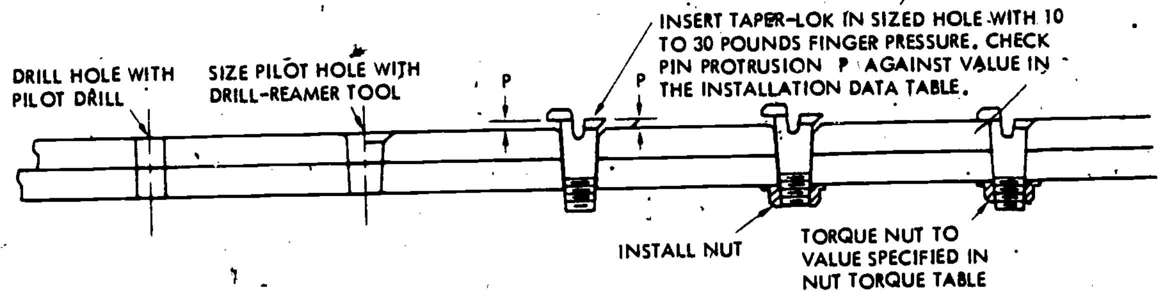


Figure 2-30 - Taper-Lok fastener installation

Inspection (Taper-Lok)

Check the heads of flush-headed Taper-Loks installed on the exterior surfaces of the airplane. The heads of these fasteners should not protrude into the airstream more than that allowed for aeordynamic smoothness. There should be no gap between the heads and their countersinks.

Removal (Taper-Lok)

Remove Taper-Loks by removing the nuts and driving the Taper-Lok shank out of the hole, using the proper removal tools as shown in figure 2-31. Be careful not to damage the nut-bearing area around the hole.

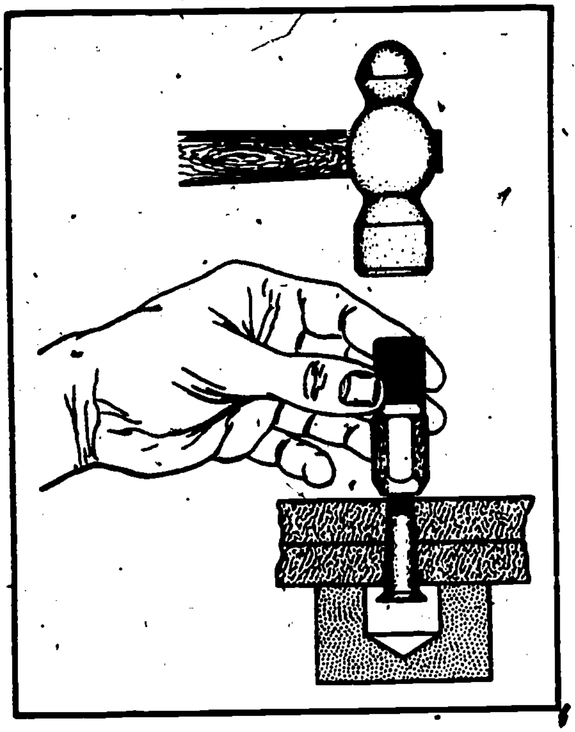


Figure 2-31 - Taper-Lok fastener removal

JO-BOLT FASTENERS

The Jo-Bolt shown in figure 2-33 is a high-strength, blind, structural fastener that is used on difficult riveting jobs, when access to one side of the work is impossible. The Jo-Bolt consists of three factory preassembled parts: an aluminum alloy or alloy steel nut, a threaded alloy steel bolt, and a corrosion-resistant steel collar. The head styles available for Jo-Bolts are the 100-degree flush head, hexagon protruding head, and the 100-degree flush millable head.

Installation Tools for Jo-Bolt Fasteners

Special tools are required for the installation of Jo-Bolts. In no case shall power screwdrivers or drill motors be converted to Jo-Bolt driving tools. The hand tool illustrated in figure 2-32 consists of a tool body, nose adapter, and wrench adapter and can be used for installing all sizes and types of Jo-Bolt fasteners. The nose adapter is secured in the

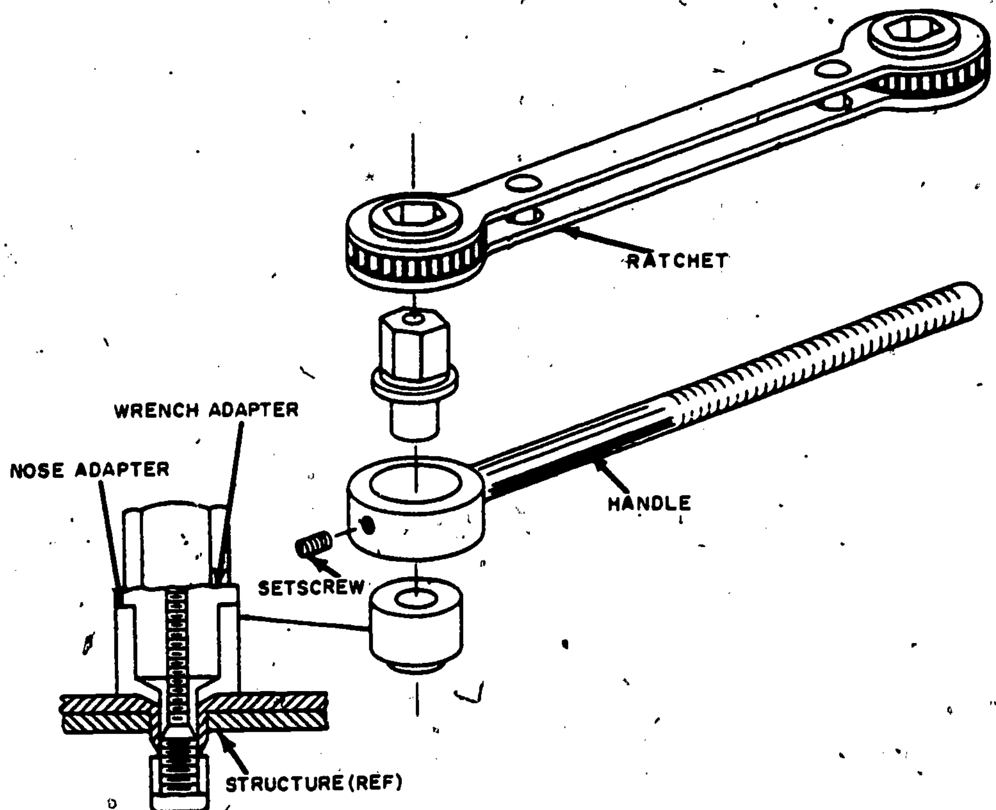


Figure 2-32 - Jo-Bolt installation tool

tool body and prevents the nut portion of the Jo-Bolt from turning during installation. The wrench adapter rides free inside the nose adapter and gets its turning action from the ratchet wrench.

Installation Procedures (Jo-Bolt)

When you are installing Jo-Bolts, it is important that the fastener holes and countersink diameters be the correct size for different types of Jo-Bolts. It is recommended that the holes be drilled undersize and then be brought up to final size by reaming. After bringing the holes up to correct size and prior to installing the Jo-Bolts, you must secure the part to be joined firmly in position. Cleco fasteners, C-clamps, or any of several varieties of temporary fasteners may be used for this purpose.

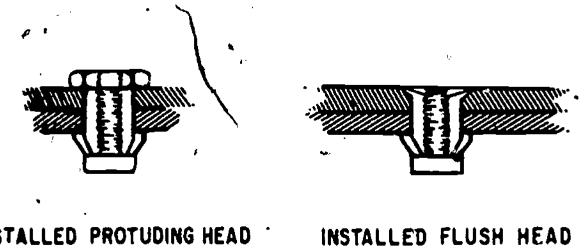


Figure 2-33 - Jo-Bolts

Figure 2-34 illustrates the installation of Jo-Bolts. Insert the correct grip length Jo-Bolt in the hole. You can push the fastener easily into a properly prepared hole and in no case shall you drive it forcibly into the hole. A very light tap fit is permissible in aluminum alloy parts but not in steel. Select the correct nose and wrench adapter for the fastener and secure them in the hand tool body. Place the nose adapter of the driving tool over the slabbed portion of the bolt shank so that it engages the head of the Jo-Bolt. On flush head Jo-Bolts the dogs on the nose adapter shall fit into the slots of the fastener head. On the protruding head, including the millable head fasteners, the nose adapter will fit over the fastener head. Hold the tool tightly against the Jo-Bolt head and perpendicular to the surface of the work. Failure to hold the tool perpendicular may result in the stem breakoff before the Jo-Bolt is tight. Holding the handle of the tool stationary, turn the ratchet handle. As you apply power, the bolt is turned while the nut is held. The sleeve, compressed between the bolt head and tapered end of the nut,

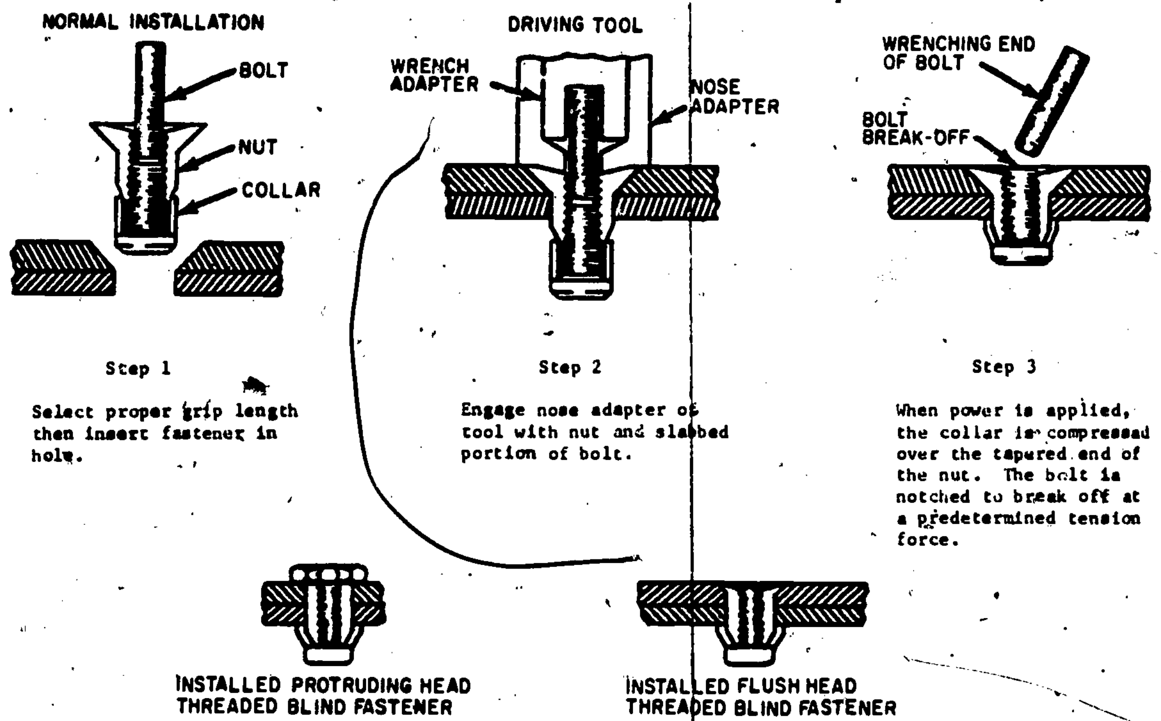
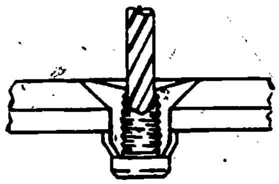


Figure 2-34 - Jo-Bolt installation

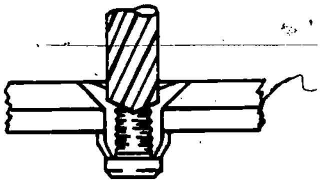
116

Drill Selection Chart		
Jo-Bolt	Column I	Column II
Nominal Diameter	Drill Size	Drill Size
5/32	No. 42 (0.089) (0.0935)	No. 23 (0.154) 5/32 (0.1562)
3/16	No. 35 (0.110 inch)	No. 12 (0.189 inch)
1/4	No. 24 (0.152 inch)	D (0.246 inch)
5/16	No. 17 (0.173)	M (0.295)
3/8	No. 5 (0.2055)	23/64 (0.3594)



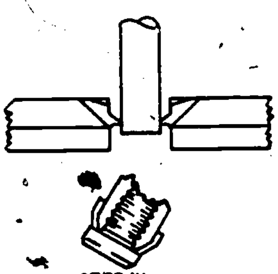
STEP I

SELECT CORRECT PILOT DRILL FROM COLUMN I OF THE DRILL SELECTION CHART, THEN DRILL BELOW THE HEAD — SHANK JUNCTION OF THE NUT.



STEP II

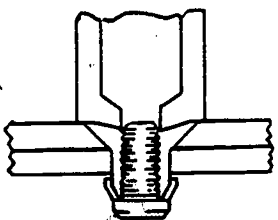
SELECT CORRECT FOLLOW UP DRILL FROM COLUMN II OF THE DRILL SELECTION CHART, THEN DRILL TO THE PILOT HOLE DEPTH.



STEP III

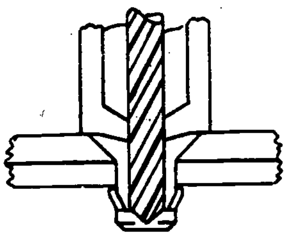
USE A HAMMER AND NOMINAL SIZE PUNCH TO DRIVE OUT THE SHANK AND BLIND HEAD.

(A) TIGHT FASTENER



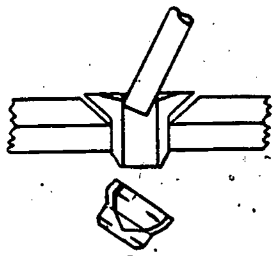
STEP I

PREVENT NUT FROM TURNING BY ENGAGING DRIVING TOOL NOSE ADAPTER; HOLDING THE NOSE ADAPTER WITH VISE-GRIP PLIERS.



STEP II

SELECT DRILL, IN ACCORDANCE WITH COLUMN I OF THE DRILL SELECTION CHART, THEN DRILL THROUGH THE SHANK, SEVERING THE BOLTHEAD.



STEP III

PICK THE NUT FROM THE HOLE WITH A PUNCH.

Figure 2-35 - Jo-Bolt removal

is drawn over the end of the nut. The sleeve is expanded, forming the blind head against the inner surface of the part. When the sleeve is drawn up tight, the slabbed portion of the bolt is snapped on, completing the driving operation. After driving, you should touch up the end of the bolt, at the breakoff point with zinc chromate primer.

Removal (Jo-Bolt)

The procedure to be used for the removal of a Jo-Bolt will depend on whether the fastener is clamped up tight or whether it is loose. If the Jo-Bolt is clamped up tight in the hole, you can remove the Jo-Bolt by drilling just through the fastener head and then driving out the shank portion with a hammer and punch. (See (A) figure 2-35.) If the Jo-Bolt is loose in the hole, you must prevent it from turning by using a drill bushing which has dogs to engage the head slots and a handle or other device to hold it. (See (B) figure 2-35.) While holding the Jo-Bolt to prevent it from turning, drill the bolt portion of the fastener completely out, removing the bolt head and fastener sleeve. After the bolt head and sleeve have been removed, pick out the nut portion of the fastener. For all drilling operations on Jo-Bolts, select a drill motor that does not turn over 500 RPM.

LESSON QUIZ

QUESTIONS	ANSWERS
13. A letter or letters following a solid rivet head-shape code identify the rivet ________.	13. material or alloy (Page 2-2)
14. Solid rivet diameter is expressed in ________ of an inch.	14. thirty-seconds (Page 2-2)
15. After heat treating alloy 2017 rivets, you can delay the rivet's aging time by ________.	15. refrigeration (Page 2-2)
16. Because of their corrosion resistant qualities, what alloy rivets should you use for joining magnesium structures?	16. 5056 (Page 2-2)
17. What is the width of the upset head of a properly driven rivet?	17. One and one-half times the original shank diameter (Page 2-3)
18. After a mechanical lock self-plugging rivet is driven, the pin is retained in place by a ________.	18. collar (Page 2-6)
19. When you are installing mechanical lock self-plugging rivets, a change in rivet diameter requires a change in which pneumatic pulling tool parts?	19. Chuck jaws, outer anvil, inner anvil, and inner anvil thrust bearing (Page 2-9)
20. To drill through the head of a 5/32 self-plugging rivet, you should use a number ________ twist drill.	20. 24 (Page 2-13)
21. What are the two Rivnut shank designs?	21. Open end and closed end (Page 2-13)
22. When a Rivnut is to be used as a nutplate, you should install a ________ Rivnut.	22. keyed (Page 2-13)
23. What is the grip length of a NAS 1055-5-7 Hi-Shear rivet?	23. 7/16-inch (Page 2-17)
24. The MOST accepted method for removal of Lockbolts is to ________.	24. cut the collar off, using a hollow end mill, and drive the pin out with a punch (Page 2-20)
25. When a Hi-Lok fastener is installed with the correct torque, the collar will ________.	25. break off (Page 2-21)
26. When a Taper-Lok fastener is being installed the fastener is secured with a ________.	26. washernut assembly (Page 2-23)
27. If finger pressure does not fully seat a sealant-coated Taper-Lok fastener, you may seat the fastener by tapping with a ________.	27. 12-ounce, or less, plastic mallet (Page 2-23)
28. For removing a Jo-Bolt that is loose in the hole, you should use a drill bushing with dogs to prevent the ________ from turning.	28. nut (Page 2-27)

PAMPHLET REVIEW QUIZ

ERIC

PAMPHLET REVIEW QUIZ

Directions: Cover the answers to the questions with the enclosed Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any question incorrectly, refer to the text material.

QUESTIONS

1. In the SAE number for steel, the second digit represents the ________.

   A. type of steel
   B. percentage of carbon
   C. percentage of the principal alloying element
   D. number of alloy modifications

2. When you are spark testing a metal, long, dull red spark shafts turn white. This color identifies the metal as ________.

   A. nickel steel
   B. low-carbon steel
   C. wrought iron
   D. cast iron

3. Medium-carbon steel contains ________ percent carbon.

   A. 0.50 to 1.05
   B. 0.30 to 0.50
   C. 0.10 to 0.30
   D. 0.05 to 0.10

4. The principal alloy of 18-8 steel is ________.

   A. chromium
   B. nickel
   C. vanadium
   D. molybdenum

5. What steel is used principally for welded aircraft structural parts and assemblies?

   A. Chrome-vanadium
   B. Nickel
   C. High carbon
   D. Chrome-molybdenum

ANSWERS

1. C - Each SAE number consists of a group of digits, the first digit represents the type of steel; the second, the percentage of the principal alloying element; and usually the last two or three digits the percentage, in hundredths of 1 percent, of carbon in the alloy. (Page 1-2)

2. C - Wrought iron produces long shafts that are dull red colored as they leave the stone and end up a white color. (Page 1-2)

3. B - Steels containing carbon in percentages ranging from 0.30 to 0.50 percent are classed as MEDIUM-CARBON STEEL. (Page 1-2)

4. A - The corrosion-resisting steel most often used in aircraft construction is known as 18-8 steel because of its content of 18 percent chromium and 8 percent nickel. (Page 1-3)

5. D - Molybdenum steels are especially adaptable for welding and are used principally for welded structural parts and assemblies. (Page 1-3)

6. The ONLY means of increasing the tensile strength in nonheat-treatable wrought aluminum alloys is by ________.

A. annealing
B. normalizing
C. casehardening
D. strain hardening

7. To indicate a solution heat-treated aluminum alloy, what letter follows the alloy designation number?

A. O
B. T
C. W
D. H

8. Titanium parts provide good corrosion resistance and moderate strength up to ________ °F.

A. 600
B. 800
C. 1,000
D. 1,200

9. What copper alloy provides fatigue and wear resistance high enough to be used for precision bearings and nonsparking tools?

A. Aluminum
B. Beryllium
C. Manganese
D. Silicon

10. The tensile strength of monel can be increased from 65,000 psi to 160,000 psi by means of ________.

A. annealing
B. casehardening
C. cold-working
D. normalizing

11. When you are selecting a substitute material for the repair of an aircraft, the MOST important requirement is maintaining the original _____.

A. strength
B. contour
C. weight
D. corrosion-resistance

6. D - In the nonheat-treatable class, strain hardening (cold-working) is the only means of increasing the tensile strength. (Page 1-4)

7. C- The letter W indicates solution heat treated. (Page 1-5)

8. A - Titanium and titanium alloys are used chiefly for parts which require good corrosion resistance, moderate strength up to 600°F, and light weight. (Page 1-8)

9. B - The resistance of beryllium copper to fatigue and wear makes it suitable for diaphrams, precision bearings and bushings, ball cages, spring washers, and nonsparking tools. (Page 1-9)

10. C - monel has a tensile strength of 65,000 psi which, by means of cold-working, may be increased to 160,000 psi. This allows this metal to classification with the tough alloys. (Page 1-10)

11. A - There are four requirements that you must keep clearly in mind in this selection. The first and most important of these is maintaining the original strength of the structure. (Page 1-10)

122

Use the rivet code number MS20470AD5-4 to answer questions 12 through 14.

12. What is the head shape code?

A. MS20
B. 470
C. AD
D. 5

13. What is the alloy code?

A. MS20
B. 470
C. AD
D. 5

14. The length of the rivet is ________ of an inch.

A. 1/8
B. 5/32
C. 1/4
D. 5/16

15. A 2117-T4 aluminum alloy rivet is identified by a/an ________ on the head.

A. indented dimple
B. raised teat
C. raised double dash
D. raised cross

16. After heat treating and quenching, 2017 and 2024 aluminum alloy rivets must be driven within a MAXIMUM of ________ minutes, unless refrigerated.

A. 10
B. 15
C. 20
D. 25

17. What is the height of the upset head of a properly driven rivet?

A. Equal to the original diameter
B. One-half the original diameter
C. One-half the original length
D. One-fourth the original length

12. B - Figure 2-2 (Page 2-2)

13. C - A letter or letters following the head-shape code identify the material or alloy from which the rivet was made. (Page 2-2)

14. C - The alloy code is followed by two numbers seperated by a dash. The second number is the numerator of a fraction in sixteenths of an inch and identifies the length of the rivet. (Page 2-2)

15. A - Figure 2-3 (Page 2-3)

16. C - 2017 and 2024 rivets must be driven withing 20 minutes after quenching, or they must be refrigerated at 32°F. or lower, which will delay the aging time 24 hours. (Page 2-2)

17. B - The upset head should be one-half the original diameter in height. (Page 2-4)

18. What is the MAIN difference between the friction lock and mechanical lock self-plugging rivets?

A. Rivet material
B. Pin length
C. Shear strength
D. Pin retention method

18. D - The main difference between the friction lock and mechanical lock rivets is in the method of pin retention. (Page 2-6)

19. You are using a pneumatic pulling tool on a specific size mechanical-lock blind rivet. When should you check the tool gage for proper air pressure?

A. After pressing and releasing the trigger as the valve shifts
B. After holding the trigger fully depressed until the valve has shifted
C. Before the air compressor cuts out
D. While driving a sample rivet

19. A - Press the trigger and release it the instant a puff of exhaust indicates that the shift valve controlling the inner anvil has shifted. The gage will then indicate the shift pressure. (Page 2-10)

20. To install a mechanical lock self-plugging rivet in a hole where there is insufficient space behind the hole, you should ________.

A. force the pin into the shank until the head touches the end of the shank
B. drill the hole oversize and partially swell the rivet
C. use a rivet one length shorter
D. cut off part of the stem head and partially swell the rivet

20. A - If there is insufficient space between two surfaces to insert the rivet, the pin may be forced into the hollow shank until the head of the pin just touches the end of the shank. (Page 2-11)

21. The FIRST step in the removal of a mechanical lock self-plugging rivet is to ________.

A. center punch the pin and drill through the head
B. file a flat on the pin and head
C. remove the locking collar with a sharp chisel
D. shear the lock by driving out the pin

21. D - Shear the lock by driving out the pin, using a tapered steel drift pin not over 3/32-inch diameter at the small end. (Page 2-13)

22. Rivnuts are primarily used as ________.

A. primary structure rivets
B. secondary structure rivets
C. a nut plate
D. attaching points for accessories

22. C - Rivnuts are primarily used as a nut plate, as in the attachment of deicer boots. (Page 2-13)

23. If the material is too thick to use a Rivnut keyway cutter to form the keyway, you should use a ________.

A. small twist drill
B. small round file
C. rod saw
D. nibbler

23. B - Sometimes the keyway cutter cannot be used because the material is too thick. In this case, use a small round file to form the keyway. (Page 2-15)

124

24. In a Hi-Shear rivet collar code number, an "A" before the dash number indicates __________.

A. fit of the collar
B. thickness of the collar
C. an aluminum alloy collar
D. size of the rivet the collar fits

24. C - An "A" before the dash number indicates an aluminum alloy collar. (Page 2-17)

25. Retention of a lockbolt pin is accomplished by __________.

A. creating an upset head with a bucking bar
B. torquing a locknut on the threads
C. torquing a collar on the threads with a wrench
D. swaging a collar into the locking grooves on the pin

25. D - Lockbolt pin retention is accomplished by swaging the collar into the locking grooves on the pin. (Page 2-20)

26. When installing a Hi-Lok fastener, you should keep the pin from turning with __________.

A. an Allen wrench
B. a socket wrench
C. channel-locks
D. vise-grips

26. A - Insert the proper size Allen wrench into the hex recess of the pin and, using a ratchet or open-end wrench, rotate the collar clockwise until the wrenching device of the collar has been torqued off. (Page 2-21)

27. To seat a Taper-Lok fastener, you should __________.

A. tap the fastener head with a 16-ounce plastic mallet
B. pull the fastener into place with nut torque
C. use the proper size pulling tool
D. use 10 to 30 pounds of finger pressure

27. D - Seat the fastener with 10 to 30 pounds of finger pressure. If a sealant-coated fastener will not sufficiently engage the hole taper with finger pressure and the nut does not engage the threads, it is permissible to lightly tap the fastener head with a plastic-tipped mallet of not more than 12 ounces. (Page 2-23)

28. What are the head styles available for Jo-Bolts?

A. 78-degree flush head and hexagon protruding head
B. 83-degree flush head, hexagon protruding head, and 100-degree flush millable head
C. 100-degree flush head, hexagon protruding head, and 100-degree flush millable head
D. 100-degree flush head and brazier head

28. C - The head styles available for Jo-Bolts are the 100-degree flush head, hexagon protruding head, and the 100-degree flush millable head. (Page 2-24)

COAST GUARD INSTITUTE

BASIC CORROSION CONTROL AND PRESERVATION

OKLAHOMA CITY

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126

BASIC CORROSION CONTROL AND PRESERVATION

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FTS: 749-4464

Questions about this text should be addressed to the Subject Matter Specialist for the AM Rating.

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NOTICE TO STUDENT

The primary purpose of this self-paced, non-resident training pamphlet is to present a general overview of the harmful effects caused by corrosion and to familiarize all aviation rates with the theory of corrosion, corrosion detection and identification, corrosion removal, and metal surface preservation. The pamphlet content is based on the Enlisted Qualifications Manual (CG-311).

IMPORTANT NOTE: This text has been compiled for TRAINING ONLY. It should NOT be used in place of official directives or publications. The text information is current according to the references listed. You should, however, remember that it is YOUR responsibility to keep up with the latest professional information available for your rating. Current information is available in the Coast Guard Enlisted Qualifications Manual (CG-311).

This text provides information on:

Each assignment is divided into three parts:

Reading assignment and objectives
Reading material
Self-quiz with answers and references. The answers are located on the page(s) immediately following the quizzes.

In addition to the self-quiz after each assignment, a pamphlet review quiz is provided at the end of the pamphlet. (In most courses).

The objectives for each assignment should lead you in the right direction for study purposes. The self-quizzes test your mastery of the objectives. The quizzes allow you to score yourself. If properly used, the quizzes will help you in preparing for your End-of-Course Test and your Servicewide Exam. You must understand all the material to pass the EOCT. Your success in a course depends entirely on YOU and YOUR determination to achieve.

When you have completed all the assignments for this course and mastered each objective, you should have a thorough understanding of the material and should be ready to pass your EOCT. You will not find any of the quiz items or review items on the EOCT.

REMEMBER -- You must receive a score of 80% or better to pass the End-of-Course Test. You should use your spare time to REVIEW the material before you take the EOCT.

SWE STUDY SUGGESTION: Servicewide exam questions for your rate and pay grade are based on the Professional and Military Requirements sections of the Enlisted Qualifications Manual (CG-311). If you use the references from this text and consult the Enlisted Qualifications Manual, you should have good information for review when you prepare for your servicewide exam.

This course is only one part of the total Coast Guard training program. By its very nature, it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a successful training program.

ERIC

BASIC CORROSION CONTROL AND PRESERVATION

TABLE OF CONTENTS

130

TABLE OF CONTENTS (cont'd)

133

HOW TO STUDY THIS COURSE

You can remember more of what you read if you ....

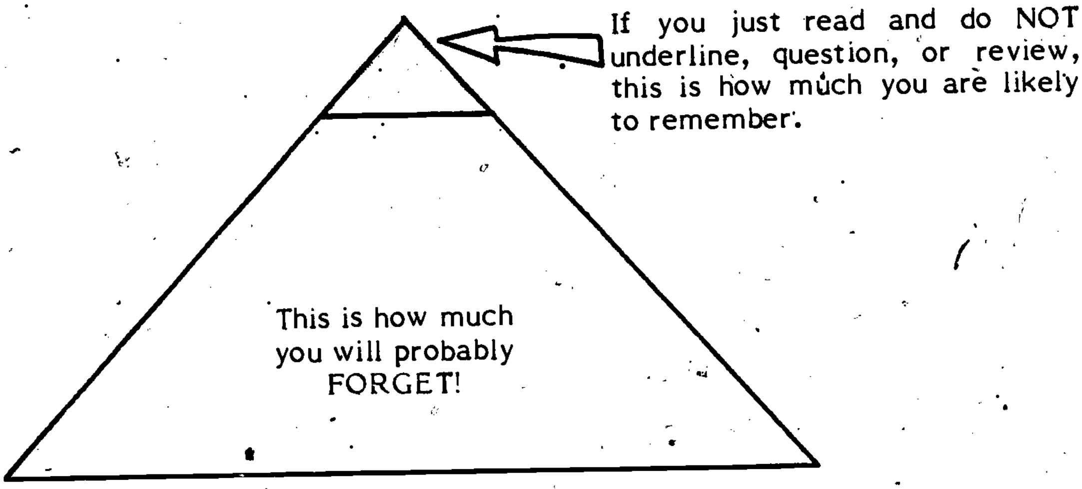
1. "Look over" the reading assignment first. Read the objectives and section headings, and look at the pictures. This gives you an idea of what to expect in the reading assignment and helps you understand the objectives.

2. Question the reading material. Ask yourself questions about a heading or a picture to help you remember what you read.

3. Note points to review later. Don't just run your eyes over a page. Underline important facts and make notes in the margin.

4. Close your pamphlet and repeat important points out loud. Discuss the reading assignment with someone if possible. This helps you recall information for a quiz or end-of-course test.

5. Review your underlined material, notes, quizzes, and objectives. This also helps you remember what you read.



CORROSION

OBJECTIVES

When you complete this section, you will be able to:

1. Describe the devastating effects corrosion can have on aircraft, aircraft components and systems, and, ultimately, flight safety.

2. Explain the theory of corrosion.

3. State the forms of corrosion and describe the appearance of each.

INTRODUCTION

Modern high-speed aircraft depend upon the structural soundness of the metals used to make most of the aircraft parts. The greatest threat to structural integrity of Coast Guard aircraft is metals corrosion. Aircraft metals must meet demands for greater strength and closer tolerances of flight safety. Because of these demands, aircraft would rapidly become inoperative without regular anticorrosion attention.

EFFECTS OF CORROSION

Corrosion endangers the aircraft by reducing the strength and changing the mechanical characteristics of the materials used in the aircraft's construction. Materials are designed to carry certain loads and withstand given stresses as well as provide an extra margin of strength for safety. Corrosion can weaken the structure and reduce or eliminate this safety factor. Replacement or reinforcement operations are costly, time-consuming, and reduce usage of the aircraft. Severe corrosion can cause failure of parts or systems. This failure is an obvious danger. Corrosion in vital systems can cause malfunctions that endanger the safety of flight, and such dangers reemphasize the importance of corrosion control.

The microscopic debris given off as a by-product of corrosion can cause INTERMITTENT circuit operation. This problem can involve many nonproductive hours of troubleshooting.

Many technicians may recognize the specific malfunctioning component, but may not be able to determine all the factors contributing to the malfunction. Age or overloading can cause physical and internal breakdown of discrete components (both active and inactive). However, some problems can be a direct result of contamination and/or corrosion.

The rate of corrosion is determined by the equipment's operating environment, construction materials, and protection. Avionics equipment, whether unused or operated, may be subjected to long periods of temperature and humidity changes. This equipment frequently deteriorates and fails from the effects of moisture and fungus growth. When fungus appears, the adverse condition produced by moisture is intensified. Exposure of components to continuously warm, damp air causes condensation of atmospheric moisture. This moisture forms electrical leakage paths which promote corrosion.

Most structural parts can withstand more severe attacks of corrosion than internal components can. However, corrosion of structural avionics components can cause possible failure or destruction of what would otherwise be a serviceable piece of equipment. For example, a transmitter is just so much excess weight if the transmitter antenna is destroyed by corrosion.

Some malfunctions, such as those by components attacked by visible corrosion, are obvious and usually easy to locate. Other circuit malfunctions, such as reduced signal strength, may require sensitive test equipment to detect and

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isolate the fault affecting the circuit. Much more difficult to isolate, however, are intermittent signals and current leakages to undesired locations or components. Contaminants, the causes of corrosion, are often the unknown and unseen reasons for early system malfunctions. Contaminants and moisture can combine to create acids or electrolytes that have corrosive effects on components. Cleanliness of avionics components is the key to preventing this condition. To have a relevant avionics corrosion control program, maintenance personnel at all levels must emphasize cleanliness.

CORROSION PROCESS

Metals corrosion is the deterioration of metals as they combine with oxygen to form metallic oxides. This combining is a chemical process which is essentially the reverse of the process of smelting the metals from their ores. Very few metals occur in nature in the pure state. For the most part, metals occur naturally as metallic oxides. These oxides may also be mixed with other undesirable impurities in the ores. The refining processes generally involve the extraction of relatively pure metal from its ore and the addition of other elements (either metallic or nonmetallic) to form alloys. Alloying constituents are added to base metals to develop a variety of useful properties. For example, in aircraft structural applications, high strength-to-weight ratios are the most desirable properties in all alloys.

After refining, regardless of whether or not alloyed, base metals possess a potential or tendency to return to their natural state. However, potential is not sufficient in itself to initiate and promote this reversion. There must also exist a corrosive environment, in which the significant element is oxygen. The process of oxidation-combining with oxygen-causes wood to rot or burn and metals to corrode.

CORROSION CONTROL

Control of corrosion depends upon maintaining a separation between susceptible alloys and the corrosive environment. The metals are protected in various ways. A good intact coat of paint provides almost all of the corrosion protection on Coast Guard aircraft. Sealants are used at seams and joints to prevent entry of moisture into the aircraft; preservatives are used on unpainted areas of working parts; and shrouds, covers, caps, and other mechanical equipment provide varying degrees of protection from corrosive media. None of these, however, provide 100 percent protection in the long run--paint is subject to oxidation and decay through weathering; sealants may work out by vibration or else be eroded by rain and windblast. Preservatives at best offer only temporary protection when used on operating aircraft, and the mechanical coverings are subject to improper installation and neglect. Control of corrosion properly begins with an understanding of the causes and nature of this phenomenon.

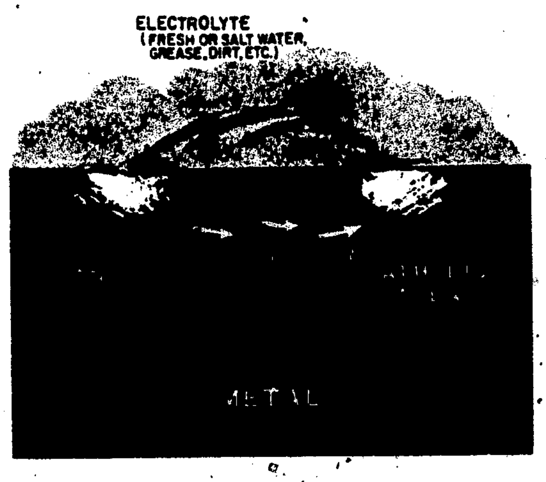

Figure 1. — Simplified corrosion cell.

THEORY OF CORROSION

Engineers have established that corrosion of metals is accompanied by both a chemical change and the production of electrical energy. This information has led to the general acceptance of the electrochemical theory of corrosion. According to this theory, corrosion is caused by electrochemical or direct chemical reaction of a metal with other elements. In the direct chemical attack, the reaction is similar to that which occurs when acid is applied to bare metal. Corrosion in its most familiar form is a

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reaction between metal and water and is electrochemical in nature.

In the electrochemical attack, metals of different electrical potential are involved, and they need not be in direct contact. For example, let's consider two metals. One metal contains positively charged ions, and the other contains negatively charged ions. When an electrical conductor is bridged between the two metals, current will flow as in the discharge of a dry cell battery. In electrochemical corrosion, the conductor bridge may be any foreign material such as water, dirt, grease, or any debris that is capable of acting as an electrolyte. The presence of salt in any of the foregoing mediums tends to accelerate the current flow and hence speed the rate of corrosive attack.

Once the electrical couple is made, the electron flow is established in the direction of the negatively charged metal (cathode). The positively charged metal (anode) is eventually destroyed. All preventive measures for corrosion control are designed primarily to prevent the establishment of the electrical circuit. However, if the circuit is established, it should be removed as soon as possible before serious damage can result. Figure 1 shows the electron flow in a corrosive environment; the anodic area is being destroyed. Note that the surface of a metal, especially alloys of the metal, may contain anodic and cathodic areas. These areas are due to impurities or alloying constituents which have different potentials than the base metal.

The evidence of electrochemical attack is in several forms. The form depends upon the metal involved, its size and shape, its specific function, atmospheric conditions, and the type of corrosion-producing agent (electrolyte) present. A great deal is known about many forms of metals deterioration resulting from electrochemical attack. But despite extensive research and experimentation, there is still much to be learned about other, more complex and subtle forms. Later in this section, we will discuss the common forms of corrosion found on airframe structures and components.

Many factors contribute to corrosion. When selecting materials, the aircraft manufacturer's primary consideration must be weight versus strength. Corrosion properties of the materials should be a secondary consideration. In the interest of aerodynamic efficiency, even the number of drain holes is limited until accumulated operational data shows a greater drain requirement. During aircraft design and production, close attention is also given to heat treating and annealing procedures, protective coatings, choice and application of moisture barrier materials, dissimilar metals contact, and access doors and plates. In other words, aircraft manufacturers take every logical precaution to inhibit the onset and spread of corrosive attack.

There are many factors that affect the type, speed, cause, and seriousness of metal corrosion. Some of these corrosion factors can be controlled; others cannot. Preventive maintenance factors such as inspection, cleaning, painting, and preservation are within the control of the operating unit. These factors offer the most positive means of corrosion deterrence.

The electrochemical reaction which causes metal to corrode is a much more serious factor under wet, humid conditions. The salt in sea water and in the air is the greatest single cause of aircraft corrosion. Hot climates speed the corrosion process because the electrochemical reaction develops fastest in a warm solution. Warm moisture in the air is usually sufficient to start corrosion if the metals are uncoated. As would be expected, hot dry climates usually provide relief from constant corrosion problems. Extremely cold climates produce corrosion problems if a salt atmosphere is present. Melting snow or ice provides the necessary water to begin the electrochemical reaction.

Thick structural sections of material are subject to corrosive attack because of possible variations in their composition, particularly if the sections were heat treated during fabrication. Similarly, when large sections are machined or cut out after heat treatment, thinner sections have different physical characteristics than the thicker areas. In most cases, a difference in physical characteristics provides enough difference in electrical potential to render the piece highly susceptible to corrosion. Another corrosion factor regarding size of materials lies in the area relationship between dissimilar metals. For example, assume that two dissimilar metals are used where possible contact may develop. If the more active metal is small, compared to the less active one, corrosive attack will

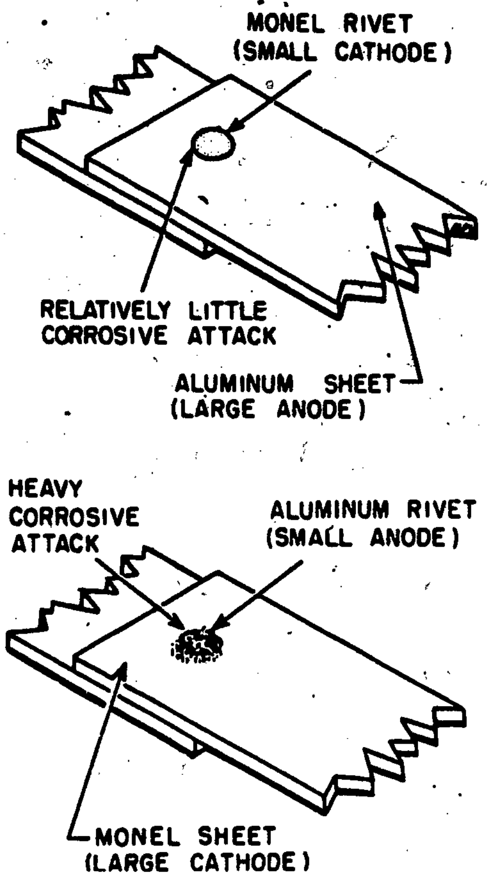

Figure 2. — Effects of area relationships in dissimilar metal contacts.

be severe and extensive if the insulation fails. If the area of the less active metal is small compared to the other, anodic attack is relatively slight. Figure 2 illustrates this factor.

One of the biggest problems in corrosion control is in knowing what materials to use, where to find them, and what their limitations are. Materials used should be covered and controlled by military specifications; the preferred materials are those authorized specifically for use on aircraft. Materials, methods, and techniques used in corrosion control are discussed in many directives and instructions. This information is constantly being revised as better chemicals and protective methods are developed. The following sources of information should be readily available in every unit's technical library or in the various maintenance shops.

1. Aircraft Cleaning and Corrosion Control for Organizational and Intermediate Maintenance Levels, NAVAIR 01-1A-509.

2. Cleaning of Aerospace Equipment, T.O. 1-1-1.

3. Corrosion Prevention and Control for Aerospace Equipment, T.O. 1-1-2.

4. Preservation of Naval Aircraft, NAVAIR 15-01-500.

5. Cleaning of Gas Turbine Engines and Parts, T.O. 2J-1-18.

6. Corrosion Control of Gas Turbine Engines, T.O. 2J-1-18.

7. Preservation of Aircraft Engines, NAVAIR 15-02-500.

8. Manual for Prevention and Control of Corrosion and Fungus in Communications, Electronic, and Meteorological Equipment, T.O. 1-1-689.

9. Aviation Life Support Systems Manual, CG-429.

10. Chart-Cleaning Materials for Naval Air Systems - Maintenance and Overhaul Operations, NAVAIR 07-1-503.

11. Chart-Corrosion Preventive Compounds Used by Naval Air Systems Command, NAVAIR 01-1A-518.

12. Corrosion Control, Cleaning, Painting, and Decontamination. (One volume of the Maintenance Instructions Manuals for all late-model aircraft discusses these subjects.)

13. Periodic Maintenance Requirements Cards and CMS Maintenance Procedure Cards (as applicable).

FORMS OF CORROSION

Corrosion is visible in many forms and is typed in various ways. For descriptive purposes, the forms are discussed under their commonly accepted titles: uniform etch, pitting, intergranular, exfoliation, galvanic, concentration cell, stress, and fatigue.

UNIFORM ETCH

Uniform etch corrosion is a result of a direct chemical attack on a metal surface. These chemical attacks may be from salts deposited from coastal operations, urine spray, battery acid spillage, or gases absorbed from the environment. Three factors that can result in a cyclical action of this type of corrosion are: (1) chemical, (2) water, and (3) oxygen.

Let's use carbon dioxide and iron in our example of a possible uniform etch reaction. The carbon dioxide reacts with water to form carbonic acid. The carbonic acid reacts with the iron to form ferrous ions. The oxygen in the solution oxidized the ferrous ions to ferric ions. This action sets the carbon dioxide free. The hydrogen has also been oxidized to form water. Now the carbon dioxide and water can recombine and repeat their corrosive cycle.

On a polished surface, uniform etch is first seen as a general dulling of the surface. If such corrosion is allowed to continue, the surface becomes rough and possibly frosted in appearance.

PITTING

Some factors influence the uniform destruction of metal surfaces, whereas other factors influence the localized attack commonly called pitting corrosion. This localized attack can be attributed to any of the factors, previously discussed, which alter the size of the anodic or cathodic areas on a metal surface. Small, evenly distributed anodic and cathodic areas result in uniform corrosion, whereas large areas of either produce pitting corrosion.

Pitting corrosion of aluminim or magnesium is first noticed as white or grey powdery deposits that blotch the metal surface. The pitting of iron will produce red and brown deposits. When these deposits are cleaned away, tiny pits or holes may be found.

INTERGRANULAR

Intergranular corrosion is a selective attack along the grain boundaries of a metal. A highly magnified cross-section of an alloyed metal shows the granular structure of that metal.

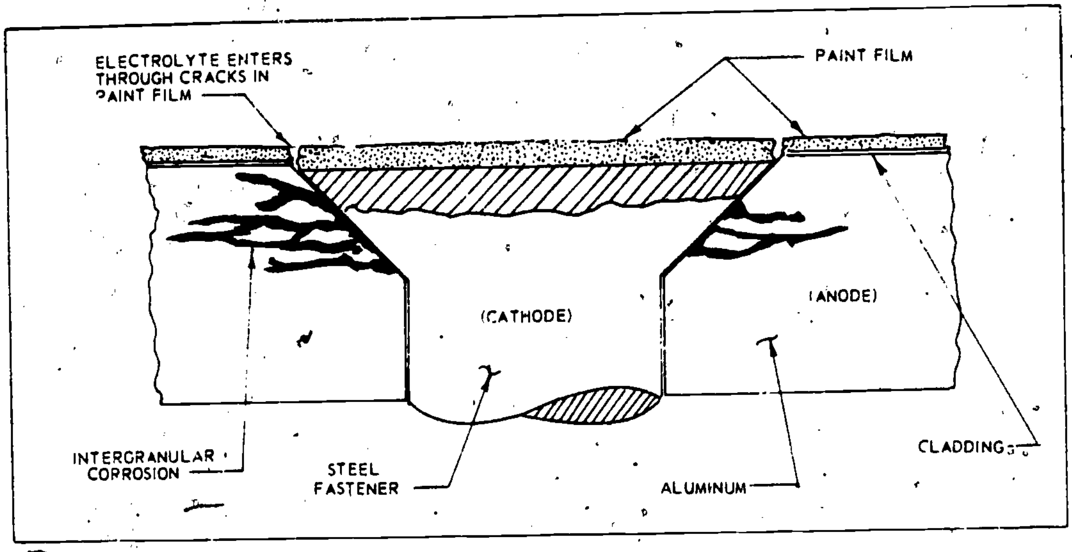

Figure 3. — Intergranular corrosion of aluminum adjacent to a steel fastener.

This structure consists of quantities of individual grains, each grain having a definite grain boundary.

Intergranular corrosion, as shown in figure 3, is caused by the alloying elements precipitating out of the grain into or near the grain boundary. The grain, losing its alloying elements, becomes anodic to the surrounding grains. In the presence of an electrolyte, current flows and rapid intergranular corrosion occurs.

EXFOLIATION

Exfoliation corrosion is a visible form of intergranular corrosion. The expanding corrosion products, just below the metal surface, cause a blister to form. Exfoliation corrosion is usually found on extruded metals. The blisters generally appear where the extruding dies have forced the metal crystal structure to change direction.

GALVANIC

The theory of galvanic corrosion is fully explained by the electrochemical theory of corrosion. When two dissimilar metals are coupled together in the presence of an electrolyte, galvanic corrosion occurs. Galvanic corrosion is usually recognized by the presence of the corrosion deposits at the place where the metals are joined together. A prime example is a brass bolt attached to an aluminum panel, as shown in figure 4.

All commonly used metals cause magnesiun to corrode. Therefore, metals or fasteners that are to be in contact with magnesium should be close to magnesium in electrical potential.

The groups of metals and alloys shown in table 1 are considered to be similar in potential in each group. The combining of metals within a group usually reduces the rate of galvanic corrosion, whereas the combining of metals from different groups increases the rate of corrosion.

When practical, use rivets, bolts, and nuts that are of the same material as the main structure. When it is not possible to use the same material, use sacrificial washers, insulating tape or sealant to isolate the galvanic couple.

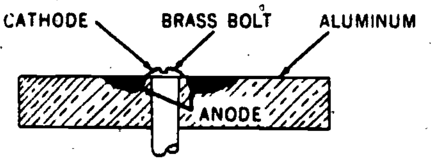

Figure 4. — Galvanic corrosion.

TABLE 1
Grouping of Metals and Alloys

Group I	Magnesium and its alloys.
Group II	Cadmium, Zinc, and Aluminum and their alloys (including the aluminum alloys in Group I).
Group III	Iron, Lead, and Tin and their alloys (except stainless steel).
Group IV	Copper, Chromium, Nickel, Silver, Gold, Platinum, Titanium, Cobalt, and Rhodium and their alloys; Stainless Steel and Graphite.

1. Metals classified in the same group are considered similar to one another.
2. Metals classified in different groups are considered dissimilar to one another.

Galvanic corrosion is not limited to easily recognizable dissimilarities. It can also occur in the following examples:

1. New metal is anodic to old metal.

2. Cut surfaces are anodic to normal surfaces.

3. Stressed surfaces are anodic to non-stressed surfaces.

4. Surface imperfections and impurities are anodic to normal surfaces.

CONCENTRATION CELL

Just as two dissimilar metals joined together will cause corrosion, so will dissimilar conditions within the electrolyte cause corrosion. This may be due to different substances in the solution or to varying concentrations of these substances. Generally, metals in more concentrated solutions will be anodic to metals in contact with the diluted part of the solution. Concentration cells are formed whenever the dissolved oxygen is not uniform throughout the entire solution.

STRESS CORROSION

Stress corrosion is produced by the simultaneous effects of tensile stress and a corrosive environment. When a part in a stressed condition is in contact with an electrolyte, severe corrosion can occur. This happens because the stressed area of a part is anodic to an unstressed area.

Internal stresses may be produced by nonuniform deformation during cold working, such as bending a piece of metal, driving rivets, bolting, or by press fitting. Any metal that has been cold-worked should be stress relieved (annealed) before being subjected to a corrosive environment.

Generally, stresses in the neighborhood of the yield strength of the metal are necessary to cause stress corrosion cracking. When a crack appears, it usually runs parallel to the granular structure of the metal.

FATIGUE CORROSION

Fatigue corrosion is a special form of stress corrosion. It is produced by the effects of an alternating cycle stress and a corrosive environment. Fatigue corrosion failure generally occurs in two stages. During the first stage, the combined action of corrosion and the cyclic stresses damages the metal by forming pits. Any further cyclic action causes the stresses to concentrate in the vicinity of these pits.

In the second stage, the concentration of stresses causes cracks to develop in the base of the pits. The cracks develop rapidly and gradually penetrate the section until fracture occurs, as shown in figure 5. Fatigue corrosion cracks are different from stress corrosion cracks in that fatigue cracks generally run across the granular structure of the metal.

Generally, fatigue corrosion cracking occurs far below the normal design fatigue limits of the metals. This happens even though there is little evidence of actual corrosion. For this reason, metals subjected to alternating cyclic stresses must be protected, even in mildly corrosive environments.

We will discuss the forms of corrosion in greater detail in another section of this pamphlet.

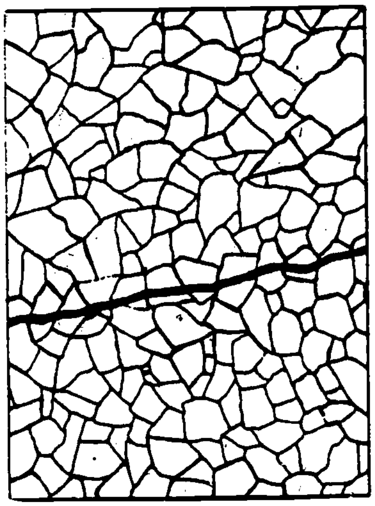

Figure 5. — Fatigue corrosion.

SELF-QUIZ #1

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the objectives of this reading assignment, the text, and the points of knowledge tested in this self-quiz. To pass the EOCT, you must study all the course material.

1. What is the key to preventing contaminant corrosion that causes intermittent signals and current leakages in electronic systems?

2. Metals corrosion is the deterioration of metals as they combine with ______.

3. All corrosion control measures are designed to prevent the establishment of an ______ between metals.

4. At an operating unit, the MOST positive means of corrosion deterrence is inspection, cleaning, painting, and ______.

5. The electrochemical reaction which causes metal corrosion is greatly increased under ______ conditions.

6. Two dissimilar metals are in contact. If the smaller metal is more active than the larger metal, the corrosive attack will be ______.

7. The result of a direct chemical attack on a metal surface is ______ corrosion.

8. What type of corrosive attack first appears as a white or grey powdery deposit that blotches the metal surface of aluminum or magnesium?

9. A corrosive attack along the grain boundaries of a metal is ______ corrosion.

10. Exfoliation corrosion, which is a blister on the metal surface, is a visible form of ______ corrosion.

11. What type of corrosion forms around the head of a brass screw in an aluminum panel?

12. Concentration cell corrosion is caused by differing conditions within an ______.

13. When a metal part in a stressed condition is in contact with an electrolyte, what form of corrosion results?

14. A metal part undergoing alternating cyclic stresses in a corrosive environment is affected by ______ corrosion.

ANSWERS TO SELF-QUIZ #1

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

1. Cleanliness (Page 2)
2. oxygen (Page 2)
3. electrical circuit (Page 3)
4. preservation (Page 3)
5. wet, humid (Page 3)
6. severe (Page 3)
7. uniform etch (Page 5)
8. Pitting corrosion (Page 5)
9. intergranular (Page 5)
10. intergranular (Page 6)
11. Galvanic (Page 6)
12. electrolyte (Page 7)
13. Stress (Page 7)
14. fatigue (Page 7)

113

INSPECTING FOR CORROSION

OBJECTIVES

When you complete this section, you will be able to:

1. Describe the visible forms of corrosion on unpainted and painted surfaces.
2. Explain how to use a dial indicator to determine the extent of corrosion.
3. Identify the aircraft areas which are highly susceptible to corrosion.

INTRODUCTION

No matter how we stress the effects of corrosion on various metals, equipment still comes into our shops for major repairs because of corrosion damage. This problem can be prevented if corrosion is detected in its early stages.

Minor corrosion in undetected areas may soon create safety hazards or cause equipment to function improperly. If corrosion is uncontrolled, it may develop into major repairs or complete loss of equipment. Corrosion must be detected and controlled at the unit level. For this reason, units must perform a definite, scheduled inspection.

Even with a scheduled inspection, our corrosion problems will not be solved unless you are aware of the areas that are prone to corrosion and know what to look for in these areas. Naturally, there are directives telling us to inspect certain areas—exhaust path, urine spray, and such—at frequent intervals. But what about other areas that are highly prone to corrosion? They are often easy to overlook or forget. One of these areas is avionics equipment.

Corrosive attack on avionics materials can have severe effects on computer, radar, electrical, instrument, and COM/NAV systems. Typical effects to avionics equipment subjected to corrosion are as follows:

1. Connectors, plugs, jacks, cables. Corroded pins, contacts, shells, wires, disintegrating insulation, components may open/close. (Figure 6)

2. Relays, switches, pilot lamp/indication systems. Contacts, mechanical action impaired. Corroded sockets and lamp bases.

3. Motors. Intermittent operation or improper positioning.

4. Antenna systems. Shorts or changes in circuit constants, presence of moisture, internal pitting of walls and joints, reduced effectiveness of gaskets, damage or loss of finish.

One of the most corrosion-prone components of avionics equipment is the antenna. Frequently, it is the last component to be suspected in response to flightcrew complaints. Yet, the antenna has often been the reason transmitters/receivers are pulled, bench-tested, found operational and, in many cases, returned and reinstalled without further troubleshooting. Such discrepancies are subsequently chalked up to crew error. Corrosion on antennas has been known to cause a system to malfunction during bad weather, yet operate normally during good weather.

Antenna and antenna mount corrosion is especially common to pressurized aircraft, particularly in lower fuselage installations. Figures 7 and 8 are examples of radome separation caused by corrosion. It is a fact of life that fluids will collect in the lower bilges of aircraft. Upon pressurization, liquid contaminants such as water, oil, hydraulic fluid, etc. are forced into every available crack, crevice, or fitting. In some of these locations, waiting for destruction by corrosion, are the inverted antenna bottom, antenna mount fasteners, and associated connectors and cables.

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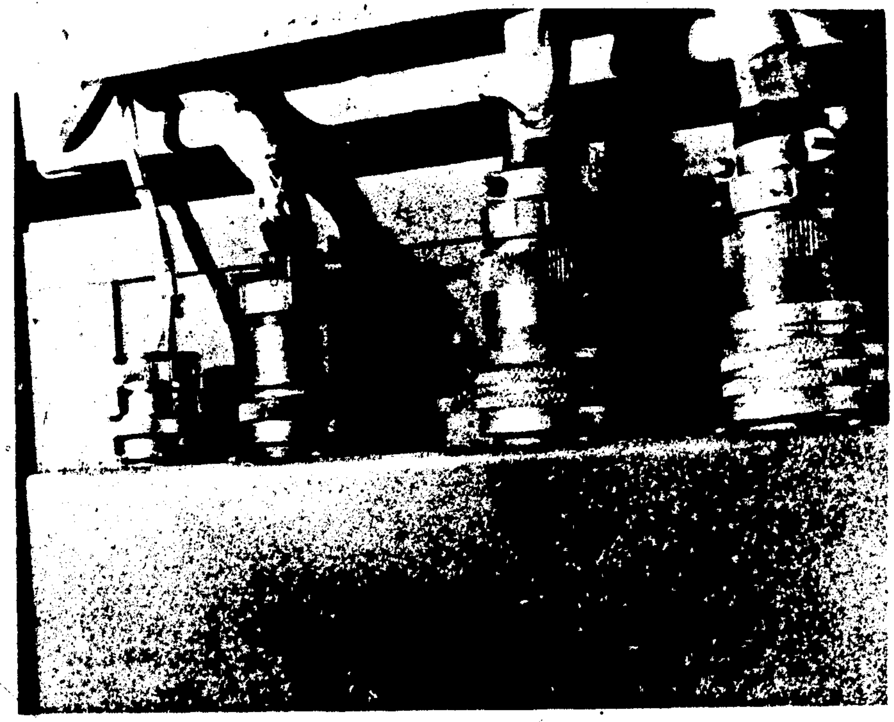

Figure 6. — Corrosive pitting is readily visible on these external connectors.

Figure 7. — Corrosion-caused radome separation.

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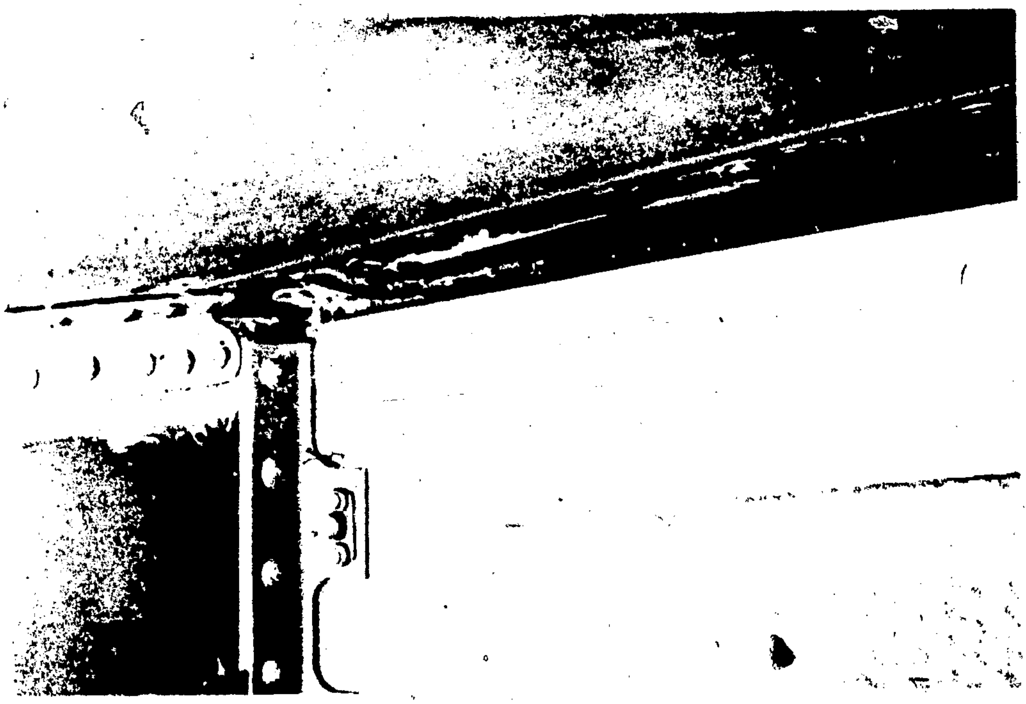

Figure 8. — Corrosion-caused radome deterioration and separation.

The lower fuselage antennas of nonpressurized aircraft are subjected to the same problems; the corrosion process just takes a little longer to become established.

5. Chassis, housing, mounting frames, or access panels. Infected with contaminants, pitted, loss of finish.

Chassis serve as mounting panels for most electronic components that interconnect to form an avionic unit. These chassis are also prime targets for corrosion. While a faulty component is being located and replaced, the chassis also is being subjected to handling abrasion, solder splashes, solder flux, etc. Each of these conditions could result in corrosion development. The avionic chassis, with all its crevices, nooks, and crannies, is a prime collecting ground for infiltrating, airborne contaminants.

Protective finishes on access panels or covers are particularly vulnerable to damage. If left untreated, the damage results in corrosion. In addition, salts and moisture from perspiration deposited on damaged covers can also promote corrosion.

6. Water traps. Excessive moisture forming at a rate faster than can be evaporated.

During maintenance, avionic system integrity is broken while a defective assembly is being replaced. In addition, seals are often left open for extended periods of time until a replacement is received. Not only is the equipment exposed to microscopic and contaminating debris, but condensation is likely to form inside the equipment. This condensation forms when systems cool after sitting in a hot/humid area. If possible, before equipment is removed from the aircraft, a replacement should be on hand for immediate installation. If a replacement is not available, plastic caps should be used as a temporary measure to seal off necessary openings. Plastic caps will not prevent the formation of moisture, but they will inhibit the intrusion of solid/microscopic contaminants. If adhesive tape is used in the absence of plastic caps, all residue from the tape must be removed from all connecting surfaces before reassembly.

As you can see, corrosion can cause problems in many areas of the aircraft. To help you learn to control corrosion in its early stages, we will discuss the techniques of detecting corrosion in areas that are highly subject to corrosion.

CORROSION DETECTION TECHNIQUES

Unfortunately, corrosion detection cannot be automated or based upon a rigid system of preconceived judgments. Therefore, we must rely on a personal visual inspection to identify the type of corrosion reaction and proficient use of corrosion inspection equipment to arrive at a proper course of action.

IDENTIFICATION OF THE TYPE OF CORROSION

During your corrosion inspection, you must be able to identify the type of corrosion that has occurred. Being able to identify the type of reaction and its location will assist you in determining the severity of the attack.

Unpainted Surfaces

Uniform Etch

A chemical directly attacking a metal surface will produce uniform etch corrosion. If the surface of the metal is highly polished, or if the anodic and cathodic areas are nearly equal, the corrosion will be evenly distributed over the entire surface. Uniform etch corrosion is first noticed as a general dulling of the surface. If the corrosion is allowed to continue, the surface will become rough and frosted in appearance.

Pitting

Pitting corrosion is the localized attack caused by differences in potential on the metal surface in the presence of an electrolyte. This corrosion is first noticeable by the white or grey powdery deposits that blotch the surface of aluminum or magnesium or by red or brown deposits on steels. When the deposits are brushed away, tiny holes or pits may be found. These holes may vary from deep pits of small diameter to relatively shallow depressions. Although pitting may occur in any metal system, it is particularly characteristic of magnesium and aluminum alloys, steels, and stainless steel.

Intergranular

Intergranular corrosion is the destructive corrosive action taking place within the metal's grain structure. This action is due to differences in the potentials of the metal's grains and the presence of an electrolyte. Intergranular corrosion is the most serious type of corrosion in that it is generally not seen until the metal has failed. Intergranular corrosion may be found in unusual cases by examining the edge surfaces of metals, e.g., cut edges or fastener holes.

Exfoliation

Exfoliation corrosion is also the result of the corrosive attack along the grain boundaries of a metal. This corrosion is generally not as serious as intergranular corrosion in that the attack is just below the surface and shows itself by lifting of the surface. The lifted surface is easy to detect. After the surface lifts or bulges, it falls away or peels off in flakes, layers, or scales. This action occurs when the grains of a metal are greatly elongated in one direction. When examined under a microscope, the layers of intergranular attack will appear as a definite separation of the grain layers. This layered structure is typical of that found in most aluminum alloy skins, piano hinges, wing blankets, and certain areas of extrusions such as those used for spars and longerons.

Exfoliation is also found on extrusions, near the radii where the grain changes direction, or near a fastener installation. This type of corrosion is insidious in nature: in some cases serious structural weakening may occur before an appreciable amount of corrosion product accumulates on the surface metal.

Galvanic

Galvanic corrosion occurs when two dissimilar metals are in contact in the presence of an electrolyte. About 90 percent of an aircraft is constructed by the use of the alumimum alloys. These aluminum alloys are anodic to most of the other metals that are used. One aluminum alloy may also be anodic to another aluminum alloy, so the tendency for galvanic corrosion is always present on any aircraft surface.

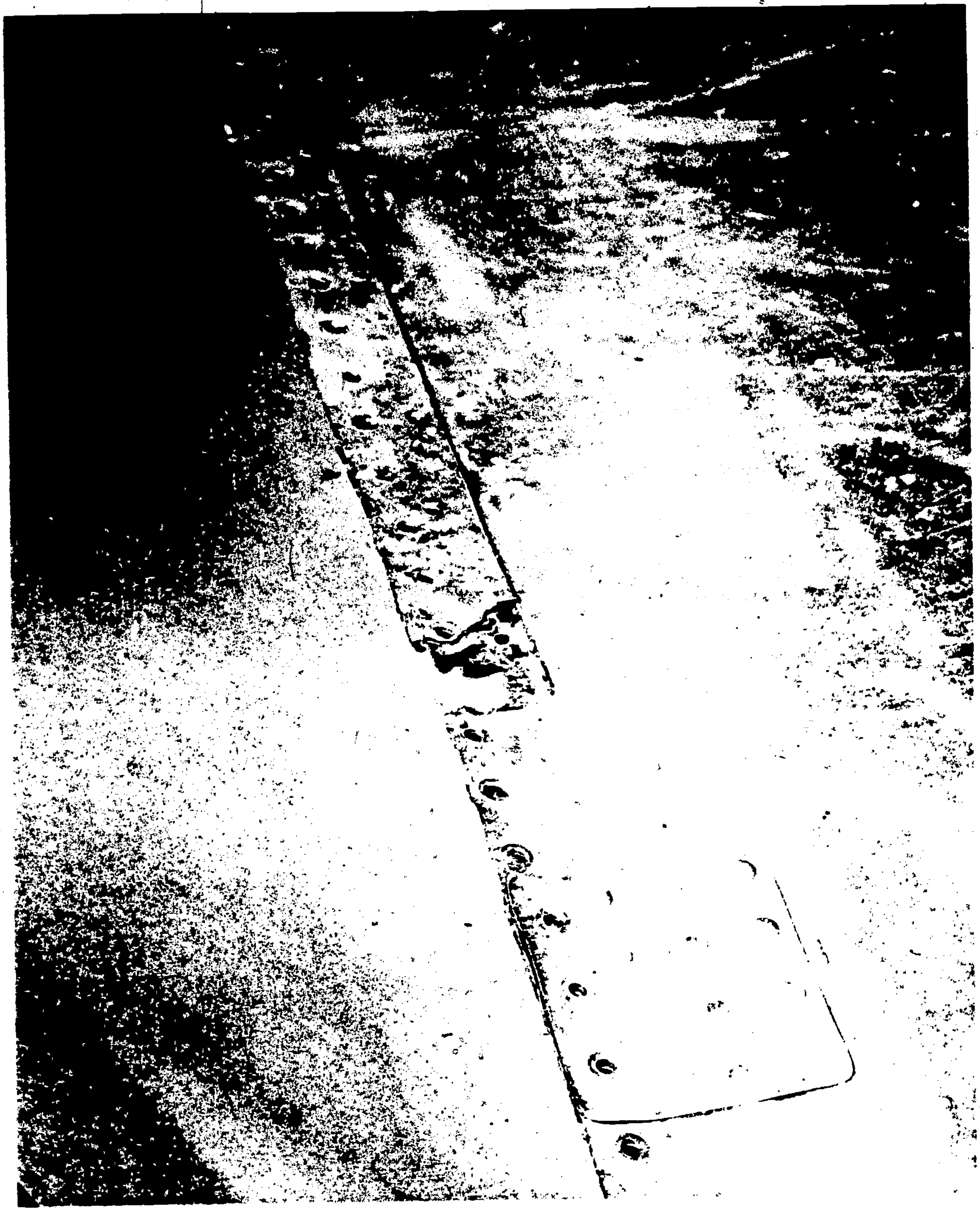

Figure 9. — Galvanic corrosion.

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Contact of aluminum with copper or its alloys will cause a more severe galvanic attack than contact with the other common metals. Contact with steel will cause moderate corrosion of the aluminum in most atmospheres, whereas contact with corrosion-resistant steels will be less harmful than common steels. Magnesium and its alloys are anodic to the aluminum alloys. Therefore, contacts of this nature will cause severe galvanic corrosion of the magnesium. However, such contact may also be harmful to the aluminum because magnesium may generate enough current to cause cathodic corrosion of the aluminum.

You may expect to find galvanic corrosion at any place on aircraft equipment where two dissimilar metals are joined together. (See figure 9). Be especially alert for corrosion deposits, e.g., red, grey, white, or brown around crevices, lap joints, and fasteners.

Concentration Cell

Concentration cell corrosion may be found wherever different areas on the metal are in contact with different concentrations of the same solution. Metal ion or oxygen cells may be found along a riveted lap joint. The cells will first be noticed by a buildup of familiar corrosion deposits. Active-passive cells may be found on unpainted metal surfaces that rely on a tightly adherent oxide film for corrosion prevention; such metals are clad aluminum, titanium, and corrosion-resistant steels. If these surfaces are allowed to collect mud or exhaust deposits, you may expect active-passive cells to form. When the deposits are cleaned away, tiny pits may be found in the metal.

Stress and Fatigue

Stress and fatigue corrosion is the result of applied stresses in conjunction with a corrosive medium. Generally the failure of parts subjected to either stress or fatigue corrosion starts as a simple electrochemical cell forming a pit. This causes the cycle or tensile stresses to concentrate in the area of the pit and a small crack to form. The cracks may follow grain boundaries or may go across grains. Here are some examples of parts susceptible to stress corrosion cracking: aluminum alloy bellcranks employing pressed-in taperpins, landing-gear shock struts with pipe-thread-type grease fittings, clevis joints, shrink fits, and exposed or overstressed tubing B-nuts. The corrosive medium then attacks the small crack, and the cycle is repeated until the part fails.

Failure is so far below the yield strength of the metal that corrosion deposits do not have time to form before the actual fracture occurs. For this reason, areas subjected to repeated stresses must be closely inspected for any evidence of pit formation.

Fatigue corrosion attack is characteristic of any part under regular cyclic stressing, such as the walls of a cylinder in an engine. The walls are subjected to cyclic explosions of the fuel mixture. Once attack begins, continuous flexing prevents the repair of protective surface coatings, and additional corrosion takes place in the area of stress. It is difficult to detect this type of attack except as cracking develops. Frequently, by the time the corrosion is noted, the only solution is replacement of the part.

Painted Surfaces

Corrosion on painted aircraft or equipment surfaces is hard to detect until the organic coating has failed. Corrosion may attack protected metals if moisture is allowed to penetrate the organic coating. If corrosion has occurred, the results may be shown as a discoloration of the paint. For this reason, any painted area where the paint is discolored must be inspected for moisture entrance holes and possible corrosion. Paint removal reveals the full extent of corrosion as shown in figure 10.

CORROSION INSPECTION EQUIPMENT

An item of equipment that you will be using in corrosion inspections is the dial indicator.

Dial Indicators

Dial indicators are used to measure the depth of corrosion pits. The purpose of measuring the depth of pits is to determine the extent of the corrosion that is present. If the pits are within allowable tolerances, as given in a specific aircraft publication, the area can be cleaned up in an acceptable manner. If the

Figure 10. — Paint removal reveals the full extent of corrosion.

pits are not within allowable tolerances, the part must be replaced.

Dial indicators are mechanical motion amplifying devices. Very little movement of the contact point results in amplified movement of the pointer. The graduated dial behind the pointer designates the values for a given amount of pointer movement. The dial indicator must be used with one of its varied supports.

Dial indicators are useful when mounted and positioned relative to an established surface. The supporting block provides the reference surface or master standard from which measurements are taken. By using a tapered contact point, you can set the dial indicator to measure the depth of grooves, pits, and recesses.

Set the gage at zero before trying to measure any pit depths. To zero the gage, loosen the bezel lock, shown in figure 11, and rotate the bezel until the pointer is on zero. Place the support block over the pitted area and insert the dial indicator into the block. With the tapered contact point in a pit, apply enough pressure to the dial indicator to move the pointer. Holding the indicator in this position, tighten the support block screw. This locks the unit to the support block. You are now ready to take further readings.

Place the support block over the corroded area and take readings at points A, B, and C, as shown in figure 12. By extending the contact point to the bottom of the pit, we obtain a reading of 0.0140 inch. Notice the positions and readings of the revolution counter and indicating hand in figure 12. The revolution counter indicates the number of times the indicating hand has made one complete revolution. In this case the indicating hand has made one complete revolution plus 0.0040 inch; thus our reading of 0.0140 inch. If the readings at A and B were, respectively, 0.0190 inch and 0.0188 inch, and using the C reading above, the depth of the pit would be 0.0049 inch.

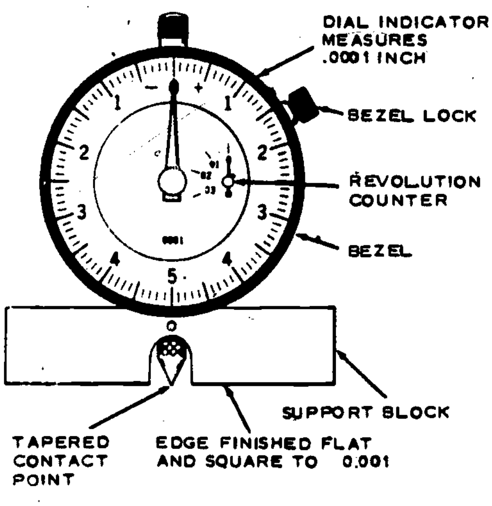

Figure 11. — Dial indicator.

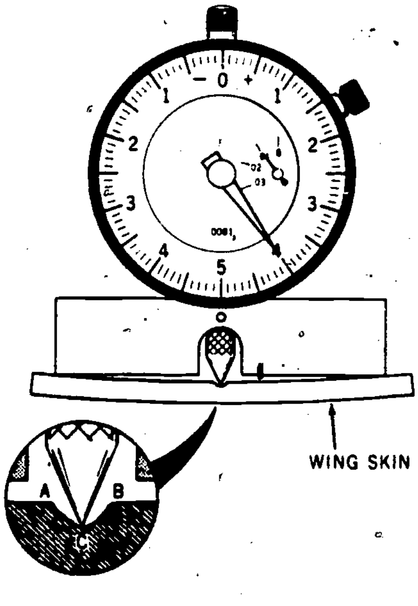

Figure 12. — Measuring depth of corrosion pits.

The maximum pit depth is obtained by subtracting the C reading from the average of the A and B readings. To obtain the average A and B, add the readings and divide by 2. The pit depth is determined by the formula:

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

Using the above readings, let's see how we obtained 0.0049 inch for the depth of pit C. When we substitute our readings in the equation, we have the following problem:

$$\text{Pit depth} = \frac{0.0190'' + 0.0188''}{2} - 0.0140''$$

$$\text{Pit depth} = \frac{0.0378''}{2} - 0.0140''$$

$$\text{Pit depth} = 0.0189'' - 0.0140''$$

$$\text{Pit depth} = 0.0049''$$

Using the formula for determining the pit depth and the dial indicator readings given below, determine the pit depth for problems 1 and 2. Problem 1. The dial indicator readings are as follows:

A = 0.0127''
B = 0.0135''
C = 0.0092''

Problem 2. The dial indicator readings are as follows:

A. 0.0060''
B. 0.0056''
C. 0.0050''

The answer to problem 1 is 0.0039 inch, and the answer to problem 2 is 0.0008 inch.

As a maintenance specialist, you must be able to detect corrosion and determine its severity. The following guidelines may help you perform these tasks:

1. Check defects, especially cracks or other sharp notches, on the surfaces of stressed parts. These defects are more likely to be harmful than any defect found below the surface.

2. Check any defect that occurs at right angles or at a considerable angle to the direction of stress. This defect is more likely to be harmful than a similar defect that occurs in a direction parallel to the direction of stress.

3. Check any defect that occurs in an area of high stress. This defect must be more critically considered than a similar defect that occurs in an area of low stress.

4. Check a crack or defect ending in a sharp notch at its base. This defect is a more serious stress riser than a defect that has a rounded base.

5. Check any defect that occurs at a fillet or at any other highly stressed area because of the design of the part. This defect must be more critically considered than a similar defect that is remote from a highly stressed area.

The preceding general guidelines are based on common sense; you must, however, consider the strength of the part and the conditions it will encounter while it is in service.

You should now be able to identify the various types of corrosion and to use the pit depth indicator to determine the severity of corrosion. Let's discuss the areas where corrosion can most likely be found.

SURFACES SUSCEPTIBLE TO CORROSION

The external and internal surfaces discussed in this section include most of the surfaces common to aircraft equipment. However, this coverage is not necessarily complete and should be modified as necessary to cover the susceptible surfaces of your particular aircraft equipment.

EXTERNAL SURFACES

Some of the more common trouble areas may be grouped under general types of external surfaces.

Magnesium Surfaces

Any inspection for corrosion should include the location and inspection of all magnesium skin surfaces, with special attention given to edges; areas around fasteners; and cracked, chipped, or missing paint.

Aluminum Alloy Surfaces

Sections of heat-treatable aluminum alloys are susceptible to intergranular corrosion and exfoliation of the metal. When inspecting external skin surfaces, look for metal exfoliation, especially around the heads of countersunk fasteners. Treatment of this type of corrosive attack must include the following: (1) remove all layers of exfoliated metal, (2) blend and polish the exposed

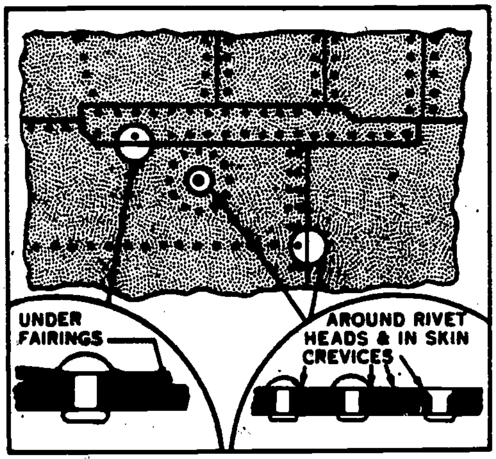

Figure 13. — Exhaust path corrosion areas.

edges of the damaged area, (3) thoroughly soak with a chromic acid inhibitor solution, and (4) restore protective surface finishes. Reworked areas should be kept well protected with a paint coating of standard thickness whenever possible.

Exhaust Paths

Both jet and reciprocating engine exhaust deposits are very corrosive. These deposits are particularly troublesome wherever seams, fairings, and fasteners are located in their paths, as shown in figure 13. Exhaust deposits may be trapped in these areas and not reached by normal cleaning methods. Therefore, exhaust paths must be thoroughly cleaned and inspected at frequent intervals.

JATO Blast Areas

Surfaces located in the path of JATO blasts are particularly subject to attack and deterioration. In addition to the corrosive effect of the gases and exhaust deposits, the protective finish is very often blistered by heat, blasted away by the high-velocity gases, or abraded by solid particles from JATO exhausts. These areas should be watched for corrosion and cleaned carefully after firing operations.

Engine Frontal Areas and Air Vents

These areas and vents are being constantly abraded with airborne dirt and dust, bits of gravel from runways, and rain erosion. All of these conditions tend to remove the protective finish. In addition, due to heat dissipation requirements, the cooler radiator cores, reciprocating engine cylinder fins, etc., are not painted. Engine accessory mounting bases usually have small areas of unpainted magnesium or aluminum on the machined mounting surfaces. The constant flow of moist air over these surfaces makes them prime sources of corrosive attack. When you inspect such areas, you should include all sections in the cooling path.

Spot-Welds

Corrosion of spot-welded materials is chiefly the result of the entrance and entrapment of corrosive agents between the layers of metal. Some of the corrosion may be caused originally by the fabrication process. However, corrosion that progresses to the point of skin bulging and spot-weld fracture is the direct result of moisture working its way in through open gaps and seams. This condition is illustrated in figure 14.

This type of corrosion should first be evidenced by corrosion products appearing at the crevices through which the corrosive agents enter. Corrosion may appear at other external or internal faying surfaces but is usually more prevalent on external areas. More advanced corrosive attack causes skin bulging and eventual spot-weld fracture.

Skin bulging in its early stages may be detected by sighting along a spot-weld seam or by using a straightedge. The only way to prevent

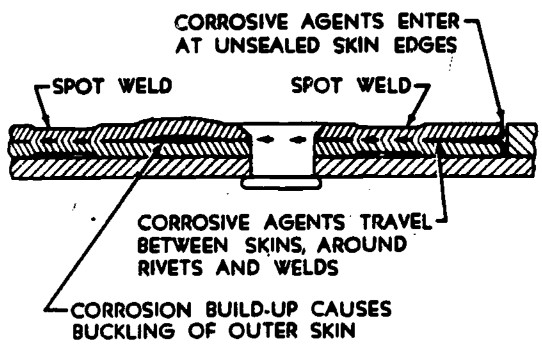

Figure 14. — Corrosion of spot-welded metals.

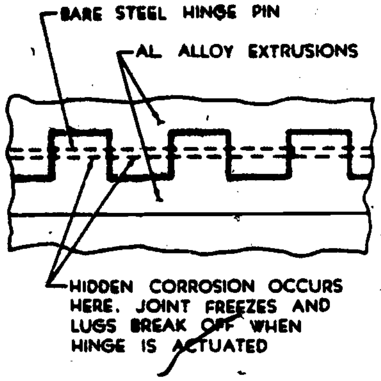

Figure 15. — Corrosion of piano hinges.

this condition is to keep potential moisture entry points filled with a sealant or a suitable preservative compound. These entry points include gaps, seams, and holes created by broken spot-welds.

Piano Hinges

The effect of corrosion on piano hinges is still a problem on aircraft. These areas are prime spots for corrosion due to the dissimilar metal contact between the steel pin and aluminum hinge tangs. Piano hinges are also natural traps for dirt, salt, and moisture. The areas where hidden corrosion occurs are shown in figure 15. When such hinges are used on access doors or plates that are actuated only during periodic checks, they tend to freeze in place between inspections. Inspection of hinges includes lubrication and actuation through several cycles to ensure complete penetration of the lubricant.

Miscellaneous Trouble Areas

Trimmed edges of panels and drilled holes should have some type of corrosion protection. A brush treatment with an inhibitor solution or the application of a sealant along the edge, or both, is recommended. Any gaps or cavities where water, dirt, or other foreign material can be trapped should be filled with a sealant. The adjacent structure should have sufficient drain holes to prevent water accumulation. Damage or punctures in panels should be sealed as soon as possible to prevent the entry of moisture if a permanent repair has to be delayed.

INTERNAL SURFACES

Internal surfaces are just as susceptible to corrosion as the external surfaces. Therefore, internal surfaces should be inspected just as diligently as external surfaces.

Electronic Compartments

Electronic and electrical package compartments are cooled by ram air or compressor bleed air. Therefore, these compartments are subjected to the same conditions as engine and accessory cooling vents and engine frontal areas. The degree of exposure is less because a smaller volume of air passes through the compartments. Also, special design features prevent water from forming or collecting in the enclosed spaces. Nevertheless, these compartments are still trouble areas that require special attention.

Circuit breakers, contact points, and switches are extremely sensitive to moisture and corrosive attack. These components should be inspected for corrosion during routine checks as thoroughly as design permits. Design features may hinder examination of these items while they are installed. In that case, maintenance personnel should take advantage of the components' removal for other reasons to carefully inspect the items.

Conventional corrosion treatment may be detrimental to some electrical and electronic components. Therefore, corrosion in these components should be treated only by or under the direction of personnel familiar with the function of the unit involved.

Battery Compartments

In spite of protective paint systems and extensive sealing and venting provisions, battery compartments continue to be corrosion problem areas. Fumes from an overheated battery electrolyte are difficult to contain and will spread to all adjacent internal cavities, causing rapid corrosive attack on unprotected surfaces. If the openings are on the skin surfaces, these areas should also be included as a part of the battery compartment inspection and maintenance procedure. Frequent cleaning and neutralization of acid deposits with a sodium bicarbonate solution will minimize corrosion from this cause.

Lavatories and Galleys

These areas, particularly deck areas behind lavatories, sinks, and ranges where spilled food and waste products may collect, are potential trouble spots if not kept clean. Even if some contaminants are not corrosive in themselves, they will attract and hold moisture, which in turn will cause corrosion. Pay attention to bilge areas located under galleys and lavatories and to personnel relief and waste disposal vents or openings on the aircraft exteriors. Human waste products are very corrosive to the common aircraft metals. Clean these areas frequently and touch up the paint whenever necessary.

Wheel Wells and Landing Gear

The wheel well area probably receives more punishment than any other area on the aircraft. This area is exposed to the mud, water, salt, gravel, and other flying debris from runways during flight operations. Because of the many complicated shapes, assemblies, and fittings in the area, complete coverage with a protective paint film is difficult to attain. During inspection of this area, pay particular attention to the following trouble spots:

1. Magnesium wheels, especially around boltheads, lugs, locking rings, and wheel web areas, particularly for the presence of entrapped water or its effects.

2. Exposed position indicator switches and other electrical equipment.

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

Frequent cleaning, lubrication, and paint touchup are the maintenance needed on aircraft wheels and wheel well areas to keep them from corroding.

Water Entrapment Areas

With the exception of sandwich structures, aircraft design requires drain holes in all areas where water may collect. However, in many cases these drains are ineffective, either because of improper location or because they are plugged. These areas are natural sumps or collection points for waste hydraulic fluids, water, dirt, loose fasteners, drill shavings, and other odds and ends of debris. Residual oil quite often masks small quantities of water which set up hidden corrosion cells. Daily inspection of possible water entrapment areas should be a standard requirement.

As you become proficient in performing corrosion inspections, you can detect corrosion by looking at a piece of equipment. You can form a mental picture of the location of corrosion deposits both on internal and external surfaces. Just remember that corrosion deposits may be found on surfaces where contaminants are allowed to collect, and wherever stagnant water and hydraulic fluids are allowed to collect.

160

SELF-QUIZ #2

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the objectives of this reading assignment, the text, and the points of knowledge tested in this self-quiz. To pass the EOCT, you must study all the course material.

1. Advanced uniform etch corrosion on an aluminum surface appears ______ and ______.

2. The MOST serious type of corrosion is ______.

3. Galvanic corrosion is MOST severe when aluminum is in contact with ______.

4. If a corrosion-resistant steel surface is allowed to collect mud or exhaust deposits, the formation of active-passive cells may cause ______ corrosion.

5. Corrosion beneath the paint coating on a metal surface is FIRST indicated by ______.

6. A dial indicator is used in corrosion control to measure ______.

7. A defect has occurred at right angles to the direction of stress. This defect is likely to be more harmful than a similar defect occurring ______ to the direction of stress.

8. When inspecting external aluminum alloy surfaces, you should look around the heads of countersunk fasteners for ______ corrosion.

9. Why are unpainted surfaces of magnesium or aluminum engine accessory mountings highly susceptible to corrosion?

10. Corrosion of spot-welded metals can be prevented by ______.

11. Why do piano hinges "freeze" in place between inspections?

12. How can you minimize the corrosive effects of battery fumes in areas around a battery compartment?

13. How often should you inspect water entrapment areas?

154

ANSWERS TO SELF-QUIZ #2

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

1. rough and frosted (Page 14)
2. intergranular (Page 14)
3. copper (Page 16)
4. concentration cell (Page 16)
5. discoloration of the paint (Page 16)
6. the depth of corrosion pits (Page 16)
7. parallel (Page 19)
8. exfoliation (Page 19)
9. There is a constant flow of moist air over these surfaces. (Page 20)
10. sealing all gaps, seams, and holes with sealant or preservation compound (Page 21)
11. Because of corrosion caused by dissimilar metal contact and entrapped dirt, salt, and moisture. (Page 21)
12. Frequently clean and neutralize acid deposits. (Page 21)
13. Daily (Page 22)

162

PREVENTIVE MAINTENANCE

OBJECTIVES

When you complete this section, you will be able to:

1. Explain the importance of frequently and properly cleaning an aircraft and its components.
2. State some of the cleaning substances approved for use on aircraft.
3. State the various types of cleaning equipment used to clean aircraft and components.
4. Explain some of the methods and procedures for cleaning aircraft and components.
5. Describe the safety precautions you should observe when using cleaning and paint removing substances.

"An ounce of prevention is worth a pound of cure." Where corrosion prevention on aircraft is concerned, the foregoing cliche is a ridiculous understatement. Compared with the millions of dollars spent for some late model aircraft, the cost of corrosion prevention is a mere pittance. Preventive maintenance is a powerful tool which can be used to effectively control even the most difficult corrosion problems.

Most corrosion prevention programs are adjusted by the operating activity to meet severe conditions aboard ship. The programs are then decreased in scope when the aircraft is returned to the relatively mild conditions prevailing ashore. During emergencies regular corrosion preventive maintenance must sometimes be neglected because of tactical operating requirements. When this happens, a period of intensive care should follow to bring the aircraft back up to standard.

Corrosion prevention measures most commonly taken require that the aircraft be kept as clean as possible and that all surfaces be kept intact. Other requirements include the correct and timely use of covers and shrouds, periodic lubrication, and the application of preservatives where required. Years of experience have proven the need for such measures if the aircraft are to remain airworthy.

When corrosion preventive maintenance is neglected, aircraft soon become unsafe to fly. Units with the best corrosion preventive programs are likely to have the best safety records, most aircraft use, and lowest operating costs.

SURFACE MAINTENANCE

Surface maintenance includes regular cleaning of the aircraft as well as touch-up of protective paint coatings. Paint touch-up is done after removal of corrosion. This does not imply that damaged paint should not be touched up unless corrosion is present. Touch-up of new damage to paint finishes will prevent corrosion from starting.

Aircraft must be kept clean to retain aerodynamic efficiency and safety. Current directives prescribe acceptable materials, methods, and procedures for use in aircraft maintenance cleaning. The guidelines in the directives must be followed. Lack of correct information about materials and equipment can result in serious damage to the aircraft exterior and interior. Shipboard procedures are not necessarily the same as procedures ashore, but the same materials are available. Comparable results are accomplished, although different application methods may be necessary.

How often an aircraft should be cleaned depends on the type of aircraft and the environment in which it has been operating. Cleaning should be repeated as often as necessary to keep the aircraft clean. The aircraft must be cleaned when the following conditions exist: (1) an appreciable amount of soil accumulation within exhaust track areas; (2) the presence of salt deposits or other contaminants such as stack gases; (3) evidence of paint surface deterioration, such as softening, flaking, or peeling; and (4) the presence of excessive oil or exhaust deposits or spilled electrolyte and deposits around battery areas. Cleaning is always mandatory immediately after exposure to fire extinguishing materials, adverse weather conditions, and salt spray. The aircraft must be cleaned after being parked near seawalls during high wind conditions. Cleaning is also required after low-level flight and after repairs or service which has left stains, smudges, or other gross evidence of maintenance. All exposed unpainted surfaces, such as struts and actuating cylinder rods, require a daily cleaning or wipedown.

Aircraft must be thououghly cleaned before being placed in storage and also at the time of depreservation. Unpainted aircraft are cleaned and polished at frequent intervals. Aboard ship, the aircraft must be cleaned and salt deposits removed as soon as possible to prevent corrosion.

Aircraft components which are critically loaded, such as helicopter rotor parts, should be cleaned as often as possible. (Critically loaded components are designed with minimum safety margins to conserve size and weight.) Components and parts exposed to corrosive environments such as engine exhaust gas, acid, or JATO blast are cleaned often to minimize exposure to these agents.

NOTE: Lubrication and preservation of exposed components are necessary to displace any of the cleaning solution entrapped during the cleaning operation.

The integrity of electronic systems should be maintained at all times to avoid the effects of contaminants and fluid/moisture combinations. Components left open for extended periods of time should be thoroughly cleaned before reassembly. When cleaning or purging any assemblies, strictly adhere to the procedures outlined in the current NA 01-1A-509, Aircraft Corrosion Control Manual, T.O. 1-1-1, Cleaning of Aerospace Equipment, and associated MIMs for aircraft.

CLEANING MATERIALS

Only approved cleaning materials may be used on aircraft and components. Approved cleaning materials are made up and compounded to accomplish definite results and are made available only after complete testing and actual field acceptance. All specification materials are inspected and tested before acceptance and delivery to the supply activities. Cleaning agents commonly used by operating units are included in the following categories.

Solvents

Solvents are liquids which dissolve other substances. There are a great number of different solvents, but for cleaning purposes, organic solvents are most often used. Some solvents are chlorinated. Solvents which contain more than 24 percent by volume of chlorinated materials must be kept in specially marked containers. Equipment in which these solvents are used must be carefully designed and operated to prevent the escape of solvents, such as a liquid or vapor, into the workroom.

All personnel occupied with or working near chlorinated solvents should be particularly careful to avoid breathing the vapors. Although the vapors from some solvents are more toxic than others, prolonged breathing of the fumes can be injurious to health.

In addition to the breathing hazard associated with solvents, they also present varying degrees of fire and explosion hazards, depending upon the material. Solvent cleaners having a flashpoint greater than 105° F. are relatively safe. Those having flashpoints below 105° F. require explosion proofing of equipment and other special precautions when used. (The flashpoint is the temperature at which the first flash from the material is seen as an open flame is passed back and forth over a sample of flammable liquid being heated in a cup.)

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Another hazard associated with solvents, and to a certain extent with all cleaning materials, is the effect on the surface or material being cleaned. Some solvents will deteriorate rubber, synthetic rubber, or asphaltic coverings. This hazard is such an important consideration that it must always be taken into account when cleaning materials are selected. The cleaner may do a good job in removing dirt, grease, oil, or exhaust gas deposits, but it may also damage the object being cleaned. The cleaner may also soften and ruin otherwise good paint coatings.

Dry-cleaning Solvent

This material is a petroleum distillate commonly used in aircraft cleaning. The material is furnished in two types, I and II. Type I material, commonly known as Stoddard solvent, has a flashpoint slightly above 100°F. Type II has a higher (safer) flashpoint and is intended for shipboard use.

In aviation maintenance, Stoddard solvent (type I) is used as a general all-purpose cleaner for metals, painted surfaces, and fabrics. The solvent may be applied by spraying, brushing, dipping, and wiping. This material is preferable to kerosene for all cleaning purposes because kerosene leaves a light oily film on the surface.

Mineral Spirits

This is another liquid petroleum distillate used as an all-purpose cleaner for metal and painted surfaces. This cleaner is also used as a diluting material for emulsion compounds, but is not recommended for fabrics. Like Stoddard solvent, mineral spirits may be applied by spraying, brushing, dipping, and wiping.

Aliphatic Naphtha

This is an aliphatic hydrocarbon product used as an alternate compound for cleaning acrylics. It is also used for general cleaning purposes that require fast evaporation and no remaining film residue. This cleaner may be applied by dipping and wiping. Saturated surfaces must not be rubbed vigorously because aliphatic naphtha is a highly volatile and flammable solvent with a flashpoint below 80°F. Avoid prolonged breathing and skin contact. Use in well-ventilated areas only.

Aromatic Naphtha

This is a petroleum aromatic distillate. It is a bare-metal cleaner and is also used for cleaning primer coats before lacquer is applied. This naphtha will remove oil, grease, and light soils. It is also highly flammable and reasonably toxic. Avoid prolonged breathing and skin contact. CAUTION: Do not use aromatic naphtha on acrylic surfaces because it will cause crazing (fine surface cracks).

Safety Solvent

Methyl chloroform is intended for use where a high flashpoint and less toxic solvent than carbon tetrachloride is required. This solvent is used for general cleaning of assembled and disassembled engine components in addition to grease removal and spot cleaning. This material should not be used on painted surfaces. Safety Solvent is not suitable for oxygen systems although it may be used for other cleaning in ultrasonic cleaning devices. It may also be applied by wiping, scrubbing, or booth spraying. The term Safety Solvent is derived from the high flashpoint. Many later issue maintenance manuals label safety solvent as trichloroethane 1, 1, 1.

Methyl Ethyl Ketone (MEK)

This material is used as a cleaner for bare-metal surfaces. It will not mix to any great extent with water but is a diluent for lacquers. MEK is applied with wiping cloths or soft bristle brushes over small areas at a time.

Water Emulsion Cleaners

Emulsion cleaners tend to disperse contaminants into tiny droplets which are held in suspension in the cleaner until they are flushed from the surface. Water emulsion compound conforming to MIL-C-22543 contains emulsifying agents, coupling agents, detergents, solvents, corrosion inhibitors, and water. This compound is intended for use on painted and unpainted surfaces in heavy-duty cleaning operations where milder specification materials of lower detergency would not be effective.

Water emulsion compound is used in varying concentrations, depending on the condition of the surface. A concentration of 1 part compound to 4 parts water, by volume, is recommended

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for heavier soiled surfaces. For mildly soiled surfaces, the concentration is changed to 1 part compound to 9 parts water, by volume. Starting at the bottom of the area being cleaned, apply the mixed solution by spraying or brushing to avoid streaking. Loosen surface soils by a mild brushing or mopping and follow with a thorough fresh water rinse. The automatic shutoff type water spray nozzle is best for rinsing. This nozzle gives hand control from a light mist for fogging spray to a full spray with high-pressure water.

Alkaline Water-base Cleaning Compound

This compound is similar to the water emulsion cleaner. The water-base compound is a general purpose cleaner used to remove light to moderate soils. It is mixed in 1 part compound to 9 parts water for light soils and 1 part compound to 3 parts water for medium soils. This cleaner may be applied to the surface by mopping, wiping, spray equipment, or foam producing equipment. This cleaner is safe for use on fabrics, leather, glass, ceramics, and transparent plastics. Follow the previously described procedure for washing the aircraft and rinse thoroughly with fresh water before the compound dries to prevent streaking.

Solvent Emulsion Cleaners

This cleaner conforms to Specification P-C-444 and is intended for heavy-duty cleaning. The cleaner should be used with caution around painted surfaces because it will soften paint if in contact with the paint finish very long. Solvent emulsion cleaner will remove corrosion preventive coatings and should not be used on parts thus protected unless the coatings are to be removed. For heavy cleaning, the cleaning compound is mixed in a concentration of 1 part compound to 4 parts of dry-cleaning solvent (Stoddard solvent) or mineral spirits. For lighter duty use, the compound can be mixed at a 1 to 9 ratio.

Waterless Cleaner

This compound is intended for use on painted and unpainted aircraft surfaces. It is used in heavy-duty cleaning operations where water for rinsing is not readily available or where freezing temperatures do not permit the use of water. This cleaner is a relatively nontoxic, noncorrosive, nonflowing gel or cream. Its detergent properties enable it to be used as an effective agent for removing grease, tar, wax, carbon deposits, and exhaust stains. Waterless cleaner should not be applied to canopies or other acrylic plastic surfaces. It is safe for use as a waterless hand cleaner.

Mechanical Cleaning Materials

Mechanical cleaning materials such as abrasive papers, polishing compounds, polishing cloths, wools, and wadding, are available in the supply system for use as needed. However, their use must be in accordance with the cleaning procedures outlined in NAVAIR 01-1A-509, T.O. 1-1-1, the specific aircraft Maintenance Instructions Manual, and directions supplied with the material being used. These procedures must be followed to avoid damage to finishes and surfaces. In cases of conflicting information, NAVAIR 01-1A-509 and T.O. 1-1-1 will always take precedence.

Aluminum Oxide Paper

Aluminum oxide paper (300 grit or finer) is available in several forms and is safe to use on most surfaces. It does not contain sharp or needle-like abrasives which can embed themselves in the base metal being cleaned or in the protective coating being maintained. Do not use carborundum (silicon carbide) papers as a substitute for aluminum oxide paper. The grain structure of carborundum is sharp, and the material is so hard that individual grains can penetrate and bury themselves even in steel surfaces.

Powdered Pumice

This material is a mild abrasive cleaner. The prumice is used as a slurry with water and is applied to the surface with clean rags and bristle brushes.

Impregnated Cotton Wadding

Aluminum metal polish is used to produce a high-luster, long-lasting polish on unpainted aluminum-clad surfaces. Do not use the polish on anodized surfaces because it will remove the oxide coat.

Aluminum Wool

Three grades of aluminum wool--coarse, medium, and fine--are stocked for general abrasive cleaning of aluminum surfaces.

Lacquer Rubbing Compound, Type III

Lacquer rubbing compound, Type III, may be used to remove engine exhaust residues and minor oxidation. Avoid heavy rubbing over rivet heads or edges where protective coatings may be thin. Coverings may be damaged most easily at these points.

CLEANING EQUIPMENT

To produce efficient and satisfactory results when cleaning an aircraft, use correct cleaning materials and properly maintained equipment. Prepare and equip a specific cleaning area for cleaning operations.

The choice of cleaning equipment depends on several factors; for example, the amount of cleaning that is regularly performed, the type of aircraft being cleaned, the location of the activity, and the availability of facilities such as air pressure, water, and electricity.

Several specialized items of equipment are available for cleaning aircraft. These include pressure type tank sprayers, a variety of spray guns and nozzles, high-pressure cleaning machines, and industrial type vacuum cleaners.

One of the latest devices for faster and economical cleaning of aircraft is a swivel type conformable applicator cleaning kit developed by the 3M Company. The kit is officially designated Scotch-Brite Conformable Applicator Cleaning Kit No. 251. It is designed to clean aircraft exteriors several times faster than using cotton mops or bristle brushes.

The applicator head of the cleaning kit is curved and flexible to conform readily to convex and concave aircraft exteriors. A swivel joint on the back of the applicator head provides further flexibility. The 5 X 7 inch Scotch Brite cleaning and polishing pad attaches easily to the applicator head and provides a more aggressive and efficient scrubbing medium than bristle fibers. The cleaning kit can be used without fear of scratching aluminum or painted surfaces.

The swivel and applicator head are attached to a standard brush handle. The excellent conformability of the applicator allows easier application of a constant scrubbing pressure on curved skin panels. This feature eliminates the need for a maintenance stand to keep brushes in maximum contact with the surface.

In addition to the equipment previously mentioned, other items such as hoses, brushes, sponges, and wiping clothes are required for aircraft cleaning. These items are procured through supply.

Items of personal protection such as rubber gloves, rubber boots, goggles, and aprons should be worn when necessary. These items protect clothing, skin, and eyes from fumes and splashing of caustic materials.

Steam Cleaner

This cleaner is used to remove dirt, grease, and heavy oil deposits from aircraft and support equipment. The steam cleaner combines the four essentials of efficient cleaning: heat, water, detergent, and friction. After blending a detergent with water, the cleaner pumps the solution into a heating unit. At this point the solution is partially vaporized, creating pressure. The solution is then directed to the cleaning hose and gun and sprayed onto the surface to be cleaned. The spray detergent, along with its impact pressure, loosens and removes dirt and other contaminants.

A steam cleaning unit may be trailer mounted, as shown in figure 16, or stationary;

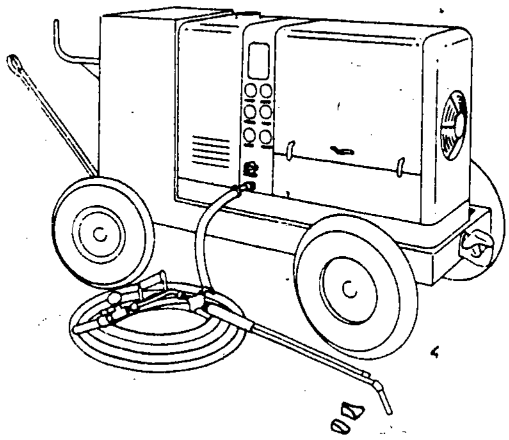


Figure 16. — Steam cleaner.

but basically all units are similar in construction. The basic steam cleaner consists of a cleaner unit and a water storage tank. Accessories include all necessary hoses and a cleaning gun with interchangeable nozzles. Operating controls, pressure gages, and inlet and outlet connections are on the outside of the unit or under hinged doors that help to form its cabinet.

Ultrasonic Cleaner.

The ultrasonic cleaner is a single self-contained unit. It cleans small aircraft parts when they are immersed in a washing compound through which high-frequency sound waves are traveling. The sound waves cause the constant formation of tiny bubbles that burst when they contact the surface being cleaned. This results in a powerful scrubbing action which thoroughly cleans immersed parts.

CLEANING METHODS AND PROCEDURES

The first step in cleaning the aircraft is selecting the proper cleaning agent for the method of cleaning to be used. The cleaning agent recommended for each method is listed in NAVAIR 01-1A-509, T.O. 1-1-1, and the applicable Maintenance Instructions Manual for the type of aircraft being cleaned. These manuals also include instructions and precautions for using the cleaning agents.

The next step is the preparation of the aircraft for cleaning. Ground the aircraft to the deck after spotting it in a cool place if possible. The aircraft may have been heated while parked in the sun or as a result of operations. Heated aircraft should be cooled by a fresh water washdown before being cleaned. Many cleaning materials will clean faster at elevated temperatures, but the risk of damage to paint, rubber, and plastic surfaces is increased. The damage is caused by cleaners which are concentrated by the rapid solvent evaporation caused by high temperatures. Static electricity generated by the cleaning operation will be dissipated through the ground wire. After securing all the obvious openings such as canopies and access panels, further secure the aircraft against entry of water and cleaning compounds. Mask or otherwise cover all equipment or components that can be damaged by moisture or the cleaning agent being used.

Water Rinse Cleaning

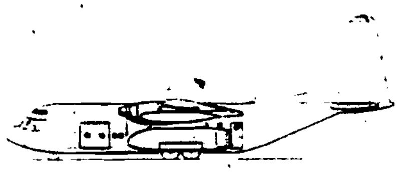
The water rinse method is the most efficient and satisfactory method of cleaning aircraft when they are only lightly contaminated with loosely adhering soils and water soluble corrosion products. Prepare the aircraft as previously outlined. Make sure all materials and equipment required during cleaning are on hand and ready for use. The proper washing procedure to ensure complete coverage is illustrated and described in figure 17. Apply water by progressing upward and outward, scrubbing briskly with a long handled fiber cleaning brush while the water is being applied. Do not scrub a dried surface. After scrubbing, rinse the surface from the top downward with a high-pressure stream of water until all the water soluble residues and loosened soils have been completely flushed off the aircraft.

Water Emulsion Cleaning

The emulsion cleaning method is used to clean aircraft contaminated with oil, grease, or other foreign matter which cannot be easily removed by other methods. The aircraft is prepared in the same manner as it was for the water rinse method.

Use fresh water to wet down the surface to be cleaned. Apply a concentrated solution of 1 part emulsion compound cleaner to 4 parts of water to the heavily soiled areas. These areas include engine nacelles, landing gear assemblies, or other special areas that will require such a strong solution. Scrub the areas and allow the concentrated solution to remain on the surface. Limit the size of the area being cleaned to that size which can be easily cleaned while keeping the surface wet.

Next mix a solution of 1 part emulsion compound to 9 parts water. Apply the diluted solution to the entire surface to be cleaned, including the areas previously covered with the concentrated solution. Scrub the surfaces thoroughly and allow the solution to remain on the surfaces 3 to 5 minutes before rinsing. Rinse from the top downward until all soils have been removed. If a high-pressure stream of water is used for rinsing, hold the nozzle at an angle and a reasonable distance from the surface being sprayed.



STEP 1 WASH WHEEL WELLS.

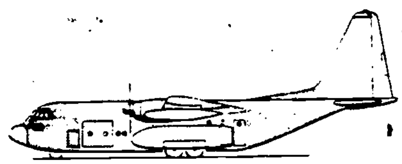
(a) WASH WHEEL WELLS, CONCENTRATING FIRST ON THE INTERIOR WELL STRUCTURE
(b) CLEAN LANDING GEAR COMPONENTS
(c) RINSE.

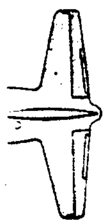
STEP 2. WASH MID-FUSELAGE
NOTE: THIS SHOULD BE DONE IN CONJUNCTION WITH WING IF POSSIBLE

(a) WASH THE UNDER SURFACE FIRST PROGRESSING UPWARD
(b) RINSE (WITH SCRUBBING) FROM TOP TO BOTTOM
NOTE: KEEP AREAS WET EITHER WITH SOLUTIONS OR WATER AT ALL TIMES

STEP 3. WASH FORWARD FUSELAGE:
(a) WASH UNDER SURFACES FIRST, PROGRESSING UPWARD. START AT MID-FUSELAGE AND SPRAY FORWARD.
(b) SCRUB IN CLEANING SOLUTIONS IN SEQUENCE.
NOTE: ALL AREAS MUST BE KEPT WET WITH CLEANING SOLUTIONS OR WATER AT ALL TIMES. RINSE OFF ALL OVERSPRAY OF SOLUTIONS.
(c) RINSE (WITH SCRUBBING) FROM TOP TO BOTTOM.

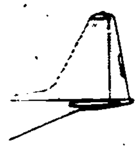
STEP 4. WASH AFT-FUSELAGE:
(a) WASH THE UNDER SURFACES FIRST (CARGO RAMP AND DOOR), PROGRESSING UPWARDS.
(b) RINSE (WITH SCRUBBING) FROM TOP TO BOTTOM.
NOTE: KEEP AREAS WET, EITHER WITH CLEANING SOLUTION OR WATER AT ALL TIMES.





STEP 5. WASH EMPENNAGE:

(a) WASH BOTTOM OF HORIZONTAL STABILIZER.
(b) TOP OF HORIZONTAL STABILIZER.
(c) WASH VERTICAL TAIL, AND THAT PORTION OF AFT FUSELAGE SUBJECT TO FLUID RUN-DOWN. BEGIN AT BASE AND WASH TO TIP.
NOTE: KEEP ALL SURFACES WET WITH SOLUTIONS OR WITH WATER AT ALL TIMES.
(d) RINSE (WITH SCRUBBING) FROM TIP TO BASE, INCLUDING AFT FUSELAGE.



STEP 6 WASH WINGS
WASH THE LOWER AND THEN THE UPPER SIDE OF WINGS. START AT CENTER AND MOVE TOWARD WING TIPS. RINSE TOWARD CENTERLINE.
NOTE: KEEP THOSE AREAS PREVIOUSLY CLEANED WELL FLUSHED WITH WATER DURING WASHING UPPER WING.

STEP 7. ON COMPLETE AIRPLANE WASH OPERATION FLUSH DOWN ALL AIRPLANE EXTERIOR SURFACES TO REMOVE RESIDUAL CLEANING SOLUTION

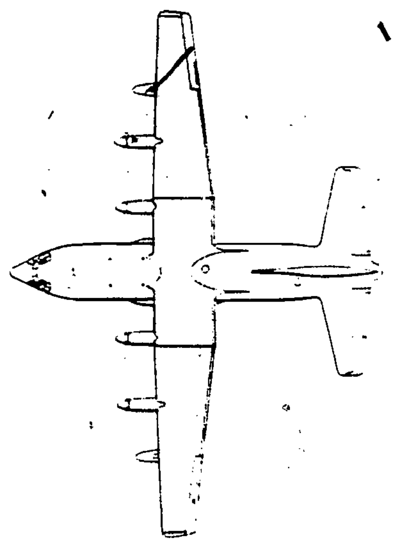


Figure 17. — Aircraft washing procedures.

31

ERIC

If any areas are still not clean, repeat the operation in those areas only. After being rinsed the aircraft may be dried with a clean sponge or cloths to ensure against streaking that could be caused by emulsion cleaning. Normally, if the aircraft is thoroughly rinsed, streaking will be held to a minimum.

Solvent-Emulsion Cleaning

Solvent-emulsion cleaning is intended for cleaning heavily soiled unpainted surfaces and parts and for removing corrosion preventive coatings. Mix the cleaning compound in a concentration of 1 part compound to 9 parts of dry-cleaning solvent or mineral spirits. Apply the solution to a water-free surface; otherwise, the water will lessen the solvent action. Since this cleaner will remove thick preservative materials, use it with care to prevent unwanted removal of such coatings.

Apply the solution by brush or with a high-pressure spray, using a nozzle that gives a coarse fanshaped spray. Scrub the surface with a brush as the solution is being applied. Allow the solution to remain on the surface long enough to loosen the soil without drying. Reapply and rescrub the more difficult soiled areas as necessary. Rinse thoroughly, using a large volume of fresh water to remove all loose soils and cleaning compound.

Spot Cleaning

Light oily soiled surfaces may be spot cleaned by wiping these areas with a dry-cleaning solvent. Apply the solvent with a saturated wiping cloth. Brush or wipe the surface as necessary; then wipe clean with a dry cloth, removing the solvent residue and loosened soil. The solvent wipe may leave a light residue, which may be removed with soap and water followed by fresh water rinsing.

WARNING: Dry-cleaning solvent should not be used in oxygen areas or around oxygen equipment. The solvent is not oxygen compatible and will cause explosion and/or fire.

Waterless Wipedown

When water is not available, heavy soils and operational films may be removed by using waterless cleaner. Apply the cleaner by dipping a dampened cloth into the creamlike waterless cleaning material and then spreading the material thinly over the area to be cleaned. Scrub the surface until the soil and cleaner become intermixed or emulsified. Allow the material to remain on the surface approximately 10 minutes; scrub and wipe off thoroughly with a clean wiping cloth. Make sure all soils and cleaning material are removed; be especially careful around fasteners and unsealed areas. In freezing weather a dry applicator should be used in lieu of a dampened one.

Immersion Cleaning

Immersion cleaning is used to clean individual parts. Units to be cleaned must be disassembled, and parts that may be damaged by the cleaning solution must be removed. Immersion cleaning can be done hot or cold. In hot cleaning, there must be some type of heating assembly to maintain cleaning solution temperature and provide hot water for rinsing. You may use either of the following solutions to clean aluminum, magnesium, steel, and brass parts.

Cleaning Compound P-C-436

This cleaning compound is used to clean both ferrous and nonferrous metal parts. Prepare the solution by dissolving 10 to 12 ounces of the compound per gallon of water in a steel tank. Immerse parts in the hot solution (200-212° F.) until the soil is removed. The immersion time may vary from 5 minutes for light soils to 30 minutes for asphaltic soils.

Paint and Varnish Remover (MIL-R-7751)

This paint and varnish remover may be used as a heavy-duty alkaline cleaner for steel, aluminum, and magnesium. Prepare this solution by mixing 3 to 5 ounces of the remover per gallon of water. Determine the total volume of the solution; then dissolve the compound in one-fifth of the total volume, keeping the solution temperature at or above 190°F. Allow the mixture to stand overnight; then add the balance of the water at room temperature.

Immerse the parts to be cleaned in the hot solution (190° to 212°F.), but avoid immersing dissimilar metals at the same time. Keep all work below the surface of the solution during the cleaning process. This solution should completely clean and strip paint coatings within 20 minutes.

Parts that have been chemically cleaned must be thoroughly rinsed. This is best accomplished by using hot water (140° to 180°F.). You may rinse by either spraying or immersion in a hot water tank. When heated water is not available, use cold rinsing and a longer rinse time.

PAINT REMOVAL

After the surfaces are cleaned, you may need to remove paint before removing corrosion. Paint may be removed by mechanical means, but you will usually use a chemical agent as well, depending on the area to be removed.

Before removing paint from any surface, mask all faying surfaces, access doors, and other openings. In addition to masking tape, wax, and barrier paper, you may use a low-adhesion rubber sealant. Allow this sealant to cure to a firm, rubbery state before you begin to remove the paint.

Accessible Areas

Apply the paint remover with a nonmetallic brush or by spraying. Allow the remover to stay on the surface until all residue is softened. Agitate the softened paint with a stiff bristle brush to aid in loosening the paint. The remover may have to be applied more than once, depending on the thickness of the paint coating. After the paint has been loosened, rinse off the residue with a stream of high-pressure water or wipe with a rag rinsed frequently in clean water.

Confined Areas

Paint may be removed with ethyl acetate, lacquer thinner, or dichloromethane. Since confined areas are hard to ventilate, you must be cautious of the toxic fumes given off by these removers. Apply the paint remover with a clean cloth or a soft-bristle brush, keeping the area wet by continued application. When the paint has loosened, remove it and the solvent with a clean damp cloth. Rinse the cloth frequently in clean water and repeat the previous step, until the paint and solvent are removed. Then dry the area with a clean lint-free cloth.

SAFETY PRECAUTIONS

All cleaning and paint removing operations present some health hazards. You must be aware of the hazards caused by a specific chemical and how you can control them. You should consult TO 42C-1-9, Toxicity, Flash Point, and Flammability of Chemicals, for more specific information about any chemical you may use.

POTENTIAL HEALTH HAZARDS

You may be exposed to chemical compounds by breathing fumes or actually handling the compound. Any procedure that may produce a health hazard must be evaluated and controlled.

Breathing Air Containing Solvent Vapors

Inhaling solvent vapors in high enough concentrations can cause injury to the body. The organ or body system affected depends upon the solvent involved. Some solvents act as irritants to nose and throat or eyes; others act as anesthetics and produce varying degrees of narcosis. In cases of narcosis, your manual dexterity and alertness may be affected. Your ability to accomplish tasks efficiently and without accident may be decreased. This can be of importance for all types of maintenance operations that require a high degree of skill and alertness.

Toxicity

Toxicity data for individual solvents or chemical compounds are difficult to apply to a mixture. Various additives and mixtures can and do affect toxicity. Some industrial solvents used in the military contain numerous organic compounds.

Absorbing Solvents Through the Skin

Many chemical compounds can be absorbed through the skin in large enough quantities to cause poisoning. Skin absorption must be considered a possible method of ingestion for all solvents.

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Ingestion By Swallowing

Swallowing of toxic chemicals is the least important means of industrial exposure. However, swallowing should not be overlooked as a contributing factor in occupational disease. Personnel handling toxic chemical compounds must be careful to avoid contaminating food, hands, or other objects that might be placed in the mouth, intentionally or unintentionally.

Dermatitis

Compounds used in cleaning can also cause irritation to the skin, resulting in dermatitis. Chemical compounds act in two ways to produce occupational dermatitis—primary irritants and skin sensitizers. A skin sensitizer is an agent which does not necessarily cause noticeable changes on first contact but which, on subsequent or prolonged contact produces dermatitis.

A primary irritant is an agent which causes dermatitis by direct action where the agent touches the skin. The dermatitis occurs if the agent is permitted to act long enough in sufficient intensity or quantity. A primary irritant forms chemical combinations with or removes essential ingredients from the skin. These combinations result in total destruction, burn, or inflammation. The type and concentration of the chemical and the period of exposure determine which of the three types of damage occurs.

Evaluating Potential Health Hazards

In many situations an evaluation of the environment is necessary to determine where a health hazard actually exists. In most cases this evaluation includes determining the solvent vapor concentrations. Many techniques are available for taking and analyzing samples. The technique used depends upon the solvent being sampled and the instruments available.

CONTROL OF HEALTH HAZARDS

To control health hazards during cleaning operations, use one or more of the following methods:

Selection of Chemical

Use the least toxic chemical or chemical compound that will do the job satisfactorily. Although the relative toxicity of a compound is not the only factor influencing the degree of hazard in using the compound, this is an important consideration. Substitute less toxic materials in cleaning. For example, use aliphatic hydrocarbons and alkaline cleaners in place of aromatic solvents.

Whenever it is economically sound, degreasing operations should be done by methods that reduce the exposure of personnel. For example, using a properly designed, located, and operated vapor degreaser for cleaning metal requires less exposure than doing the job by hand-cleaning methods.

Equipment

Select equipment to prevent the escape of chemicals into the breathing zone of the worker. Whenever closed processes are economically and operationally possible, use them. Once maximum health hazard control is built into equipment, operate and maintain it carefully. Inadequately designed or maintained health hazard controls are frequently more hazardous than uncontrolled processes because of the false sense of security they create.

Ventilation

Clean air can be supplied to a work area to dilute the toxic vapor concentration below the threshold limit values. The uncontaminated air may be provided by natural draft, open doors or windows, or preferably by forced ventilation. This method of control should be used only when the chemical is of low toxicity or when small quantities of toxic vapors are escaping into the air.

Using exhaust ventilation to capture the contaminants and remove them from the workroom air is the most effective method for controlling the concentration of toxic materials. The exhaust system must produce enough air movement to ensure capture of the contaminant as close as possible to its course. The exhaust system must then convey the contaminant through the system to some adequate discharge point. A local exhaust system should do this while

165

removing only a minimum of workroom air and still not interfere with the operation of the normal ventilation system.

No method used to control exposure to toxic compounds is foolproof. Therefore, you need to learn certain hygienic fundamentals concerning the materials you are using, and you must remember the need to prevent excessive exposure. If you are indifferent or uninformed, the control devices won't keep you from producing the maximum amount of atmospheric contamination.

Protective Clothing

Use respirator devices only for emergency or supplementary protection; rarely, if ever, rely upon them as the primary method of protection. There are occasional, isolated, or emergency jobs where you must depend on respiratory protective devices for the prevention of injury. However, the first line of defense should consist of one or more of the control measures discussed earlier.

There are a variety of respiratory devices available, each having its specific use and

Figure 18. — Protective clothing.

limitation. Be sure that you are using the proper one for the particular job. Keep respiratory protective devices clean and in good repair, and change filters, canisters, or cartridges as necessary. Respirators can be divided into two main groups: air supplied respirators and air purifying respirators.

Air supplied respirators provide you with air from a source of supply independent of your working environment. They are used where there is a possible oxygen deficiency—for example, inside tanks or in high atmospheric concentrations of chemical contaminants.

Air purifying respirators provide you with safe air by removing the toxic components from the workroom by mechanical or chemical filtration. Respirators of this group cannot be used in oxygen deficient atmospheres or in high atmospheric concentrations of contaminants.

Protective clothing, as shown in figure 18, protects the skin against toxic, irritant, or corrosive chemicals. Some chemicals can be absorbed through the skin in harmful quantities; many are primary irritants, and a few are sensitizing agents. When other control measures fail to protect your skin adequately, get and use protective clothing.

Such items as rubber and plastic gloves, aprons, suits, boots, hoods, and face shields are available. Keep these items clean and in good repair so they will be effective.

Occupational dermatitis can result from exposure to any of the compounds used in metal cleaning. Protecting yourself from the chemicals by the control methods discussed above will prevent these irritants from reaching your skin, thus preventing dermatitis as well as intoxication.

Next to avoiding exposure, personal cleanliness is the most important control measure for preventing dermatitis. Make sure you have adequate washing facilities, including hot and cold water and a good industrial skin cleanser. Allow yourself enough time for a thorough cleansing before lunch and at the end of the shift. Protective ointments have some value as a preventive measure, but their usefulness is frequently overemphasized. In some instances, where the use of bare hands is essential to the operation, or the face cannot be covered with protective devices, ointments may be the only means of protection available.

ERIC

SELF-QUIZ #3

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the objectives of this reading assignment, the text, and the points of knowledge tested in this self-quiz. To pass the EOCT, you must study all the course material.

1. Surface maintenance includes regular cleaning and ______.

2. After the aircraft cleaning operation, exposed aircraft components require ______ and ______.

3. When using chlorinated solvents, you must be especially careful because of the ______.

4. What type of dry-cleaning solvent has the HIGHEST flash point?

5. Which naphtha may be used as a cleaning solvent for acrylic surfaces?

6. Safety solvent is good for most general cleaning, but MUST NOT be used on oxygen systems or ______.

7. To find information about approved aircraft cleaning materials, you should refer to the applicable Maintenance Instructions Manual, ______, or ______.

8. What applicator cleaning kit cleans aircraft exteriors several times faster than using mops or bristle brushes?

9. Which aircraft small parts cleaning machine cleans by sending high-frequency sound waves through a washing compound?

10. Before beginning the aircraft cleaning operation, you must ensure that the aircraft is properly ______.

11. Which cleaning method should you use to remove corrosion preventive coatings?

12. When using ethyl acetate or lacquer thinner to remove paint in a confined area, you must be cautious of ______.

13. Through prolonged contact, a skin sensitizer can produce ______.

14. When working with toxic agents, you should use respiratory devices ONLY for ______ or ______ protection.

15. Next to avoiding exposure, the MOST important control measure for preventing dermatitis is ______.

ANSWERS TO SELF-QUIZ #3

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

1. touch-up of protective paint coatings (Page 25)
2. lubrication and preservation (Page 26)
3. hazards to breathing (Page 26)
4. Type II (Page 27)
5. Aliphatic (Page 27)
6. painted surfaces (Page 27)
7. NAVAIR 01-1A-509, T.O. 1-1-1 (Page 28)
8. Scotch-Brite Conformable and Applicator Cleaning Kit No. 251 (Page 29)
9. Ultrasonic cleaner (Page 30)
10. grounded (Page 30)
11. Solvent-emulsion cleaning (Page 33)
12. toxic fumes (Page 34)
13. dermatitis (Page 35)
14. emergency or supplementary (Page 36)
15. personal cleanliness (Page 36)

LIGHT CORROSION REMOVAL AND PRESERVATION

OBJECTIVES

When you complete this section, you will be able to:

1. Describe the procedures and materials used in the removal of light corrosion.
2. State the purpose of preservatives.
3. State some common aircraft preservatives and their uses.

The complete removal of all corrosion products from the surface of an affected metal is an important step in the corrosion control procedure. Which method of removal you select depends on several factors: (1) the type of metal affected, (2) whether the corrosion deposits are in a readily accessible area, (3) the materials and tools available, and (4) local policies.

After all the corrosion has been removed, the surface of the reworked area must be converted to a corrosion-resistant surface. This is done by applying a chemical surface treatment or by electroplating. The selection of the proper conversion method depends on the type of metal, size of the area to be treated, and availability of equipment. Before attempting to remove corrosion products and treat any metal surface, you should consult TO 1-1-2, Corrosion Control and Treatment for Aerospace Equipment, or the specified corrosion control manual. If there is any conflict between the two publications concerning removal or treatment procedures, the equipment manual governs the entire operation.

MECHANICAL CORROSION REMOVAL

For light corrosion, remove the corrosion deposits using any suitable nonpowered mechanical equipment. After removing all deposits visible through a four-power or stronger magnifying glass, remove an additional 0.002 inch to ensure that no corrosion products remain.

Blend the surface of the reworked area smoothly with the surrounding area to prevent stress concentrations. Make the width of the cleaned-up area at least 10 times the depth, as shown in figure 19; make the length of the cleaned-up area at least 20 times the depth.

Polish the cleaned-up area as smooth as the surrounding surface by making a finish cut to the cleaned-up area with a fine abrasive paper. First use a coarse grit abrasive paper and then finish with either 400 or 600 grit.

The mechanical corrosion removal equipment you select is governed by the accessibility of the area, the size of the job, and the type of metal. No hard and fast rules can be laid down; consequently, you must study your particular removal problem and select the most suitable equipment.

HAND TOOLS

You will use certain hand tools to remove corrosion deposits whether or not the area is readily accessible.

Wire Brushes

Wire brushes are available with carbon steel, stainless steel, or brass bristles. The bristles vary in size and length, and consequently in stiffness.

Usually, carbon steel hand wire brushes are used to remove corrosion deposits from ferrous alloys, and a stainless steel wire brush is used to remove corrosion from aluminum.

The bristles of this brush should not exceed 0.010 inch in diameter. After using this brush, polish the surface first with No. 400 then with No. 600 grit aluminum oxide abrasive paper.

Abrasives

There are many different types of abrasives. Each type is available in a variety of grit sizes. Among the more common types in use are the flint, emery, aluminum oxide, and silicon carbide:

1. Flint is used because of its low cost, but it dulls and wears out quickly.

2. Emery makes a good cutting agent, but because of its fine mineral face the results are slow. Emery is used mostly for final polishing of metals.

3. Aluminum oxide is used on metal surfaces because its tough coating cuts faster and lasts longer than flints.

4. Silicon carbide is produced by fusing silica and coke. This sharp abrasive is used on paints and metals for both wet and dry sanding.

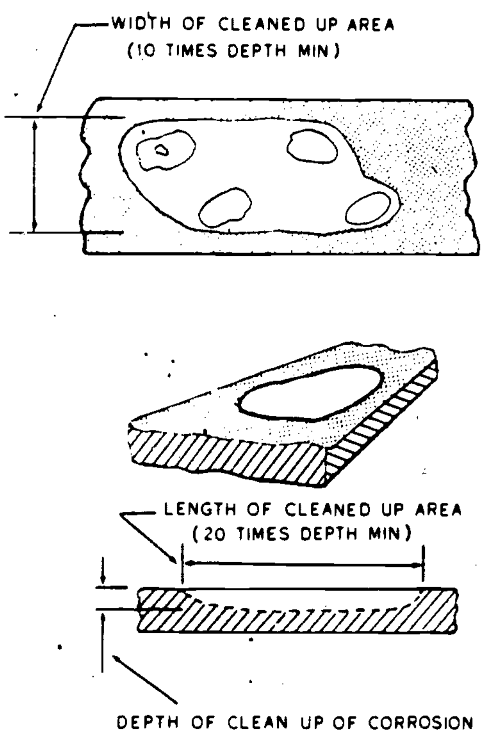

Figure 19. — Acceptable clean-up of corrosion pits.

	Garnet and Aluminum Oxide	Flint
Superfine	10/0--400	
Extra fine	9/0--300	
	8/0--280	
	7/0--240	
Very fine	6/0--220	4/0
	5/0--180	3/0
	4/0--150	2/0
Fine	3/0--120	
	2/0--100	0
Medium	0--80	1/2
	1/2--60	1
Coarse	1--50	1 1/2
	1 1/2--40	2
Very Coarse	2--36	2 1/2
	2 1/2--30	3
	3--24	

Figure 20. — Abrasive paper grit size.

The abrasives are bonded to paper, cloth, or fiber and are available in sheets and rolls. Paper-backed abrasives are available in four popular weights: A is soft and flexible and is used where flexibility is desired; C and D are thicker and are used where flexibility is not necessary; E is heavier and is used mostly for machine sanding. Cloth-backed abrasives are available in weight J for hand sanding.

Until recently, manufacturers listed their abrasive according to grit sizes. This was a complicated system, so now they have started labeling their abrasive paper as fine, medium, coarse, etc. Figure 20 shows the corresponding numbers and grit comparisons.

The selection and use of any abrasive paper is governed by the type of metal and the degree of corrosion deposits. You can use aluminum

	GRADE	USE
Very Fine	000	Final Smoothing
Fine	0	Most Commonly Used
Medium	1	General Purpose
	2	Rough Work
Coarse	3	Restoration Work

Figure 21. — Grades of metallic wool.

oxide abrasive paper to remove deposits from all metals. Do not use flint or silicon carbide abrasives on aluminum alloys.

Metallic Wool

Metallic wool has a variety of uses, and in many areas it is better than abrasives. The four major types of metallic wools are aluminum, copper, stainless steel, and steel. Each type is used on its corresponding metal surface. Metallic wools are available in six grades ranging from No. 3, coarse, to 3/0, very fine. Figure 21 is a guide to help you select the correct grade of metallic wool.

Scrapers

Heavy corrosion deposits may be removed using a locally manufactured carbide-tipped scraper like the scrapers shown in figure 22. After you scrape all of the corrosion deposits away, polish the surface with the appropriate abrasive.

Files

A file is a precision-made hardened steel tool with cutting edges across the surfaces. You will use it for cutting, smoothing, and removing small amounts of metal.

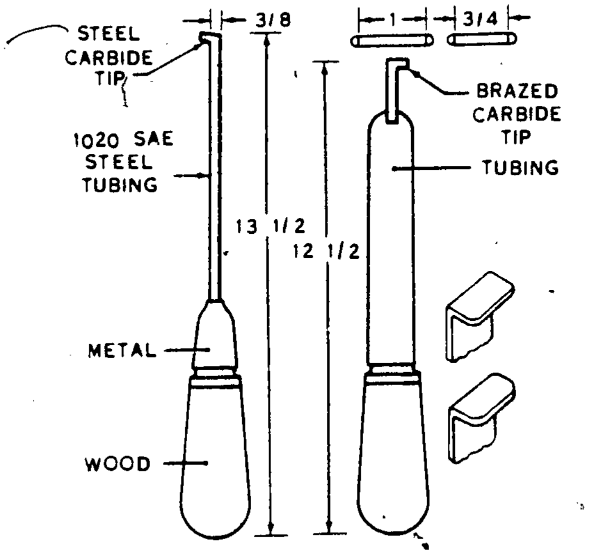

Figure 22. — Carbide-tipped scraper.

POWER TOOLS

Only qualified personnel should use power tools to remove corrosion on aircraft and aircraft components. If an extensive amount of corrosion requires the use of power tools, request assistance from a structural mechanic.

ELECTROPLATING AND CHEMICAL TREATMENT OF METAL SURFACES

After all corrosion deposits are removed, most metals require some type of surface treatment to prevent further corrosive attacks. These surface treatments may be applied by depositing one metal on the surface of another metal or by chemical treatments. In any case, the treatments are all extremely complex and critical. If they are not applied correctly, more damage can result to the base metal than had originally occurred. For this reason, the treatments should be applied only by competent, qualified personnel. Request the assistance of a qualified structural mechanic for the performance of these surface treatments.

PRESERVATIVES AND PRESERVATION

The susceptibility of an aircraft to corrosion damage is greatest during those periods when the aircraft is dirty, inactive, or being shipped. Since aircraft spend more time on the ground than in the air, even at an active unit, the need for effective protection becomes apparent.

Suitable protection against corrosive attack is achieved essentially by placing a barrier between the cleaned surface that is to be protected and any possible source of moisture. During manufacture or overhaul of the aircraft, protective barriers such as electroplate, paint, or chemical surface treatment are provided. Surfaces that cannot be so treated, and in some instances the treated surfaces themselves, must be covered with special corrosion-preventive compounds. The protection these compounds give is effective only if no moisture, dirt, or active corrosion is present on the treated surface. Therefore, the surface must be thoroughly clean

ERIC

and dry before a preservative compound is applied. It is also necessary that an unbroken film of preservatives be applied in as moisture-free an atmosphere as practicable.

Under operating conditions, the preservation of aircraft surfaces means supplementing the protection already present, or providing temporary protection to damaged areas. This protection is provided by the use of various protective coatings and barrier materials. We will discuss these preservation materials in detail later in this section. Now let's discuss some of the methods of protecting avionics systems from corrosion.

PROTECTION OF AVIONICS SYSTEMS

Sometimes we tend to overlook some of the obvious means of minimizing the intrusion of moisture and contaminants into our aircraft, and hence, into our avionics systems. Sound maintenance practices dictate that, unless in actual use, hatches, canopies, main entrance doors, equipment component panels, and hellhole doors should be kept closed at all times. This is especially important at sea where aircraft are constantly exposed to salt spray, stack gases, dust, jet exhaust, and rain. Since moisture tends to collect, the corrosion prevention task becomes relatively simple with thorough inspection, cleaning, and elimination of moisture traps. The immediate performance of minor repairs precludes future major repairs.

Corrosion of contact arms and mating surfaces of relays is often caused by exposure to a salt-laden atmosphere. If contact points can be cleaned and other relay components are in working order, the relay winding can be cleaned and covered with an appropriate varnish. Then the relay can be returned to service. If the relay is the open type, it may be bath-cleaned with an appropriate solution to remove dirt and dust, then dried thoroughly. Contacts may be burnished with an appropriate tool. Relay contacts should not be filed or sanded to present a clean appearance. Filing or sanding the points removes the protective hard plating and exposes the soft base metal. A relay so treated will usually perform only for a relatively short period of time. If burnishing does not clean the contact, consider replacing the relay to provide dependable operation.

Rotary switches are most commonly encountered inside control boxes. In some cases, the switches have little or no protection against dust and moisture, which accumulate in the area of the switch contacts. With such a concentration of dust and moisture, fungus and corrosion can begin and develop at a rapid rate. Whenever equipment is removed from an aircraft for bench check and/or repair, this is the logical time to remove all dust covers and housings for a corrosion check and, if needed, appropriate treatment. Little can be done to clean toggle-type switches or other semisealed types. If corroded or otherwise damaged, the switches usually need to be replaced. Switch and switch-shaft boots and seals, if available, should be used to prevent dirt and moisture intrusion.

Corroded/contaminated lamp sockets respond very well to scrubbing with an appropriate aerosol-type contact cleaner, a rubber eraser can be used if the lamp does not have a bayonet-type base.

Multipin-type connectors have caused some of the most time-consuming repairs in avionics maintenance. Such connectors should be checked routinely for the presence of contaminants or corrosion each time one is removed. Fungus growth between connector pins and on connector inert material can cause degeneration of insulation (dielectric) material between the pins.

Although multipin connectors are not necessarily described as structural components, the connectors electrically connect electronic units housed within structural components. Because of their configuration, the connectors are difficult to clean and keep clean. A little corrosion or fungus on a connector's components could create hard-to-locate circuit response problems. Potting has generally been considered a cure-all treatment for connectors. However, experience has proven that corrosion can and still does occur despite this treatment. A corroded, unpotted connector can be cleaned, whereas a potted connector with similar corrosion usually must be replaced. Recent technology has produced connectors with integral seals, which preclude the need for potting.

Cable corrosion will occur if cables are improperly protected. However, with the use of proper protection techniques, cable corrosion can be virtually eliminated. Use of plastic coverings can prevent moisture from contacting cable insulation. Newer Teflon insulation materials have virtually eliminated penetration of moisture. However, no cutoff end of the cable should ever be left exposed; otherwise, through capillary action and/or gravity, moisture can work itself well into the cable. Generally, individual wires in a bundle can be cleaned of moisture by wiping; however, wires that are damaged must be replaced. Entire harnesses may need replacing in severe cases.

Seals and filters used with electronic assemblies retain required operating pressures and prevent direct water and microscopic debris intrusion into critical areas. This action prevents high voltage arcing. Systems having an all-time pressurization capability should remain pressurized, regardless of aircraft status.

Examples of applications where these seals are used:

1. Pressure Seals
   a. Some high-voltage generating networks (chassis/subchassis).
   b. Avionic bay pressure bulkheads.
   c. Cockpit-enclosed radios.
2. Water Seals
   a. Connectors exterior to the airframe, such as wing butts and pods. Aircraft manufacturers have recently employed sealed aircraft harness connectors between bulkheads.
   b. Blade antennas and other exterior-mounted sensors.
   c. Radomes.

Loss of or damage to these accelerates introduction of contaminants. During maintenance, the material condition of the seals should be determined. If seal damage is suspected or visible, consider replacing the seals immediately.

Avionics devices provide continuity of electrical energy paths through various networks of connectors and components. Maintaining the integrity of these electrical energy paths can be quite a problem. Boxes and housings are meant to protect avionic equipment not only from mechanical damage but from environmentally caused damages as well. Units should always be sealed, as outlined in the Maintenance Instruction Manuals (MIMs), to prevent the admittance of dust, dirt, and corrosive atmospheres.

Antenna corrosion can be significantly reduced by two means. First, bed and seal the antenna base and fasteners thoroughly with the type of sealer specified in the MIMs. Secondly, inspect and clean frequently those areas within the fuselage where the antenna base may be exposed to liquid contaminants.

Metallic surfaces within the chassis that cannot be painted or uniformly coated should be treated with a corrosion-preventive compound. (The surfaces include electric contact and nonelectronic areas alike.) The treatment for these surfaces should be in accordance with the applicable MIM manual or the NA 01-1A-509 manual.

PRESERVATION MATERIALS

Some of the more common materials used in aircraft preservation and readily available through supply are briefly described in the following paragraphs.

Corrosion-Preventive Compound
(Solvent Cutback)

This material is familiarly known as "paralketone." It is supplied in three grades (1, 2 and 4) for specific application. All grades of this compound may be applied by brush, dip, or spray. The compound may be easily removed with Stoddard solvent or mineral spirits. These materials are designed for cold application. Some preservative compounds must be applied hot; therefore, when intending to use one of the grades of this solvent cutback material, always verify the specification number (MIL-C-16173).

Grade 1 forms a dark, hard-film, opaque cover. Its general use is limited because of the difficulty in removing aged coatings and also because of the hiding power of the material when it is applied over corroded areas. This material is used only where maximum protection against salt spray is required. Present instructions generally limit its use to seaplanes and amphibian surfaces.

ERIC

Grade 2 is a soft-film, grease-type material that can be used on most operating parts. Its chief disadvantage is the fact that it may be washed off under direct exposure to salt water or may be removed by inadvertent wiping. This material protects under relatively severe conditions and, given adequate maintenance and touch-up as necessary, can be used for most maximum protection requirements.

Grade 4 preservative forms thin, semitransparent films through which identification data can usually be read. It also sets up relatively dry to the touch so that preserved parts can be easily handled. This grade has proved particularly effective in protecting wheel well areas and other exposed surfaces where film transparency is required and moderate protective characteristics can be tolerated. The main disadvantages of this material are that it is easily removed by water spray and requires replacement at 1-month intervals under severe exposure conditions.

Corrosion-Preventive Petroleum
(MIL-C-11796)

These preservatives are designed for hot application and are available in two classes—Class 1 (hard film) and Class 3 (soft film). Both consist of corrosion inhibitors in petroleum. These preservatives are removed with Stoddard solvent or mineral spirits. Where a hard film is not necessary, Class 3 should always be used. This class is easier to apply and remove, yet renders the same degree of protection. Class 1 is generally used for long-time indoor protection of highly finished metal surfaces and aircraft control cables. Class 3 is used to provide protection of metal surfaces such as antifriction bearings, shock-strut pistons, and other bright metal surfaces.

Class 1 must be heated to 170° to 200°F. before being applied by brush or dip. For brushing Class 3 material, it must be between 60° and 120°F. and, for dipping, between 150° and 180° F.

Preservative Oil for
Hydraulic Equipment

This oil is used in the preservation of hydraulic systems and components and shock struts. The oil is similar in appearance to, but is not interchangeable with, operating hydraulic fluid. Therefore, before using operating hydraulic fluid (MIL-H-5606) or this preservative oil (MIL-H-6083) for any purpose, check the specification number to ascertain that the correct oil is being used. The preservative oil contains oxidation and rust inhibitors, viscosity improver, and antiwear agents. Hydraulic parts and components being turned in for screening and repair are flushed and drip drained with MIL-H-6083 oil before being forwarded.

Designed primarily for hydraulic components, this oil may be used on any bare critical surface that needs protection. Operating hydraulic fluid will protect a steel panel immersed in water for only about 48 hours. The same metal panel coated with MIL-H-6083 inhibited hydraulic oil will show 100-percent protection for a period of 30 days or more.

General-Purpose Lubrication Oil
(Preservative)

There are several different types of lubricating oil, some of which contain preservatives. To be absolutely sure that the proper oil is used in a given situation, identify each with its specification number. The specification number for the oil discussed in this section is VV-L-800.

VV-L-800 oil was compounded for lubrication and protection of piano-wire hinges and other critical surfaces. This oil is also used whenever a water-displacing, low-temperature, lubricating oil is required.

VV-L-800 may be applied, as received, by brush, spray, or dip methods. It is readily removed with Stoddard solvent or mineral spirits.

General Purpose Lubricating Oil
(Low Temperature)

This general-purpose oil (Specification MIL-L-7870) is suitable for use anywhere that a general-purpose lubricating oil with low temperature, low viscosity, and corrosion-preventive properties is required.

This oil is suitable for brush, spray, dip, or general squirt-can application. It does not need to be removed before reoiling or for inspection.

Corrosion-Preventive Compound (MIL-C-81309)

This material is a water-displacing corrosion-prevention compound and lubricant. It forms a thin, clear protective coating when applied by aerosol, brush, dip, or spray. This compound offers only short term protection, so it must be reapplied frequently. On exposed surfaces, protection at its best is 7 days between applications and up to 30 days on internal surfaces protected from direct outside environments. This material is easily removed with dry-cleaning solvents. It is very effective when used in the following areas: Piano-wire hinges, removable fasteners, B-nuts, linkages, bolts and nuts, control surface hinges, electrical connectors, and microswitches.

Organic Coating Materials

Organic coating systems are commonly classed as paints, varnishes, enamels, or lacquers. To enable metallic surfaces to resist their environments, coat the surfaces, where possible, with an organic coating system. The appropriate system is specified in Coast Guard Aircraft Paint and Marking Details. Except for very small touch-up on components, application of organic coating systems is the responsibility of the structural mechanic and should not be attempted by unqualified personnel.

SELF-QUIZ #4

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the objectives of this reading assignment, the text, and the points of knowledge tested in this self-quiz. To pass the EOCT, you must study all the course material.

1. To ensure that no corrosion products remain after removing all visible deposits, you should remove an additional ______ inch of material.

2. After removing corrosion with a coarse-grit abrasive paper, you should finish smoothing the surface with ______.

3. What abrasive should you use on paints and ferrous metals for both wet and dry sanding?

4. What governs the selection and use of abrasive paper?

5. To remove heavy corrosion deposits, you may use ______.

6. What are the MAIN disadvantages of Grade 4 solvent cutback material?

7. What water-displacing corrosion-prevention compound is very effective when used on removable fasteners and B-nuts?

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ANSWERS TO SELF-QUIZ #4

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

1. 0.002 (Page 39)

2. 400- or 600- grit abrasive paper (Page 39)

3. Silicon carbide (Page 40)

4. Type of metal and degree of corrosion deposits (Page 40)

5. a carbide-tipped scraper (Page 41)

6. This material is easily removed by water spray and requires replacement at 1-month intervals under severe exposure conditions. (Page 44)

7. Corrosion-preventive compound (MIL-C-81309) (Page 45)

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PAMPHLET REVIEW QUIZ

PLEASE NOTE: Many students study ONLY the self-quizzes and pamphlet review quiz, thinking that this will be enough to pass the End-of-Course Test. THIS IS NOT TRUE. The End-of-Course Test is based on the objectives of this reading assignment, the text, and the points of knowledge tested in this self-quiz. To pass the EOCT, you must study all the course material.

1. In a corrosive environment, the significant element which causes metals to corrode is ______.

   A. heat
   B. oxygen
   C. salt
   D. fungus

2. Control of corrosion depends upon maintaining ______.

   A. surfaces free of microscopic debris
   B. low temperature and constant humidity
   C. a separation between susceptible alloys and the corrosive environment
   D. contact of metals of different alloys

3. Once the electrical couple is made between metals, the electron flow will continue until the ______ is destroyed.

   A. positively charged metal (anode)
   B. negatively charged metal (cathode)
   C. least active metal
   D. nonstressed surface

4. Uniform etch corrosion is FIRST detected on a polished surface by ______.

   A. white or grey powdery deposits
   B. general dulling of the surface
   C. small pits
   D. small blisters

5. Exfoliation is a form of ______ corrosion.

   A. ga' anic
   B. pitting
   C. uniform etch
   D. intergranular

6. What causes galvanic corrosion?

   A. A stressed metal in a corrosive environment
   B. Improper heat treating
   C. Reaction of a metal with an acid
   D. Dissimilar metals joined by an electrolyte

7. When fastened together, which group of metals will exhibit the MOST corrosion?

   A. Aluminum and copper
   B. Magnesium and aluminum
   C. Zinc and aluminum
   D. Iron and titanium

8. If uniform etch corrosion on a metal surface is allowed to continue, how will the surface appear?

   A. Blistered
   B. Dull or rough and frosted
   C. Pitted
   D. Powdery

9. What causes a pitting corrosion reaction?

   A. Direct chemical attack on a metal surface
   B. Advanced stage of intergranular corrosion
   C. Difference in potential on a metal surface in the presence of an electrolyte
   D. Attack along the grain boundaries of a metal

10. What type of corrosion attacks the interior structure of a metal?

   A. Concentration cell
   B. Intergranular
   C. Fatigue
   D. Galvanic

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11. You can identify exfoliation corrosion by the ______ metal surface.

A. dull
B. pitted
C. blotched
D. lifted

12. What are the visible indications of the second stage of fatigue corrosion?

A. Pits
B. Blisters
C. Cracks
D. Powdery deposits

13. Corrosion on a painted surface is FIRST indicated by ______ paint.

A. discolored
B. blistered
C. peeling
D. cracked

14. What should you use to measure the depth of corrosion pits?

A. Dial indicator
B. Micrometer caliper
C. Calibrated 10-power magnifying glass
D. Borescope

15. An external defect is more harmful than an internal defect when the external defect is ______.

A. constantly exposed to the elements
B. parallel to the lines of stress
C. on an airfoil
D. on a stressed part

16. What metal surfaces are especially susceptible to intergranular corrosion?

A. Magnesium
B. Corrosion-resistant steel
C. Aluminum alloys
D. Titanium

17. When inspecting spot-welded metal, you can detect the results of a corrosive reaction by ______.

A. bulging skin
B. pits in the weld
C. powdery residue in the weld
D. a discolored spot-weld

18. Why do piano hinges remain a corrosion problem?

A. Inaccessibility
B. Infrequent use
C. Inadequate lubrication
D. Dissimilar metals

19. Who should perform corrosion treatment on electrical and electronic equipment?

A. Person discovering the corrosion
B. A qualified structural mechanic
C. Personnel familiar with the system
D. Any electrical or electronic maintenance personnel

20. What constantly causes corrosion of unprotected surfaces in a battery compartment?

A. Fumes from overheated electrolyte
B. Electrolyte spilled during servicing
C. Electrolyte boiling over from an overfilled battery
D. Constant removal and replacement of batteries

21. Even though some contaminants are not corrosive, they can cause corrosion by ______.

A. acting as an electrolyte
B. joining with other materials to form a corrosive compound
C. removing the protective coating
D. holding moisture

22. Which technical order outlines procedures for cleaning aerospace equipment?

A. T.O. 1-1-1
B. T.O. 1-1-2
C. T.O. 1-1-5
D. T.O. 1-1-8

23. Besides being a breathing hazard, solvent type cleaners are dangerous because they ______.

A. evaporate rapidly
B. present a fire hazard
C. ineffectively disperse contaminants
D. require out-of-doors use

24. Which solvent is used as a general all-purpose cleaner for metals, painted surfaces, and fabrics?

A. Aliphatic naphtha
B. Safety solvent
C. Dry-cleaning solvent, Type I
D. Methyl ethyl ketone

25. Which solvent has a high flashpoint and is recommended for general cleaning and grease removal of assembled and disassembled engine components?

A. Dry-cleaning solvent, Type I
B. Methyl ethyl ketone
C. Safety solvent
D. Aromatic naphtha

26. Which heavy-duty cleaning compound, if used without caution, will soften paint coatings and remove corrosion-preventive compounds?

A. Alkaline waterbase
B. Waterless
C. Water emulsion
D. Solvent emulsion

27. What abrasive is safe for use on most surfaces because it does NOT contain sharp or needle-like abrasives?

A. Emery cloth
B. Silicon carbide paper
C. Aluminum wool
D. Aluminum oxide paper

28. The actual cleaning action in an ultrasonic cleaner results from the ______.

A. short cycles of metal expansion and contraction
B. bombardment of parts by tiny bubbles of washing compound
C. sharp fluctuations in temperature
D. impact of high-frequency sound waves

29. If an aircraft is only lightly contaminated with loosely adhering soils and water soluble corrosion products, what method of cleaning should you use?

A. Water rinse
B. Water emulsion
C. Solvent emulsion
D. Waterless

30. When immersion cleaning several metal parts simultaneously in the same solution, what precaution should you take?

A. Increase the temperature of the solution
B. Increase the volume of the solution
C. Avoid immersing dissimilar metals
D. Avoid immersing more than four parts

31. You can increase the effectiveness of paint-removing chemicals by ______.

A. increasing the time the remover remains on the part
B. agitating the softened paint with a stiff-bristle brush
C. agitating the remover with air pressure
D. mixing the remover with paint thinner

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32. If an individual is suffering from narcosis induced by breathing toxic vapors, one of his symptoms is ______.

A. extreme mental depression
B. keen mental alertness
C. loss of dexterity
D. hypertension

33. What is the MOST effective method of controlling toxic vapors during equipment cleaning?

A. Use exhaust ventilation
B. Substitute nontoxic for toxic solvents
C. Bring in an extra supply of fresh air
D. Adhere strictly to closed processes

34. When should the extent of corrosion product removal be considered satisfactory?

A. After removing 0.004 inch of material
B. When the material thickness reaches its minimum tolerance
C. After removing all deposits visible through a 4-power magnifying glass
D. When the width of the cleaned-out area is 20 times the depth

35. Wire brushes are available with bristles made from carbon steel, stainless steel, and ______.

A. aluminum
B. titanium
C. magnesium
D. brass

36. Stainless steel wire brushes are usually used to remove corrosion deposits from ______.

A. aluminum
B. brass
C. carbon steel
D. copper

37. When you mechanically remove corrosion products, the FINAL step is to use fine abrasive paper to ______.

A. clean out the area until the width is 20 times the depth
B. polish the cleaned-out area as smooth as the surrounding area
C. clean out the area until the length is 10 times the depth
D. blend the cleaned-out area with the surrounding area

38. Before you apply a preservative compound to a metal surface, the surface must be ______.

A. clean and dry
B. chemically treated
C. painted
D. heated

39. To eliminate corrosion and fungus from electrical connectors, potting is being replaced by ______.

A. RTV
B. shrinkable tubing
C. integral seals
D. swaging

40. What general-purpose lubricating oil has low-temperature, low-viscosity, and corrosion-preventive properties?

A. MIL-H-6083
B. MIL-C-11796
C. MIL-C-81309
D. MIL-L-7870

193

PAMPHLET REVIEW QUIZ

ANSWER KEY

Following are the correct answers and references to the text pages which cover each question and correct answer. To be sure you understand the answers to those questions you missed, you should restudy the referenced portions of the text.

QUES.	ANS.	REF.	QUES.	ANS.	REF.
1	B	2	21	D	22
2	C	2	22	A	26
3	A	3	23	B	26
4	B	5	24	C	27
5	D	6	25	C	27
6	D	6	26	D	28
7	A	6	27	D	28
8	B	14	28	B	30
9	C	14	29	A	30
10	B	14	30	C	33
11	D	14	31	B	34
12	C	16	32	C	34
13	A	16	33	A	35
14	A	16	34	C	39
15	D	19	35	D	39
16	C	19	36	A	39
17	A	20	37	B	39
18	D	21	38	A	41
19	C	21	39	C	42
20	A	21	40	D	44

182

REFERENCES

Cleaning of Aerospace Equipment	T.O. 1-1-1
Corrosion Prevention and Control for Aerospace Equipment	T.O. 1-1-2
Aircraft Cleaning And Corrosion Control for Organizational and Intermediate Maintenance Levels	NA 01-1A-509
Corrosion Control Specialist	CDC 53550
Aviation Structural Mechanic S 3 & 2	NAVTRA 10308-C
Mech - The Naval Aviation Maintenance Safety Review	Spring 1977

13

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183

COAST GUARD INSTITUTE

OKLAHOMA CITY

ADVANCED CORROSION CONTROL AND PAINTING

DEPARTMENT OF TRANSPORTATION
U. S. Coast Guard (02/81) AM2-0207

U. S. Coast Guard Institute
PAMPHLET NO. 605

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184

NOTICE TO STUDENT

This pamphlet contains lesson quizzes and a pamphlet review quiz. Correct answers and text references are printed in the right-hand column of each quiz page. A 3 1/4 X 9-inch Answer Key Mask is provided with each course. Lay the mask over the answers in the right-hand column. After you answer the questions, remove the mask to check your answer with the printed answer. Try to answer the questions in each quiz before looking back at the text.

185

This pamphlet contains original material developed at the Coast Guard Institute and also excerpts from:

Aircraft Painting and Marking Details	CGTO 42A-1-2
Corrosion Control Specialist	CDC 53550
Aviation Structural Mechanic S 3 & 2	NAVTRA 10308-C

IMPORTANT NOTE: In February, 1981, the information contained in this pamphlet was current according to the latest updates of those Directives/Publications listed. This pamphlet was compiled for training **ONLY**. It should **NOT** be used in lieu of official Directives or publications. It is always **YOUR** responsibility to keep abreast of the latest professional information available for your rate.

The personnel responsible for the latest review and update of the material in this component during February 1981 are:

AMCM S. R. Carter .... (Subject Matter Specialist)

Darla Burns .... (Education Specialist)

YN2 P. J. Schneider .... (Typographer)

YN2 P. J. Schneider .... (Typist)

Questions about the text should be addressed to your course writer.

186

ADVANCED CORROSION CONTROL
AND
PAINTING

TABLE OF CONTENTS

CORROSION REMOVAL, ELECTROPLATING, AND PASSIVATION

OBJECTIVES

When you complete this section, you will be able to:

1. State the different types of power tools for use in corrosion removal.
2. Demonstrate the proper use of the different types of power tools in corrosion removal.
3. Describe the use of acid corrosion removers.
4. Describe the use of alkaline corrosion removers.
5. Explain the purpose of electroplating and passivating metal surfaces and describe the passivating process.
6. Identify the safety precautions you must observe when using hazardous chemicals.

When corrosion is apparent, a specific and immediate program for corrective treatment is required. A complete treatment involves removing and cleaning paint from all corroded areas, removing corrosion products, restoring protective surfaces treatment films, and applying protective coatings and finishes. Each type of corrosion has its own peculiarities and requires special treatment.

The types of corrosion and light corrosion removal have been discussed in the basic corrosion control pamphlet. This pamphlet will explain corrosion control on a larger scale. It requires the use of power tools, special chemicals, and the special talents of qualified, knowledgeable structural mechanics. Remember, an unqualified person attempting to correct corrosion damage can unknowingly effect catastrophic results.

MECHANICAL CORROSION REMOVAL

POWER TOOLS

If the area of corrosion removal is large and readily accessible, you should use power tools to save time. However, you must be careful when using powered equipment. It is easy to use too much pressure, even when you are using the specified brush, grinding wheel, or sanding disc. This excessive pressure will damage the metal.

Before using any powered equipment, remove all rings, watches, and other jewelry. Always wear the proper personal safety equipment, (for example, goggles, face shield, or respirator). Insure that all electrical powered equipment is grounded. Check all pneumatic powered equipment air hoses for breaks or bulges in the coverings.

Sanders And Buffers

Electric or pneumatic sander-buffers provide a simple method of sanding or polishing metal surfaces. There are many varied types of sanders and buffers. They are available with oscillating heads for sanding and buffing, or with interchangeable heads so that grinding wheels or wire brushes may also be used. When you use the power tool as a sander, be sure to check the size and type of the abrasive disc. Insure that the type of disc is compatible with the metal.

To prevent the sander from digging into the metal, start it before you touch it to the metal. Upon completion of the sanding stroke, lift the sander from the metal before releasing the stop switch. Do not lay the unit down with the motor running.

You will obtain the best results by applying moderate pressure while you hold

188

the sander against the work. You should keep the sanding disc tilted to approximately a 10° angle so that only one side of the disc is in contact with the metal surface, as shown in figure 1. If the entire disc surface is in contact with the surface, a "bucking" effect will occur.

Move the sander over the surface with parallel and slightly overlapping strokes. Move it as slowly as possible without burning the metal. Generally, the cleaning rate should be about 2 square feet per minute.

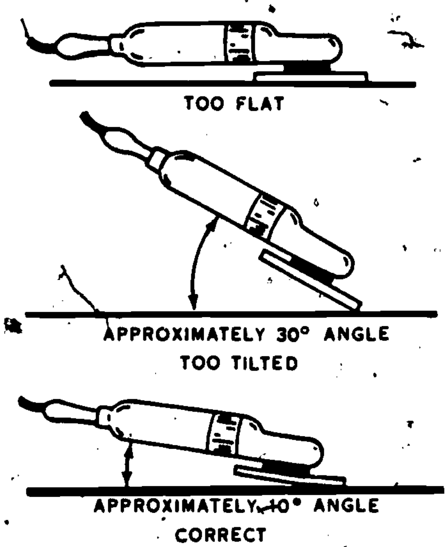

Figure 1. - Sander.

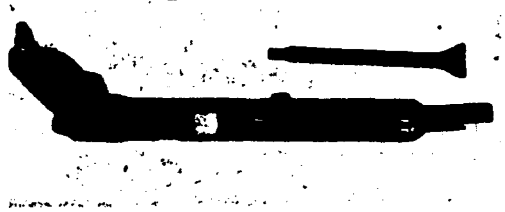

Figure 2. - Needle descaler.

When using the sander-buffer as a buffer, apply a small amount of jewelers rouge, or other buffing compound, to the buffing wheel. Then follow the same procedure as for sanding.

Pneumatic Drill

A portable pneumatic drill may be used to turn rotary files, grinding wheels, sanding pads, or buffing wheels. These drills are available in many shapes and sizes to satisfy almost any requirement. The maximum chuck capacity of the portable powered drill is usually 1/4 inch; that is, the chuck of the drill will hold a tool shank up to 1/4 inch in diameter.

When it is difficult or impossible to reach the work area with a straight drill, you may use flexible shafts or angle adapters. The flexible shaft permits working around obstructions with a minimum of effort.

To prevent the rotary file, abrasive wheel, or sanding disc from digging into the metal, keep the tool off the metal when the drill is started. Upon completion of the grinding stroke, lift the tool from the metal before releasing the drill switch.

When using the air drill, insert the tool shank and securely tighten the chuck with the chuck key. Holding the drill motor with both hands, apply moderate pressure as you hold the rotary file, sanding disc, or abrasive wheel against the work. Excessive pressure will cause a "chattering" effect.

Move the tool over the surface with slightly overlapping strokes. Do not grind, sand, or file in one area for any length of time without stopping and allowing the metal to cool. Excessive metal heating alters the granular structure, which can result in severe corrosion.

Needle Descaler

The needle descaler, shown in figure 2, is a pneumatic hammer having a multiple-needle or chisel head. This tool is used to remove corrosion from metal surface areas that are hard to get at, such as grooves, corners, and around nuts and bolts. Do not use the needle descaler on thin metal surfaces.

The descaler operates with a reciprocating action delivering 4,600 blows per minute. Its 19 wear-resistant alloy needles hammer the surface clean. Air exhausting through the front of the tool keeps the work free of debris.

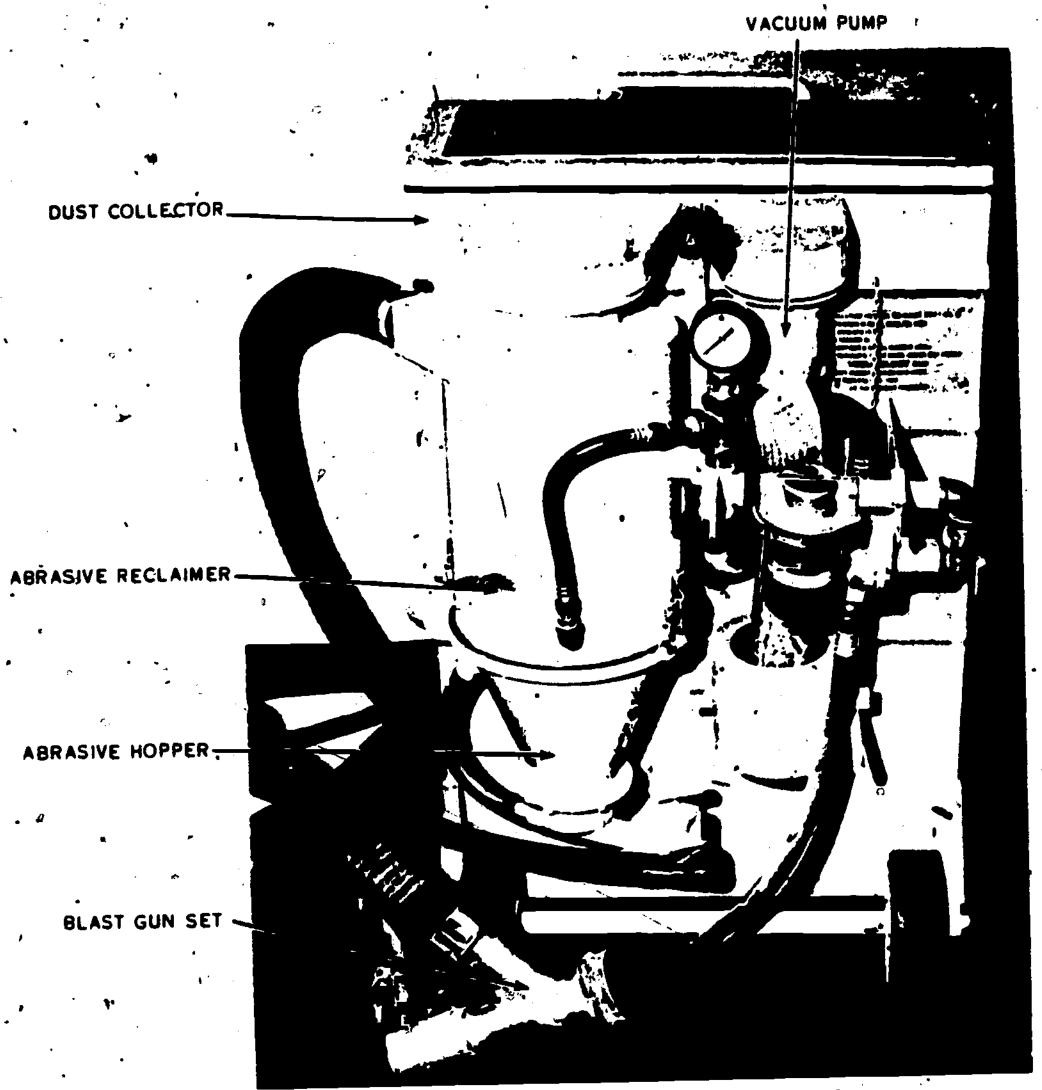

Figure 3. - Abrasive blaster.

Abrasive Blaster

Portable abrasive blasters are used to remove corrosion and paint from metal surfaces. The abrasive blaster is operated by compressed air bombarding the surface with an abrasive (sand, grit, shot, or glass beads) at high velocity. Abrasive blasting equipment is simple to operate, but each type of equipment has its own peculiarities. Therefore, you have to follow the operating instructions for a particular type of equipment to prevent damage to the equipment or the material being cleaned.

A vacu-blaster, one type of an abrasive blaster, contains five individual items of equipment assembled into one common portable unit. These individual units are the abrasive hopper, abrasive reclaimer, dust collector, vacuum pump, and the blast gun set, as shown in figure 3.

The abrasive hopper has a capacity of 5 pounds and is secured to the bottom of the abrasive reclaimer. It continuously receives the abrasive from the reclaimer to supply the feed mechanism. The feed metering valve sends a controlled volume of air upward through the hopper, thus causing the abrasive to flow through the feed valve and hose to the blast gun.

TABLE 1

Corrosion Removal Procedures for Aluminum

TYPE OF CORROSION	STEP 1 CLEANING TO REMOVE FOREIGN MATTER	STEP 2 PAINT STRIPPING (WHEN APPLICABLE)	STEP 3 CORROSION REMOVAL
Light or heavy pitting or etching of aluminum (clad).	Remove foreign matter with cleaner, Spec MIL-C-25769.	Readily accessible areas: Strip with stripper, Spec MIL-R-25134. Confined areas: Strip with solvent.	Remove corrosion with Corrosion Removing Compound MIL-C-38334.
Light or heavy pitting or etching of aluminum (nonclad).	As above.	As above	Remove corrosion by mechanical method or Corrosion Removing Compound MIL-C-38334.
Intergranular or exfoliation corrosion of aluminum.	As above.	As above	Remove corrosion by mechanical method.
Light or heavy corrosion on small aluminum parts which can be removed for treatment	Painted Parts Clean and strip in solution of paint and varnish remover, Spec MIL-R-7751. Unpainted Parts Clean with compound, Spec P-C-436, MIL-C-5543, or vapor degrease.	Not Required If cleaning was accomplished with paint and varnish remover, Spec. MIL-R-7751.	Remove corrosion and oxide film by immersion of parts in phosphoric-chromic acid solution.
Stress corrosion cracking of aluminum.	Not Applicable Replace or repair defective part as required in applicable -3 technical order.	See Step 1.	See Step 1.

To prevent plugging of the feed hose between operations, a duct is installed between the feed tee housing and the vacuum chamber. This results in a reverse flow of air through the feed hose, conveying the abrasive back to the hopper.

The abrasive reclaimer is a cyclone separator which receives all abrasives returned by the vacuum unit. The cyclone action separates the abrasive particles from the airstream. They are deposited on a vibrating screen located between the reclaimer and the hopper. Oversized debris is trapped by the vibrating screen, which must be periodically cleaned. Unusable dust is carried by the airstream from the abrasive reclaimer to the dust collector unit.

The dust collector contains envelope type cloth filter bags. A manually operated bag shaking mechanism permits the dust to fall into the dust tray. This dust tray must be emptied frequently. The upper panel of the dust collector is removable so that the dust bags may be periodically removed for thorough cleaning and inspection.

Functioning as a vacuum cleaner, the air ejector vacuum pump is mounted on the dust collector housing. It produces a vacuum of 40-inch static pressure to pick up the abrasives at the gun nozzle and return them to the abrasive reclaimer.

The blast gun set includes 20-foot lengths of air hose, abrasive hose, and

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TABLE 2

CORROSION REMOVAL PROCEDURES FOR MAGNESIUM

TYPE OF CORROSION	STEP 1 CLEANING	STEP 2 PAINT REMOVAL	STEP 3 CORROSION REMOVAL
Light pitting or surface oxidation.	Remove foreign matter with cleaner, MIL-C-25769 or P-D-680 Type II.	Readily accessible areas: MIL-R-25134. Confined areas: Paint thinner.	Remove corrosion with chromic acid pickle solution.
Heavy pitting or etching.	As above.	As above.	Remove corrosion by mechanical and chemical methods.
Intergranular or exfoliation.	As above.	As above.	Remove corrosion by mechanical method.
Stress.	Not applicable Repair/Replace as required in structural handbook.	Not applicable.	Not applicable.
Light or heavy corrosion on small parts which can be removed for treatment.	Immersion, spray, or vapor cleaning if practical.	Use mechanical or chemical methods. Readily accessible areas: Paint stripper, Spec MIL-R-25134. Confined areas: Ethyl Acetate, Spec TT-E-751 or lacquer thinner, Spec TT-T-266.	IAW TO. 42C2-1-7.

vacuum hose. The hand-held gun is constructed of aluminum and is approximately 7 1/2 inches long. The lower end of the gun housing is protected by a replaceable rubber liner. A circular nylon brush is also mounted on the lower end of the gun housing. This brush prevents escape of the abrasive particles until they are picked up by the vacuum system. The entire vacuum blast unit operates on an air supply of 100 cfm at 100 psi.

CHEMICAL CORROSION REMOVAL

The removal of corrosion by chemical means is recommended when there is no danger of the chemical becoming trapped in crevices and recesses. Acid and alkaline chemical solutions are used to remove oxide formations, rust, and other types of corrosion.

ACID CORROSION REMOVERS

The acid corrosion removers are adaptable to either immersion or brush applications. We shall now describe the basic acid corrosion removers.

Corrosion Removing Compound, MIL-C-38334

The compound MIL-C-38334 is used to chemically remove corrosion from aluminum and its alloys. It is a phosphoric acid solution for use only on aluminum alloy parts and must not be rinsed over magnesium, plated steel parts, or operating mechanisms. The acid must be confined to the area of corrosion removal by using barrier paper and masking tape.

Dilute the corrosion removing compound with an equal volume of water before use. Mix the compound in a wood, plastic, or plastic-lined container. Apply the compound to the corroded area with a sprayer, mop, sponge, or brush. When it is necessary to apply the compound to a large area, begin the application at the lowest surface to prevent streaking.

TABLE 3

CORROSION REMOVAL PROCEDURES FOR FERROUS METALS

TYPE OF CORROSION	STEP 1 CLEANING TO REMOVE FOREIGN MATTER	STEP 2 PAINT STRIPPING WHEN APPLICABLE	STEP 3 CORROSION REMOVAL
Light or heavy rust on structural parts or assemblies, such as beams, columns, panels, brackets, gussets, racks, cases, and housings.	Remove heavy grease or foreign matter with cleaner, Spec. MIL-C-25769, or other material.	Normally not required.	Abrasive blasting, grinding, wire brushing, and/or sanding.
Light or heavy rust on parts as above where chemical rust removal is practical.	As above.	As above.	Remove corrosion by wire brushing and/or sanding followed by phosphoric acid etch with Spec MIL-M-10578 material.
Light or heavy rust on small parts where vat treatment is practical.	Remove grease or foreign matter. Cleaning not required if alkaline corrosion removal is used.	Not required if alkaline corrosion removal method is used or if cleaning is accomplished with paint and varnish remover, Spec MIL-R-7751.	Acid Method: Remove corrosion by immersion in phosphoric acid solution. Alkaline Method: Remove corrosion by immersing parts in alkaline solution.

Allow the compound to remain on the surface no longer than 12 minutes while agitating with a stiff bristle nonmetallic brush. After all corrosion deposits are loosened, rinse with a stream of water or wipe the compound off with a cloth rinsed frequently in clean water. A summary of the procedures to follow when you are removing corrosion from aluminum alloy parts is given in table 1.

Pasa-Jell 101 and 102

In areas where liquid oxygen compatibility is a requirement, use Pasa-Jell 101 on corrosion-resistant steel, and Pasa-Jell 102 on aluminum, to remove the corrosion deposits. Apply the concentrated compound with a fiber brush. Agitate areas of deep pitting with an acid-resistant fiber brush or a non-metallic abrasive mat until all corrosion deposits are loosened. Wipe off the residue with a moist cloth rinsed frequently in clean water.

Chromic Acid Pickle

Use the chromic acid pickle solution to remove surface oxidation and light corrosion deposits from magnesium and magnesium alloys. This solution is not adequate for cleaning deep pits or heavy corrosion deposits. Deep pits or heavy corrosion deposits require corrosion removal by mechanical methods.

Prepare the chromic acid pickle solution by mixing 24 ounces of chromium trioxide with enough water to make 1 gallon of the solution. Mix the solution in a lead-lined steel, corrosion-resistant steel, or an 1100-aluminum container.

Use masking tape and barrier paper to protect nearby operating mechanisms, crevices, plated steel, or copper parts. Apply the solution with an acid-resistant brush. Allow the solution to remain on the surface for approximately 15 minutes while re-applying to keep the surface wet and agitating if necessary. When all corrosion deposits are loosened, rinse the surface thoroughly with clean water. A summary of the procedures you should follow when removing corrosion from magnesium and its alloys is given in table 2.

Phosphoric Acid Base Rust Remover, MIL-M-10578

The phosphoric acid solution is used to remove corrosion from steel, corrosion-resistant steel, and copper surfaces. It is also used to condition these surfaces before painting. If heavy rust deposits are present, first remove them by mechanical methods.

Dilute the concentrated remover with an equal volume of water. After the solution is thoroughly mixed, apply it to the corroded surface with a brush or swab or immerse the part in the solution. Allow the remover to remain on the surface from 2 to 10 minutes to loosen the deposits. Then rinse the remover from the surface with plenty of water, preferably hot. After rinsing, dry the part and immediately apply a protective paint or finish. Table 3 lists a summary of the procedures to follow when you are removing corrosion from ferrous alloys.

Nitric-Hydrofluoric Acid

Use the nitric-hydrofluoric acid solution to remove light corrosion and oxide films from corrosion-resistant steels and titanium. Remove heavy scale or corrosion deposits by mechanical means, and give the metal an acid dip to remove any remaining deposits.

Since the acid content of this solution can vary from 5 to 50 percent nitric acid and 0.5 to 5 percent hydrofluoric acid, determine the correct percentages by using test panels. Make the test panels, 1 x 4 inches, of the same material as that being cleaned. Then process the test panels through the complete cleaning cycle. Observe the reaction of the solution; referring to TO 1-1-2, adjust the acid concentrations until you get a suitable remover.

Never use an acid solution to remove corrosion from high-strength steel parts. Acid causes hydrogen embrittlement of the steel, which leads to accelerated corrosion and premature failure of the part.

Sulfuric Acid

Use the sulfuric acid solution to remove corrosion from copper parts that can be disassembled for immersion cleaning. Prepare the solution by adding the acid to the water until you obtain a 5- to 10percent sulfuric acid solution.

Immerse the copper parts in the acid solution while maintaining a solution temperature between 60° and 120° F. Determine the required temperature, immersion time, and acid concentration by test.

If a red stain appears following the above treatment, immerse the parts in a solution containing sulfuric acid, 4 to 10 percent by volume; sodium dichromate, 4 to 8 ounces; and enough water to make 1 gallon of solution. You also determine the immersion time and acid concentration of this solution by test. When you remove the parts, rinse them thoroughly and dry them rapidly to prevent water staining.

ALKALINE CORROSION REMOVER

Use the alkaline corrosion removing compounds to remove corrosion from ferrous and copper alloys. The compounds also remove dirt, grease, and paint from the parts, eliminating the precleaning step from the corrosion removal procedure.

Prepare the alkaline corrosion removing solution by mixing approximately 5 pounds of sodium hydroxide to 1 gallon of water. The mixing may be done in a steel mixing tank. Immerse the parts in the solution until they are cleaned. Use high temperatures, up to 212° F., to speed the cleaning process. When you remove the parts, rinse them thoroughly, preferably in hot water. Dry the parts and immediately apply a protective finish.

ELECTROPLATING AND PASSIVATION OF METAL SURFACES

After you have removed all corrosion deposits, most metals require some type of surface treatment to prevent further corrosive attacks. These surface treatments may be applied by depositing one metal on the surface of another metal or by treating with chemicals. Make sure that the part or parts are thoroughly cleaned before attempting any type of surface treatment.

PLATING PROCESS

Plating (electrodeposition) is a method of producing a metallic coating by electrochemical means. In the plating process, metal particles are transferred from a soluble anode through the plating solution to the cathode (the metal being plated).

Plating is made possible by applying a DC voltage great enough to overcome the natural resistance of the system and furnish sufficient energy to transfer the metal particles to the cathode. The voltage required for the plating process may vary from 6 to 28 volts direct current. The plating solutions contain various chemicals to produce the type of deposit wanted. The concentrations of these chemicals are rigidly controlled to give the desired condition of acidity or alkalinity, current density, anode corrosion, etc.

The plating process causes metal crystals to form on the surface of the item being plated. The control of the concentration of the chemicals, temperature, current density, etc., are factors which affect the size and brittleness of the crystals. Small crystal size is usually desirable to reduce labor cost and the time required to finish (buff or polish) the surface after plating.

CHEMICAL PROCESS

Use chemical surface treatments to form oxide films on the surface of metals. These induced films are more corrosion resistant than the films that are formed naturally. They are also more wear resistant than natural films and give the parts greater service life.

You can test small areas of the surface to be chromate coated for cleanliness by performing a water-break test. Spray an atomized mist of distilled water on the surface. If the water gathers into droplets within 25 seconds, the surface has failed the cleanliness test. If the water forms a film by flashing out suddenly, it is evidence that the surface is contaminated. If the water droplets gather into a continuous film, without sudden flashout, the surface is clean and ready to receive the chromate coating.

Chromate Conversion Coating, MIL-C-5541

The chromate coating is used to form the oxide film on aluminum and its alloys. This film provides an acceptable paint base for the enamel or lacquer coating systems. It does not provide a suitable paint base for the epoxy coatings as the bonding power of the epoxy to the chromate is greater than the chromates' bonding power to the metal. Prepare the chromate solution according to the manufacturer's instructions. Then allow the solution to stand 1 hour before use.

Apply the solution to the cleaned aluminum surface by spraying, or immersing, or by using a fiber bristle brush, sponge, or cloth. Keep the surface wet until the coating is formed, which may take from 1 to 5 minutes. Do not allow the chromate solution to dry on the metal surface, because it is difficult to wash off and provides poor paint adhesion.

Rinse the treated area with clean water, or sponge the area with a clean cloth rinsed frequently in water. After the excess chromate solution is removed, allow the surface to air dry. Do not agitate the new coating before it is completely dry, as it can be removed by brushing or rubbing.

Chromic Acid Brush-On Solution

The chromic acid brush-on solution may be applied to all magnesium parts that require touchup. This treatment is less critical to apply than other brush-on treatments. It is inexpensive and does not present the toxic hazard of the other brush-on treatments.

* Prepare the chromic acid brush-on solution by mixing 1 1/3 ounces of chromic acid, 1 ounce calcium sulfate, and enough water to make 1 gallon of solution. The solution should be prepared in a stainless steel, aluminum, vinyl, or rubber container.

Apply the solution with a brush, keeping the surface wet until the desired film color is formed. The treatment time must not be less than 30 seconds nor longer than 3 minutes. Treatment time up to 1 minute produces a brassy film, while 2 to 3 minutes produces a dark brown coating. For best paint adhesion, the dark brown coatings are preferred. Remove the excess solution with cold running water, and allow the surface to air dry.

Most metals require the application of an organic coating for further corrosion protection. After removing corrosion and applying chromate coatings, paint the surfaces as soon as possible. Refer to the applicable aircraft painting and marking details drawing for the specified type of coating and CGTO 42A-1-2 for the proper finishing procedures.

SAFETY PRECAUTIONS

Safety precautions may seem like a little bit of a nuisance to you, but when you become a supervisor in this field, you will learn that a preventable accident even if it's only a minor one - is much more of an aggravation than the little trouble it takes to be careful. You will find then that you are the one who has to fill out accident reports, medical reports, etc., and that you, the supervisor, will have to answer higher up for not making sure that the men working for you avoid unsafe practices. When you become a supervisor, just what are your responsibilities in the field of safety? Let's take a look at them.

Adequate personal protective equipment must be provided to all personnel engaged in handling chemical solutions. However, this does not guarantee safe working conditions. Safe working conditions depend on adequate ventilation, light, fire and health precautions, and intelligent conduct on the part of each person.

Supervisors are directly responsible for insuring that all possible safety measures are employed. If a work safety problem exists, the supervisor should seek the advice of the Safety Officer or the Engineering Officer.

Safe working conditions require that safety instructions be given each new person and a continuing reinstruction program be given all maintenance personnel. First aid training should be taught and practice sessions permitted.

All personnel should practice the following safety techniques:

1. Wear personal protective equipment when handling or mixing any chemical solution.
2. Do NOT allow chemicals to come into contact with open wounds or skin abrasions.
3. Do NOT store, handle, or eat foods where toxic fumes are present.
4. Wash hands thoroughly after handling any chemical.
5. ALWAYS add the acid to the water, not the water to the acid, when mixing a chemical solution.

STORAGE OF HAZARDOUS SUBSTANCES

Sulfuric, nitric, hydrochloric, phosphoric acids, and other hazardous chemicals must be properly stored. Quantities in excess of the immediate use should not be kept in the shop area. Because of the hazards involved in the use of these materials, you must take measures to prevent their use by unauthorized personnel. Proper storage is also essential to protect and prolong the usefulness and effectiveness of chemicals.

Toxic Materials

Areas in which toxic materials are stored and mixed should be completely enclosed and locked to prevent the materials falling into the hands of unauthorized personnel. Storage spaces should be located where the toxic contents cannot contaminate food supplies or create fire hazards. Chromic and nitric acid may ignite when in contact with combustible material or vapors. Therefore, these acids should be isolated from combustible material and from alcohols, acetone, or turpentine.

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Facilities

In addition to providing for the safe storage of toxic materials, shops must be equipped with hot and cold running water, soap, and shower facilities, to enable personnel to quickly remove any spilled chemicals. Locker space must be provided for storing work clothing. Work benches are needed for minor equipment maintenance. Scales, volumetric measuring devices, and adequate mixing vessels must be provided for the safe preparation of chemical solutions.

SOLUTION DISPOSITION

Do not discard highly toxic chemicals into storm or sanitary sewers unless approval has been obtained from the Engineering or Public Works Officer. Until such approval of the method of disposal is obtained, store the solutions in isolated, appropriately marked, containers.

Before you start forgetting what we have discussed about the supervisor's responsibilities in the safety area because you are not a supervisor yet, remember that these are the responsibilities of your current supervisor. Now, ask yourself, "Who's he trying to protect?" That's right - among others, you. So why not help him out?

ERIC

LESSON QUIZ

Directions: Cover the answers to the questions with the enclosed Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any question incorrectly, refer to the text material.

QUESTIONS

1. To prevent a power sander from digging into the metal to be sanded, you should ______________.

2. When you are using a power sander, generally how much surface area should you cover per minute?

3. When you are sanding or grinding with power tools, excessive metal heating alters the ______________.

4. The five individual units which compose a vacu-blaster are the abrasive hopper, abrasive reclaimer, dust collector, blast gun, and ______________.

5. In a vacu-blaster, after the abrasive particles are separated from the airstream, where are they deposited?

6. One of the MAJOR considerations before using chemicals to remove corrosion is that ______________.

7. When using the corrosion removing compound, MIL-C-38334, on an aluminum alloy, you should allow it to remain on the surface a MAXIMUM of ________ minutes.

8. The alkaline corrosion remover solution is a mixture of ________ and water.

9. In the electroplating process, metal particles are transferred to the metal being plated from a ________.

10. In the chemical treatment process, small areas of the metal surface to be chromate coated are checked for cleanliness by a ________ test.

11. When preparing a chemical solution, how should you mix acid and water?

12. Why should chromic and nitric acid be isolated from alcohols, acetone, and turpentine?

ANSWERS

1. start it before touching it to the metal. (Page 1.)

2. Two square feet (Page 2.)

3. granular structure (Page 2.)

4. vacuum pump (Page 3.)

5. on the vibrating screen (Page 4.)

6. there is no danger of the chemical becoming trapped in crevices and recesses. (Page 5.)

7. 12 (Page 6.)

8. sodium hydroxide (Page 7.)

9. soluble anode (Page 8.)

10. water-break (Page 8.)

11. Add the acid to the water, not the water to the acid. (Page 9.)

12. The acids may ignite when they come in contact with combustible material or vapors. (Page 9.)

AIRCRAFT AND COMPONENT PAINTING AND PAINT TOUCHUP

OBJECTIVES

When you complete this section, you will be able to:

1. State the primary and secondary purposes of paint coatings.
2. State the authority for Coast Guard aircraft paint color schemes.
3. Describe the procedure for applying the polyurethane paint system.
4. Describe the procedure for painting radomes.
5. Identify the types of equipment for applying paint coatings.
6. Explain the proper use of a paint spray gun.
7. State the safety precautions you must observe while mixing, applying, and storing paint.

Surfaces of aircraft equipment are subjected to many natural and man-made environments. Protecting surfaces from these environments is one of the most important functions of an aviation structural mechanic. Inadequate control of corrosion can shorten equipment life, hinder mission accomplishment, or endanger personnel or equipment.

To enable metallic surfaces to resist their environments, the surfaces may be coated with an organic coating system. This organic coating is a liquid or semiliquid material which is applied to the surface by mechanical means. When dried or cured, the coating provides an adherent film that tends to isolate the metal from its environment. Organic coating systems are commonly classed as paints, varnishes, enamels, or lacquers.

The primary objective of any paint finish is the protection of exposed surfaces against deterioration. There are secondary reasons for particular paint schemes: the reduction of glare by nonspecular coatings, the use of white or light colored high-gloss finishes to reduce heat absorption, comouflage or high visibility requirements, or special identification markings. There is seldom justification for repainting for appearance sake only. A faded or stained, but well-bonded, paint finish is better than a fresh touch-up treatment improperly applied over dirt, corrosion products, or other contaminants.

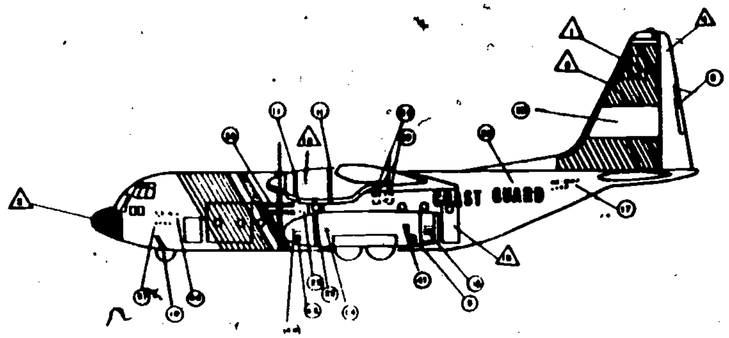
The amount of paint touch-up at the unit level will vary widely with the activity involved, the availability of facilities, and the area of operations.

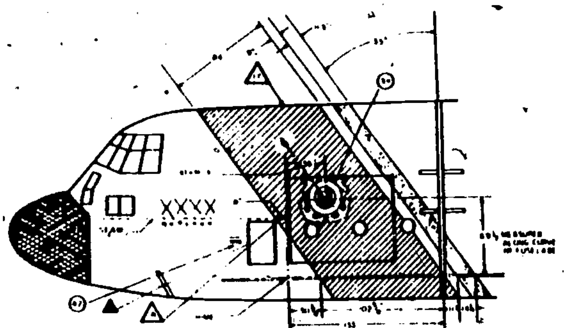
Complete refinishing, particularly under field conditions, should be restricted to those areas in which existing paint finishes have deteriorated, through age and exposure, until they fail to perform their protective function. Renewal of special finishes and markings should also be restricted to those situations where the purpose of the special finish is not being served. However, maintenance and repair of paint finishes at the unit level is extremely important. This period covers the evaluation of initial paint finishes at the time of aircraft receipt through the constant surveillance and maintenance of finishes during a service tour.

For this type of application, it is often impractical to touch-up small surface areas when the total of the areas would not justify the time consumed for set-up, cleaning, surface preparation, paint mixing, spraying, etc. It would be more practicable to strip a large section or panel when the aircraft is in scheduled maintenance. Corrosion removal, surface treatment, and painting could be accomplished at that time.

After retouched areas become dry, color contrasts for the same colors in

1. DO NOT PAINT NON-METALLIC AREAS OF ANY ANTENNAS, ANTENNA MASTS OR ANTENNA COVERS
2. RADOME TO BE PAINTED IAW USCG ATN2-68B ONLY WHEN NECESSARY BECAUSE OF DETERIORATED CONDITION
3. FINISH INTERIOR AND EXTERIOR OF AFT NACELLE FAIRING AND EXHAUST TRAIL BEGINNING 8.75 IN. AFT OF THE LEADING EDGE OF THE FIRST MILLED PANEL WITH TWO COATS BLACK, FS NO. 17038, MIL-C-81773 (REV). PAINT ON ALL ENGINES.
4. CONTROL SURFACES TO BE PAINTED IAW ATN 2-68B.
5. FLAP WELLS, AILERON WELLS, AND ASSOCIATED PARTS TO BE PAINTED, WHITE POLYURETHANE.
6. ELEVATOR WELLS, RUDDER WELL AND ASSOCIATED PARTS TO BE PAINTED WHITE POLYURETHANE.
7. INTERIOR OF WING BAYS: MILLED PANELS TO BE PAINTED WITH TWO COATS MIL-C-27725(REV) AND ONE COAT WHITE MIL-C-81773(REV).
8. APPLY WHITE POLYURETHANE TO ALL EDGES SO THAT 2 1/2-3MILS THICKNESS OF TOPCOAT IS APPLIED BY TWO COAT APPLICATION. NOTE THAT THIS THICKNESS IS GREATER THAN THAT SHOWN IN REFERENCE (a), ENCLOSURE (1), PARAGRAPH 5.c. FOR AIRCRAFT SKIN SURFACES.
9. ALL NOSE AND MAIN LANDING GEAR WELLS AND ASSOCIATED PARTS TO BE PAINTED WHITE POLYURETHANE.
10. DO NOT PAINT STAINLESS STEEL AREAS SUCH AS NACELLE ENGINE AIR INLET SCOOPS, OIL COOLER INLET SCOOPS OIL COOLER OUTLET DUCTS, GAS TURBINE COMPRESSOR EXHAUST.
11. CENTER WING WALKWAY (W.S. 220L TO W.S. 220R) PRIME IAW ATN 2-68B OVERCOAT WITH THREE COATS MIL-W-5044, TYPE I WALKWAY COATING.
12. MID OUTER WING WALKWAY (W.S. 220 TO W.S. 413, BOTH WINGS) PRIME IN ACCORDANCE WITH ATN NO. 2-68B. OVERCOAT WITH THREE COATS MIL-W-5044, TYPE I WALKWAY COATING.
13. OUTER WING, FUSELAGE, AND HORIZONTAL STABILIZER WALKWAY COATING PRIME IN ACCORDANCE WITH ATN 2-68B, OVERCOAT WITH THREE COATS MIL-W-5044, TYPE I WALKWAY COATING. USE COLORS INDICATED.
14. MASK END OF FUEL DUMP MAST DURING APPLICATION OF PAINT TO AVOID ACCUMULATION OF PAINT ON SCREEN.
15. DO NOT PAINT PROPELLER DOMES. SEE DETAIL "M" FOR PROP. BLADE TIPS, PAINT IAW ATN 2-68B, & MIL-C-81773(AS)
16. ALL EMERGENCY OPENING HANDLES TO BE PAINTED YELLOW, BOTH EXTERIOR AND INTERIOR.
17. THE RED AND BLUE STRIPES SHOULD GIVE THE OVERALL APPEARANCE OF STRAIGHT STRIPES AT AN ANGLE OF 35 TO THE VERTICAL WHEN VIEWED FROM THE SIDE. NO "S" EFFECT CAUSED BY MAINTAINING STRAIGHT LINES ON A CURVE SURFACE IS ALLOWED.
18. FWD EDGE OF RED AREA LOCATED 8" FWD OF THE INTERSECTION OF SEAM AND STA.245 35 ANGLE TO BE TAKEN AT THIS SEAM
19. 1" YELLOW BORDER AROUND FRAME OF ALL EMERGENCY EXITS (EXTERIOR) SEE NOTE 16
20. REMOVE OLD FABRIC AND REPLACE WITH NEW FABRIC PATCH PAINTED YELLOW.
21. FABRIC PATCHES SHALL BE INSTALLED OVER ALL LIGHTING HOLES OF CONTROL SURFACES, FLAP WELLS WHEEL WELLS AND DOORS, AND PAINTED TO MATCH SURROUNDING AREA.
22. ALL PAINT AND OTHER COATING SHALL BE IN ACCORDANCE WITH ATN 2-68B OR REVISIONS THEREOF, EXCEPT AS NOTED HERE.
23. DO NOT PAINT STATIC DISCHARGE WICKS
24. DELETED
25. ICE DETECTION MARKING. A 6" DIA. BLACK CIRCLE, SYMETRICAL ABOUT THE LEADING EDGE HORIZONTAL CENTER LINE. BOTH WINGS.





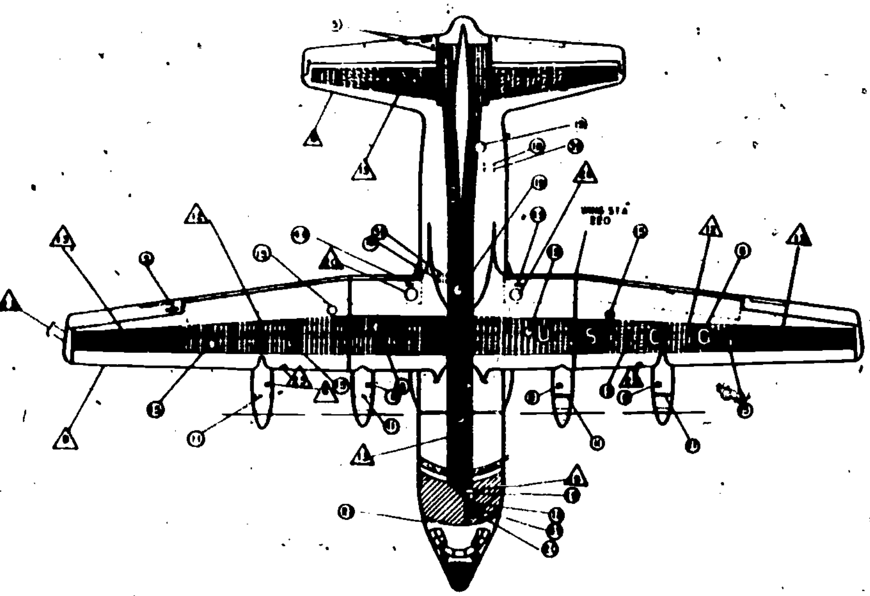
L.H. SIDE VIEW
(PARTIAL)

26. THE ENTIRE PAINTED SURFACE OF THE ACFT SHALL HAVE ONE COAT OF EPOXY PRIMER IAW ATN 2-68B, EXCEPT THE WING WALKWAY SURFACES WHICH SHALL HAVE TWO COATS EPOXY PRIMER.

27. EXCEPT FOR UNPAINTED AREAS, WALKWAY AREAS AND EXHAUST TRAIL AREAS, THE WHITE PAINT SYSTEM SHALL BE APPLIED FIRST SO OTHER PAINT WILL BE APPLIED OVER IT.

28. WHEN THE SKIN SURFACE ADJACENT TO THE STATIC HOLES IS PAINTED, THE PRIMER ONLY SHALL EXTEND TO THE RING OF THE HOLES. FINISH COATS SHALL NOT BE APPLIED WITHIN A RADIUS OF (.7)(.8) OF THE HOLES. THE EDGE OF THE FINISH COAT SHALL BE CAREFULLY SMOOTHED AND BLENDED INTO THE PRIMER.

ERIC



STENCIL LEGEND

1. LETTERS AND NUMERALS IAW MIL-I-18464(REV) UNLESS OTHERWISE SPECIFIED.
2. STENCILE COLORS ARE BLACK FS NO.17038 OR WHITE FS NO,17875 POLYURETHANE ENAMEL UNLESS OTHERWISE SPECIFIED.
3. NUMBERS IN OR ARE ALSO SHOWN ON DRAWING
4. STENCIL LETTERING HEIGHT AND COLOR ARE SHOWN BY (HT.COLOR)
5. "CAUTION PAINT IAW (1/2" BLACK) 10 PLACES PORT SIDE, OF LATEST ACFT TO" RUDDER ONLY
6. "USCG"(60")BLACK PARALLEL TO AND LOCATED AFT OF NOT LEADING EDGE SEAM ON BOTTOM OF WING AND 4" AFT OF SEAM ON TOP OF WING
7. NATIONAL INSIGNIA, STAR 50" DIA. IAW MIL-I-6140(REV) LOCATED IN LINE WITH THE "USCG"
8. "OIL MIL-L-23699"(1/2"BLACK) LOCATED ON OIL TANK FILLER ACCESS DOOR, 4PLACES.
9. ALL STATIC GROUND POINTS PER T.O. 1C-130-816AT.O.1-1-4
10. 2"X37" RED STRIPE BEGINNING AT FWD CORNERS OF NOSE WHEEL WELL AND EXTENDING OUTWARD AT 60 ANGLE
11. 2" RED BAND, VERTICALLY ENCIRCLING ENGINE ONE 32" AFT OF FWD EDGE OF COWLING AND THE SECOND 30" AFT OF WING LEADING EDGE
12. "WARNING STAND CLEAR (3/4" RED) ON INBOARD AND OUTBOARD STARTER TURBINE PLANE" SIDES OF EACH ENGINE
13. 2" RED VERTICALLY BAND 24"FWD OF MAINLANDING GEAR DOOR, PORT SIDE ONLY
14. "KEEP CLEAR (2" RED) LOCATE AFT OF RED BAND, TURBINE EXHAUST" PORT SIDE ONLY
15. RED FUEL CAPS "FUEL(1/2"WHITE) ON FUEL CAPS, 6 PLACES ON JP-5" WING, 1 PLACE EACH EXTERNAL TANK.
16. "FUEL (1/2"BLACK) ON SINGLE POINT REFUELING ACCESS COVER, JP-5
17. "HC-130X(4" BLACK) AIRCRAFT TYPE WITH USCO NUMBER CENTERED 3" BELOW. LOCATED WITH THE AFT LETTER AT STA. 1000 AND 2" BELOW THE HORIZONTAL STABILIZER.
18. "PULL-CAUTION(1" YELLOW) BLACK BACKGROUND. ON OVERHEAD STAND CLEAR WHEN OPENING" ADJACENT TO HANDLE(IN SIDE)
19. "NO STEP"(1" BLACK) ON THE ESCAPE HATCHES
20. "PULL HANDLE(1" YELLOW) BLACK BACKGROUND ON OVERHEAD TO JETTISON CREW DOOR" ADJACENT TO HANDLE (IN SIDE)
21. "ICE OBSERVER (1/2" BLACK) ON CONNECTION BOX COVER RADAR RELAY & ICE CONNECTION BOX (INSIDE)
22. "EMERGENCY EXIT (1/2" YELLOW) BLACK BACKGROUND LOCATED ON UPPER HALF OF ESCAPE HATCH (INSIDE) GROUND & DITCHING USE ONLY"
23. "CAUTION (1" YELLOW) BLACK BACKGROUND F.S.390 STAND CLEAR WHEN OPENING" ADJACENT TO YELLOW HANDLE (INSIDE)
24. 3" RED VERTICAL STRIPE FROM DECK TO 96" HEIGHT, AT STARBOARD F.S. 401 AND 440. (INSIDE)
"P (2" WHITE) 4 PLACES; TWICE IN EACH STRIPE
R
O
P
E
L
L
E
R"
25. "BEWARE (2RED) WHITE BACKGROUND. 6 PLACES (INSIDE) PROPELLER" AT 48" AND 96" HEIGHTS OF F.S. 390, 420 AND 450. STARBOARD SIDE ONLY
26. 1" YELLOW BAND(INSIDE) ON SOUNDPROOFING AROUND OUTER EDGES OF ALL EMERGENCY ESCAPE OPENINGS.
27. 3" RED VERTICAL STRIPE FROM DECK TO 96" HEIGHT AT PORT FUSELAGE STATIONS 245 AND 337 (INSIDE)
"P (2" WHITE) 4 PLACES; TWICE IN EACH STRIPE
R
O
P
E
L
L
E
R"

28. "NEWARE (2" RED) WHITE BACKGROUND 3 PLACES AT 48" AND 96" HEIGHTS OF F.S. 255 AND ONCE AT 72" HEIGHT AF F.S. 347 PROPELLER"

29. 1" YELLOW CUT OUT MARKINGS VERTICAL LOCATION TO BE WITHIN 76-100" HEIGHT ABOVE DECK AND 4 HORIZONTAL LOCATIONS TO BE WITHIN FUS. STA. 620-652 AND 660-652 PORT AND STBD SIDES (INSIDE AND OUTSIDE)

30. "CUT HERE FOR (1" YELLOW) BLACK BACKGROUND IN CENTER OF CUT OUT MARKINGS(NOTE)(INSIDE & OUTSIDE)

31. INSIDE FUS. STA. NUMBERS(1/2" BLACK) ARE STENCILED EVERY 10" AT 24" AND 70" HEIGHTS BEGINNING WITH F.S. 250 AND THRU F.S. 840. BOTH SIDES.

32. CARGO LOADING COMPARTMENTS ARE INDICATED WITH 3" BLACK LETTERS AND 1" BLACK F.S. NUMERALS AND LOCATED 96" ABOVE THE DECK BOTH SIDES.

33. NATIONAL INSIGNIA. STAR 50" DIA IAW MIL-I-6140(NEW) CENTERED IN WHITE AREA OF VERTICAL STABILIZER BOTH SIDES.

34. USCG EMBLEM 40"DIA DECAL (ARSC 7690-851-3105) HORIZONTALLY CENTERED IN RED AREA, BOTH SIDES ON STBD SIDE CUT OUT 1" CIRCLE TO SHOW OXYGEN BLOW OUT DISC

35. SEE DETAIL "A" FOR PROPELLER WARNING BAND.

36. USCG AIRCRAFT NUMBER (15" BLACK) UNIVERS 73 TYPE NUMERALS IAW USCG ARSC DWG. 550-5-1 BOTH SIDES.

37. STATION NAME OF UNIT TO RECEIVE AIRCRAFT (4" BLACK) LOCATED 4" BELOW AND CENTERED UNDER THE USCG AIRCRAFT NUMBER BOTH SIDES

38. "COAST GUARD"(20" BLACK) UNIVERS 73 TYPE LETTERS IAW USCG ARSC DWG 550-5-1. PARALLEL TO AND 6" ABOVE THE TOP OF THE AFT TROOP DOOR WITH THE FORWARD MOST LETTER AT STATION 617 BOTH SIDES.

39. "FOR GROUND AND (1" YELLOW) BLACK BACKGROUND. ADJACENT TO DITCHING USE ONLY" ESCAPE HATCHES (INSIDE)

40. "WARNING STAND CLEAR (1" RED) FORWARD OF RED BAND GTC TURBINE WHEEL" PORT SIDE ONLY.

41. "WARNING" (1. RED) ON SPOILER DOOR. BOTH SIDES

42. WARNING" "WITH CREW MEMBERS ABOARD THIS DOOR WILL BE OPENED FROM INSIDE ONLY.

43. DELETED

44. DELETED

45. "EMERGENCY RADIO AND (1" YELLOW) LIFE RAFT RELEASE" BLACK BACKGROUND.

46. "LIFERAFT RELEASE" (1" YELLOW) BLACK BACKGROUND .

REV	DATE	APPD	
N			RETRACED ENTIRE DRAWING
M			REVISED 1 AND 2 PER EAE NR 3000 DTD 8-17-78
L			REV PAINT DETAIL NOTE 22
K			DELETE NOTES 43 44 47 24 CHANGE NOTES 11 12 16 CHANGE COLOR CODE
J			CHANGE NOTES 11 12 13 47 ADD NOTES 26 27 28
I			ADD NOTES 47 24 25 CHANGE NOTE 10 CHANGE COLOR CODE
H			CHANGE STENCIL LEGEND 29 30 46 46
G			CHANGE STENCIL LEGEND 9 10 28 41 ADD 45 46 CHANGE PAINT DETAIL NOTE 11 12 13 14 16 1 ADD 19 20
F			CHANGE ALL LEADING LINES TO WHITE DELETE DETAIL C & CG GUARD COLOR CODE SYMBOL CHANGE PAINT NOTES [illegible]
E			CHANGE NOTES 4 [illegible] 42 REV. SLASH ADD DIMENSIONS
D			ADD LH SIDE VIEW ADD NOTES 16 CHANGE NOTE 34
C			CHANGE RED & BLUE STRIPES ON SIDE VIEW
B			NOTE 3 CHANGED
A			NOTES 43 44 & 11 ADDED 34 RAISED EMBLEM

DESIGNER DRAWN BY TRACED CHECKED	U.S. COAST GUARD AIRCRAFT REPAIR AND SUPPLY CENTER ELIZABETH CITY N.C. [illegible]		
	C-130 PAINT AND MARKING DETAILS		
APPROVED DATE	SIZE	CODE IDENT NO. 27426	DRAWING NO. 360-[illegible]-2
	SCALE 1/40		SHEET

Figure 4. - Typical Painting and Marking Details drawing

masked off areas may be quite noticeable; therefore if practicable, painting full panels is desired. Adjacent areas should be masked off to eliminate overspray.

When painting aircraft or applying touch-up paint, operating units must comply with Coast Guard Technical Order 42A-1-2 or supersedure.

Operating units must apply the Coast Guard color scheme and markings in accordance with the aircraft model "Painting and Marking Details" drawings. AR&SC maintains current drawings for all Coast Guard aircraft models. Applicable copies are furnished to operating units initially, upon revision of a drawing, and upon request. Figure 4 illustrates a typical AR&SC drawing for the C-130 aircraft. A list of AR&SC drawing numbers for all Coast Guard aircraft models is given in table 4.

To break the gloss of existing finishes and to feather (smooth out) the edges for overlap, scuff sand, using 150-grit sandpaper. After sanding, use a water rinse to remove the abrasive residues. Next, wipe all sanded areas and exposed bare metal surfaces with a 1 to 1 mixture of xylene and acetone.

Treat bare metal with cleaner-brightener (MIL-C-5410) and allow it to set for 5 to 15 minutes maximum. Then follow it with a water rinse. Apply MIL-C-5541 chemical conversion coating immediately following the cleaner-brightener, while the surface is still wet from the water rinse.

Remove any loosened seam sealants in the area to be touched-up and replace as necessary. Also, resecure any loose rubber seals, using the type adhesive specified in the applicable Maintenance Instructions Manual.

Table 4. - Aircraft "Painting and Marking Details" drawings.

AIRCRAFT MODEL	AR&SC DRAWING NUMBER
C-131	900-3-1
C-130	300-14-2
VC-4A	200-1-1
HU-16E	100-38-2
HH-52A	475-8-2
HH-3F	700-1-1

The insignia and exterior markings on Coast Guard aircraft must meet the requirements given in table 5. In the event of conflict between the specifications cited in the table and the aircraft model paint and marking drawing, the latter will take precedence. Exceptions to the general paint systems are noted on the drawing. Suitable silk screen processes for the application of miscellaneous markings may be used wherever practicable.

SURFACE PREPARATION

The effectiveness of any paint finish and its adherence depends on the careful preparation of the damaged surface before touch-up. The procedures used in paint and corrosion removal have been described previously. The touch-up paint should overlap onto the existing good paint finish. The touch-up materials will not adhere properly to glossy finishes. Also, any edges of the existing film will show through the overlap unless they are smoothed out.

The area to be painted is then outlined with tape and masking paper. This protects the adjoining surfaces from overspray and unwanted paint buildup.

TOUCH-UP PROCEDURES

In the past, it was necessary to identify the specific surface finish (paint system) applied to an aircraft at the time of manufacturer or rework. Each surface finish (nitrocellulose lacquer, acrylic lacquer, and epoxy) required a specific touch up procedure that was compatible with the present finish. Failure to properly identify the present surface finish and apply the specific touch-up procedures usually resulted in wasted manhours and material.

To prevent this problem and more effectively control corrosion, the Coast Guard uses a standardized paint system for all maintenance level painting and paint touch-up. This system consists of an improved epoxy primer, specification MIL-P-23377B, and a polyurethane coating, specification MIL-C-81773(AS) or MIL-C-83286 (USAF).

EPOXY-POLYAMIDE PRIMER (MIL-P-23377B)

The epoxy-polyamide primer is supplied as a two-part kit; each part must be stirred or shaken thoroughly before mixing. One part contains the pigment, ground in an epoxy vehicle, and the other part is composed of a clear polyamide solution which functions as hardener for the epoxy solution. This primer is supplied by various manufacturers. Mix only as much primer as needed, since the storage life of the primer is limited after mixing. CAUTION: Do not substitute part 1 or part 2 from another manufacturer. Established mixing rations supplied by the manufacturer must be followed; otherwise, the primer will exhibit unsatisfactory properties, such as poor adhesion, poor chemical resistance, or inadequately dried film.

For mixing, pour the specified amount of part 1 into an empty container; then slowly pour part 2 into the container, stirring constantly. CAUTION: Always add part 2 to part 1.

To thin the primer for spraying, add 1 1/2 parts thinner, Specification MIL-T-19588, to 2 parts primer. The thinned primer should be stirred thoroughly, strained, and allowed to stand 1 hour before use. If necessary, the thinning ratio may be varied slightly to obtain the proper spraying viscosity. The 1-hour standing time is necessary to permit the components to enter into chemical reaction, shorten drying time, reduce cratering, preclude part 2 from "sweating out" or migrating, and allow any bubbles (formed while stirring) to escape.

To apply the primer, ensure that the surface to be primed has been cleaned, chemically treated, and prepared for spraying as previously described in this section. Apply a wet coat of epoxy primer to 1 mil thickness and allow to dry from 1 to 2 hours. One hour is sufficient when temperature and humidity range is ideal.

POLYURETHANE COATING

Since the original polyurethane coating specifications were issued some years ago and this paint coating was accepted for Coast Guard-wide use, it has proven

Table 5. - Aircraft Insignia and External Marking Requirements.

MARKING	IN ACCORDANCE WITH
National Insignia	MIL-I-6140 and aircraft drawing
Coast Guard Emblem	Aircraft Drawing
"Coast Guard" on side fuselage	Univers 73 letters & aircraft drawing
"USCG" on airplane wing and helo underside	MIL-I-18464 letters & aircraft dwg.
Station name	MIL-I-18464 letters & aircraft dwg.
Aircraft model designation	MIL-I-18464 letters & numerals and aircraft drawing
Large aircraft serial number	Univers 73 numerals & aircraft dwg.
Fuselage prop warning stripe	Aircraft drawing
Jet intake warning chevron	MIL-M-25047 & aircraft drawing
Fuel fill caps (align marker)	MIL-M-25047 & aircraft drawing
Fuel service points	Aircraft drawing
Oil service points	Aircraft drawing
Walkways and steps	MIL-M-25047 and aircraft drawing
Instrument static openings	Aircraft drawing
Helo tail rotor warning	Aircraft drawing
Main rotor blade tips	MIL-M-25047
Helo tail rotor blades	MIL-M-25047
Propeller tips	Aircraft drawing
Turbine wheel plane warning	Aircraft drawing
Emergency exit release	Aircraft drawing
Escape hatches	Aircraft drawing
Safety markings	Aircraft drawing

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to be a highly reliable and durable system for the protection and appearance of our aircraft. It has also proven, however, to be such a health hazard to those personnel who must apply the paint and work in areas where the paint is being used that some other acceptable paint system less detrimental to the health of personnel must be found. For this reason, the polyurethane coating is being phased out in the Coast Guard today, and several other types of paint systems are being experimented with on aircraft coming out of overhaul. The polyurethane coating is still to be used for paint touch-up, however, as long as the touch-up kits remain available. This touch-up system is also considered compatible with the newer experimental paint systems.

During this interim period, the AM must know and understand the correct application procedures for the polyurethane paint system, as well as the accompanying health hazards and the precautions to be taken during the application of this system.

Polyurethane Application Procedures

Proper application of the polyurethane coating is of prime importance. When the polyurethane coating has been properly applied, relatively little touch-up will be required at a later date. Proper application requires the following considerations:

1. Adequate lighting.
2. Adequate dust control.
3. Proper amount of paint. (Do not apply an excessive amount.)
4. Proper air pressure. (For the conventional hand pot spray gun, the air pressure should be 60-65 psi, dependent on the temperature.)
5. Proper paint thinning.

Proper thinning of the paint is very important. If the paint is not properly thinned, eventual chipping will occur, especially around fastener holes.

If no thinner is mixed with the paint, its application will not be smooth and will have an orange-peel effect that will not smooth out if a large amount of paint is applied. This practice is costly and time-consuming and does not provide the desired paint finish.

When thinner is added, the application of polyurethane paint is much like that of other paints. When the paint is applied to the surface, the paint will quickly smooth out and have a high-gloss finish. In addition, a more even coat of paint can be applied.

In all instances, measure the viscosity of the material to insure that the viscosity is correct for the method of application being used. When thinning is required, use only the recommended compatible thinning agents.

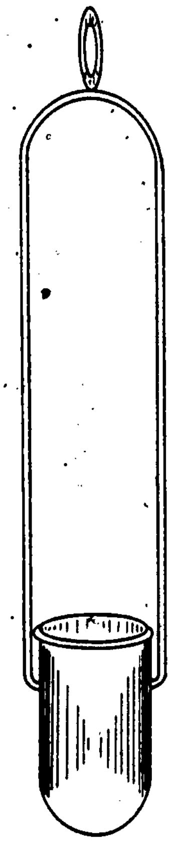

Figure 5. - Zahn cup.

Viscosity Measurements

Viscosity is measured by various methods and instruments and is expressed in various units of measurement. The methods most frequently cited in the coating industry use either the Ford or the Zahn viscometer cups. In both methods, viscosity is expressed in seconds through the cup. The seconds indicate the length of time

205

it takes at a given temperature for a known quantity of the coating material to flow through a certain size orifice in the cup. For example, at 77° F., viscosities of 16 to 22 seconds through a No. 4 Ford cup or 19 to 27 seconds through a No. 2 Zahn cup are generally right for spraying enamels. Lacquers require about 4 seconds less in either cup. For comparison, the viscosity of water and some thinners is 10 seconds through a No. 4 Ford cup.

The Zahn cup is usually considered the standard and most appropriate for field use. The Zahn cup is designed to measure the viscosity of fluids directly from their containers. It consists of a 44-mil cup with a hold (orifice) and a wire handle, as shown in figure 5. The cup is filled by immersion in the fluid, and the flow is timed from withdrawl to first interruption in the flow.

Five graduated orifice sizes, or cup numbers, are available. The No. 2 cup is most suitable for equipment painting. For mixing primers, the correct siphon spray gun viscosities measured in seconds for the No. 2 Zahn cup are listed as follows:

Wash primer	Mil-C-8514	24 to 31 seconds
Zinc chromate	Mil-C-8585	9 to 14 seconds
Modified zinc chromate	Mil-P-7962	15 to 22 seconds

The above is not a complete listing of viscosity measurements. When preparing any coating system, always refer to CGTO 42A-1-2, Aircraft Painting and Marking Details, for the correct viscosity measurement of a specific coating.

Thin polyurethane with MIL-T-81772 thinner to achieve 15 to 18 seconds with a No. 2 Zahn cup. Allow the paint to stand 1/2 hour before spraying.

Polyurethane overspray is greater than that for other paints; therefore, extra masking and papering are usually required. Masking tape should be of the pressure-sensitive type to prevent paint from running under the tape.

After allowing a drying time of 1 hour for the primer, spray a wet coat of polyurethane paint about 0.8 mil thick; then spray another wet coat of the same thickness. For touch-up or overpainting, apply one even light topcoat of paint and allow it to dry for 15 to 45 minutes; then apply a final full topcoat.

The coating will be ready for taping insignia colors in 4 to 6 hours.

You should remove masking tape from painted surfaces before the paint is completely dry. If the paint becomes dry with the masking tape in place, the paint will have a sharp edge and will leave a place for peeling to start. If you remove the masking tape before allowing the paint to dry, the edge will role or flatten, making a smooth, even surface.

If runs occur while painting small areas, stop the painting and remove the paint with rags and thinner. Then resume painting with the finish coat. Small areas may also be retouched by use of a small, long-bristled camel hair brush.

If runs occur while painting large areas, continue painting until you are finished and allow the area to dry. Then remove runs with #320 wet or dry sandpaper, and work down to a finer grit sandpaper to remove sanding scratches. If any bare metal is exposed, you should treat it as previously described. Then you should mask, paper, and paint the complete panel.

Polyurethane thinner should not be used for cleaning. Instead, use methyl ethyl ketone (MEK) TT-M-261.

Polyurethane paint should be allowed to air dry a minimum of 48 hours before you subject it to service use.

When you are working on fiberglass surfaces, follow approved Coast Guard procedures. Although fiberglass surfaces may be reconditioned, NEVER use a paint stripper to remove the existing paint finish. Strippers presently available for removing the paint will attack the fiberglass resins and weaken the structure. The approved Coast Guard method for touch-up of fiberglass surfaces is to use lacquer thinner to thoroughly clean the area to be repainted and sand lightly with 320-400 wet or dry sandpaper. After sanding, reclean the area with lacquer thinner and apply a polyurethane topcoat.

Decals on Polyurethane Coatings

Decals may be used for the application of the national insignia, the Coast Guard emblem, and other markings on the aircraft. When decals are used, they must be approved and conform to specification MIL-D-8634 (MIL-D-38477 for C-130). Decals must be applied in accordance with MIL-D-23890. To increase the retention capability of decals on the smooth surface of cured polyurethane coatings, lightly sand or roughen the area to which the decal is to be applied and then seal the edges with Scotchcal Edge Sealer No. 3950.

EPOXY FINISH ON RADOMES

Two epoxy systems are approved as the paint finish for radomes. They are the CAT-A-LAC and the BROLITE systems. The CAT-A-LAC system is procurable from the Finch Paint and Chemical Company, Torrance, California, and the BROLITE system from Andrew Brown Company, Laurel, Maryland. Neither system may be applied over any other type of paint.

APPLICATION OF THE CAT-A-LAC SYSTEM

The CAT-A-LAC system is applied in the following manner. Prepare the surface by removing the old paint. If the old paint is GACO N-79 neoprene, the best way to remove it is by applying a cloth wet with toluene or methyl ethyl ketone (MEK) to the painted surface. As the paint softens, wipe or scrape off with a plastic or phenolic scraper. Fill the pinholes, scratches, and surface pores of the radome with filler putty, No. 467-2, and apply a full, wet coat of primer, No. 454-1-1. Allow the primer to dry for 24 hours and sand lightly before spraying with a full covering topcoat, No. 443-1-17. Allow the topcoat to dry for 24 hours befoe handling. The total film thickness should be approximately 3 mils.

If the existing paint is CAT-A-LAC, you may refinish it by wet or dry sanding the topcoat of paint down to or almost to the primer coat. Then, after wiping down with toluene or MEK, apply a topcoat only. Allow the topcoat to dry for 24 hours.

Aged CAT-A-LAC surfaces may be touched up by sanding and wiping down the area to be painted, applying the topcoat, and allowing to dry for 24 hours.

APPLICATION OF THE BROLITE SYSTEM

In contrast to the CAT-A-LAC system, the BROLITE system is applied in this manner. If the existing finish is GACO N-79 neoprene, the old paint should be removed in the same manner as that given for the CAT-A-LAC system. After removing the old paint, fill pits and scratches with Sky Spar Epoxy Filler, No. 954. Sand the filler smooth and allow to dry overnight at room temperature. Apply a full, wet coat of primer, No. P-953, and allow to cure overnight. Before applying the finish coat, No. 423, sand lightly to a total thickness of approximately 2 mils.

> NOTE: The finish coat may be applied over the primer within 3 or 4 hours by omitting the sanding; however, the finish will not be as smooth as when the primer has been sanded.

The finish coat may appear dry in a few hours; however, full curing may require as much as 7 days, depending upon the ambient temperature. Do not subject the finish to chemicals or cleaners during the cure period.

If the old finish is BROLITE and the topcoat must be completely removed, the best way to remove it is with toluene. After removing the topcoat, lightly sand the primer coat and wipe with MEK before applying the new topcoat.

If the old BROLITE topcoat does not need to be completely removed, you may refinish it by wet or dry sanding the old topcoat down to, or almost to, the prime coat. After wiping with MEK, apply the new topcoat.

Aged BROLITE surfaces may be touched up by sanding and wiping down the area to be painted, applying the topcoat, and allowing to dry for 24 hours.

> NOTE: There are numerous stripping compounds that will remove paint from radomes. However, any stripping compound strong enough to remove CAT-A-LAC or BROLITE may damage the fiberglass radome.

RAIN-EROSION-RESISTANT COATINGS

Repairs to "Corogard" coatings can be made without exposing the bare metal, if nicks, rips, and thin spots do not extend through the original coatings. Enough material is cut away from the imperfection to produce a scarf approximately four times the thickness of the coating. The scarf is sanded to produce a rough finish and wiped clean with acrylic lacquer thinner. The cavity is then filled with aluminized "Corogard" applied in successive thin layers. After complete drying, sand as necessary to restore contour.

Repairs to neoprene coatings are impracticable in the field due to their slow cure. If the coating should fail and corrosive attacks develop, the damaged coating should be cut away until good adherence is reestablished at all edges. Treat the corrosion in accordance with established procedures and repaint the exposed surfaces with an epoxy topcoat.

PAINT APPLICATION EQUIPMENT

Organic coatings are applied using either hand or power equipment. Selection of the proper application method depends on the size and accessibility of the area to be coated.

TYPES OF EQUIPMENT

Spray Cans

Some coating materials are packaged in self-contained spray cans or aerosols. They are primarily a convenience package and are not to be used as a substitute for conventional spray methods. Spray cans are authorized for emergency touch-up painting where the area is less than 1/2 square foot or for spraying areas that are not accessible to conventional spray equipment.

When using aerosol spray paints, shake the can to thoroughly mix the paint and propellant. Hold the can approximately 12 inches away from the surface while spraying. This will prevent the propellant from becoming trapped within the paint film. Shake the can repeatedly throughout the spraying process. To clean the spray orifice after painting and keep the spray button from clogging between spraying operations, turn the can upside down and depress the spray button until only propellant comes out.

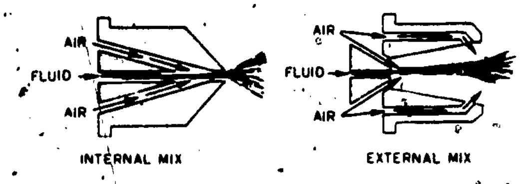

Figure 6. - Spray gun caps.

Conventional Spray Equipment

The conventional spray gun may be of the suction-feed or pressure-feed type. A suction-feed spray gun is one in which pressurized air passes over the tip of the fluid tube, sucks fluid from it, and sprays the fluid into the airstream. A suction-feed spray gun can be identified by the presence of an air vent hole in the paint cup cover. The suction-feed spray gun is ideal for spraying lacquer, varnish, and other light materials. It is not good, however, for spraying heavy coatings, since it will not pull the heavy materials up to the nozzle.

A pressure-feed spray gun is made with an airtight container. Pressurized air directed into the container places the fluid under pressure, forces it up the fluid tube, and sprays it. It is considered one of the best general-purpose spray guns because it can spray heavy materials when supplied with a low volume of air.

The mechanisms of the pressure-feed and suction-feed guns are the same, and both types can mix the fluid and air both internally and externally. Since no siphoning effect is necessary for pressure-feed application, it is the tool to use for volume spraying.

Internal-mixing spray guns mix the paint and air inside the spray cap, as shown on the left of figure 6. The internal-mixing cap requires less air pressure than the external-mixing cap and is popular on small units. The main fault of the internal-mixing feature is that fast-drying materials atomized inside the cap tend to collect inside and around the outlet. Pressure-feed spray guns are usually of the internal-mixing type. The external-mixing spray gun mixes the paint and air outside of the gun spray cap, as shown on the right side of figure 6.

Spray guns are classed as bleeder and nonbleeder types. A bleeder spray gun is

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constructed in such a way that air passes through it at all times. This feature prevents excessive pressure buildup in the compressor. If a spray gun is to be connected directly to a small (low-pressure) compressor, the gun should be of the bleeder type. The non-bleeder spray gun, as the name implies, does not pass any air until the trigger is pulled. This type of gun is normally used when controlled air pressure is supplied.

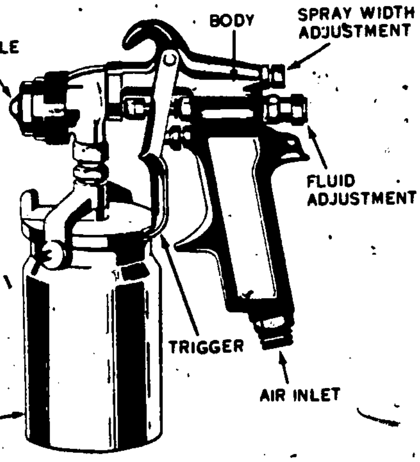


Figure 7. - Spray gun and cup.

Spray guns can be further classed as the attached container type and the separate container type. An attached container spray gun is usually referred to as a cup type, since the paint is held in a cup attached to the bottom of the gun. This gun is illustrated in figure 7. A separate container spray gun is one which does not have a paint container or cup attached to the lower portion of the gun. This gun receives paint materials through a fluid hose from a separate container called a material pressure-feed paint tank.

The pressure-feed paint tank, shown in figure 8, is a large metal container that provides a constant flow of paint material at uniform pressure to the spray gun. The spray gun is connected to the tank with two hoses, one for the air and the other for paint material. The capacities of such tanks range from 2 to 60 gallons. Basically, the tanks consist of a container with a clamp cover, an air-pressure regulator, and connections for fluid and air.

In operation, air pressure from a compressor or some other air supply is forced into the paint tank. This air pressure causes the material to flow out of the tank through a fluid hose to the spray gun. When the paint reaches the head of the gun, it comes in contact with the airstream, which atomizes and sprays the paint.

If you use good clean equipment and material that is thinned for spraying, using a spray gun should be no problem to you. In the following few paragraphs, let's go through a make-believe job so that you can imagine yourself actually using a spray gun.

Before starting to spray paint, check the adjustment of the spray gun. There are adjustments for various purposes; for example, some adjustments control the air pressure and flow of material and provide a means of changing the direction of a spray pattern. For a low-pressure spray gun, the air pressure should be in the low and mid psi range; the high-pressure gun should have between 80 and 100 psi.

The proper air pressure is essential to a good spray job. Too high an atomization pressure thins out the center of a spray pattern. Too little air pressure fails to atomize the material sufficiently, causing a coarse, spattered effect that is unacceptable. You can check this adjustment most satisfactorily by studying the spray pattern made by the gun. Such an adjustment may be made with the air control screw located above the handgrip, as shown in figure 9.

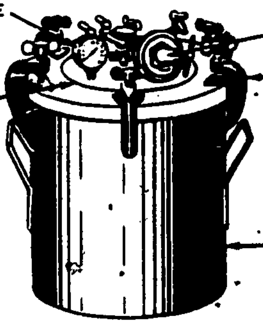


Figure 8. - Pressure feed tank.

The flow of materials is controlled by the fluid needle also located above the handgrip. The speed of operation at which you move the gun across the surface being painted determines how you adjust the flow of material from the gun nozzle. Experiment

209

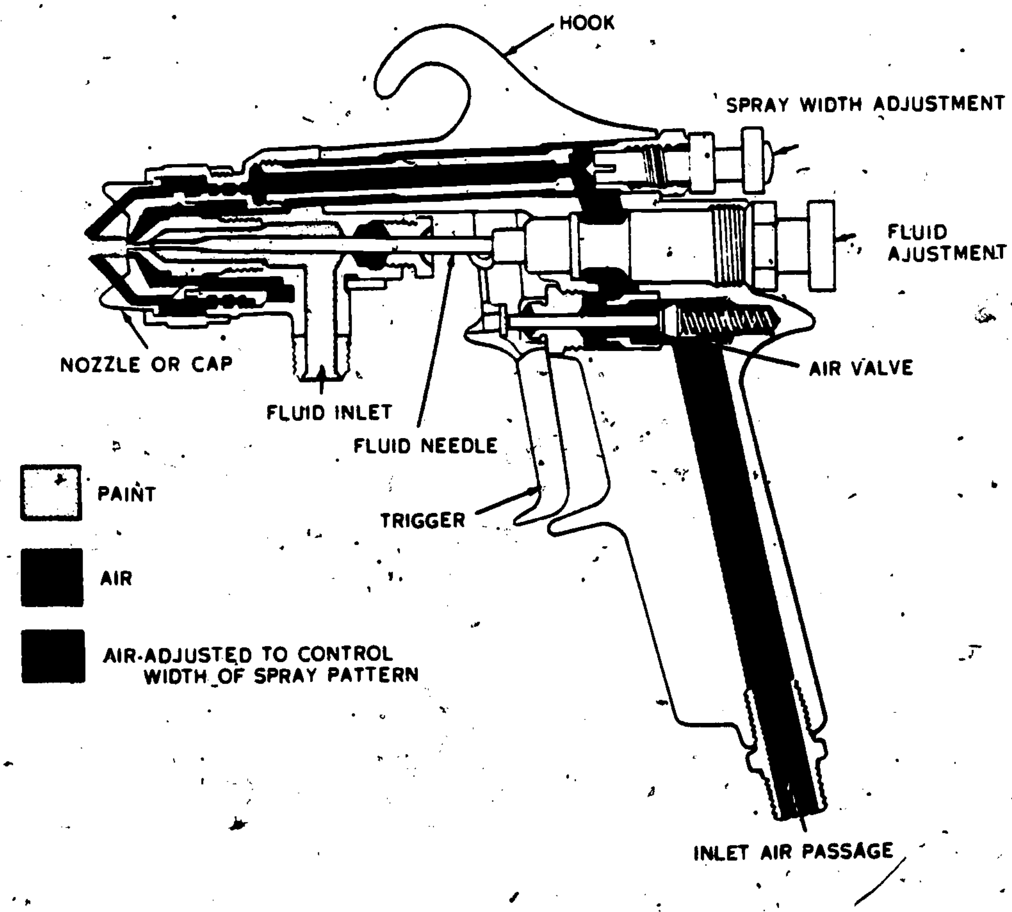


Figure 9. - Spray gun sectional view.

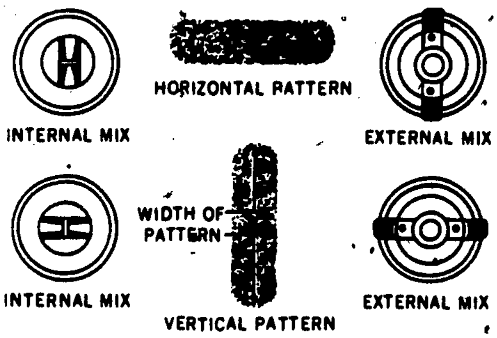


Figure 10. - Spray patterns.

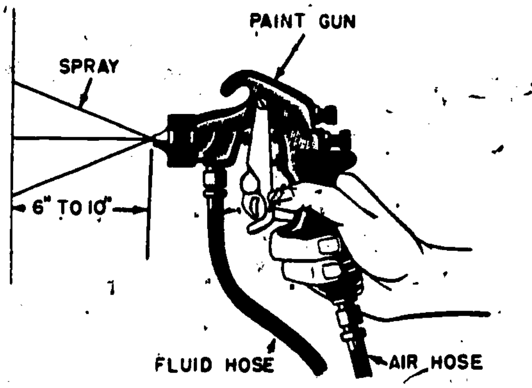


Figure 11. - Holding spray gun correctly.

217

with various settings of the adjustments at first to find what settings give you the most efficient operation. The adjustment should permit a comfortable, rapid stroke that gives sufficient coverage without runs or sags.

You may change the direction of a spray pattern by rotating the spray gun cap or air nozzle, as shown in figure 10. You can produce a spray pattern about 6 to 8 inches wide when you hold the gun 6 to 10 inches from the surface.

Hold the spray gun perpendicular to the surface, as illustrated in figure 11. Tilting the gun up or down gives an uneven spray pattern. The distance of the spray cap or nozzle from the surace depends upon the air pressure used and the consistency of the paint. Generally, the distance varies from 6 to 10 inches. Holding the spray gun at a greater distance causes a dry spray and excessive spray dust.

Move the spray gun with straight uniform strokes, backward and forward across the surface in such a way that the spray pattern overlaps about 50 percent of the previous stroke. Use a free arm motion and feather-cut the end of each stroke. You do this by pulling the trigger before beginning the stroke and releasing it after completing the stroke. Be careful not to arc the gun, since this causes an uneven deposit of paint and excessive overspray at the end of each stroke. Figure 12 illustrates a proper spray gun stroke as well as an incorrect stroke.

Start with a dry stroke, that is, with the trigger released, a few inches to the left of the panel, as shown in figure 13. Pull the trigger when the gun nozzle is even with the left edge of the panel. Aim the gun at the top edge of the panel as you continue the stroke across it. Release the trigger when the gun nozzle is even with the right edge of the panel. Continue the dry stroke a few inches before reversing for the second stroke. When the gun nozzle is even with the right edge of the panel, pull the tirgger, but this time aim the nozzle of the gun at the bottom of the first stroke. In this manner, about half of the second stroke will overlap the first stroke. This gives double coverage to the surface and assures a full wet coat without streaks. A half overlapping stroke is usually used for all work. Continue with right and left strokes until the panel is completed.

Use a banding technique in order to reduce overspray at the right and left ends of a panel. This procedure calls for single vertical strokes at each end of the pans. Banding assures complete coverage and saves the paint which is normally wasted as a result of your trying to spray right up to the vertical edge with horizontal strokes. Spray the top and bottom of the panel with horizontal strokes aimed at the edges of the panel. These strokes automatically become banding strokes. Then finish the panel with horizontal strokes.

When the edges, as well as the face of a panel, are to be sprayed, use a modified banding technique. A single stroke along the edges paints the edges and bands the face of the panel at the same time. Spray outside corners in the same manner. In such cases, aim the gun at the corner so that the spray coats both adjoining surfaces with one stroke of the gun, as shown in figure 14.

Inside corners are more difficult to spray, since more strokes are required. When spraying an inside corner, spray each face of the corner separately, as shown in figure 15. First, make a vertical stroke at the corner from the top down. Then use horizontal strokes to spray the area next to the corner.

Paint can clog the side ports of the mixing cap and restrict the passage of air so that the full air pressure from the clean side port forces the fan pattern in the direction of the clogged side causing a distorted spray pattern, as shown in figure 16. Should this happen, dissolve the dried material with thinner or solvent. Do not use a metal instrument to clean the ports, since this may enlarge or mutilate them. When the dried material is located around or on the outside of the center hole in the mixing cap, you get a spray pattern like the bottom one shown in figure 16. A loose mixing cap may also cause this pattern. If dried material is to blame, clean the cup with thinner or a cloth saturated with thinner.

When the atomizing pressure is too high, it causes a split spray pattern that

211

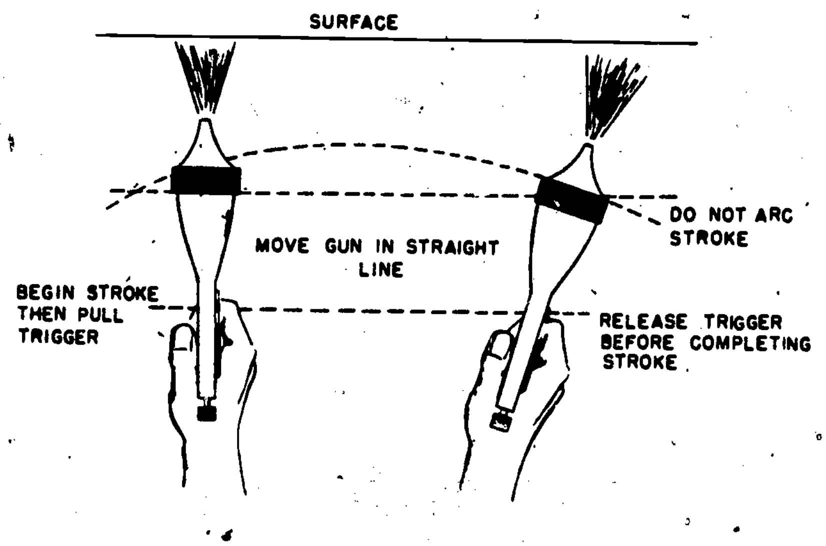
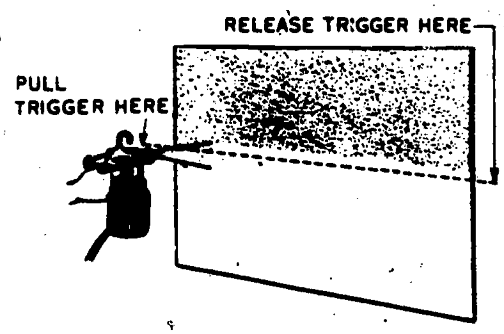


Figure 12. - Spray gun stroke.



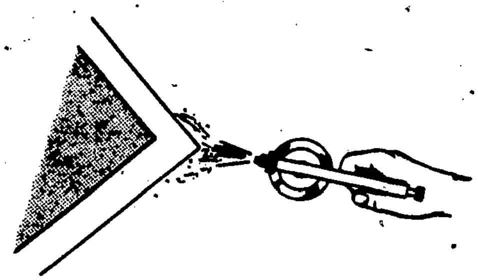


Figure 14. - Spraying an outside corner.

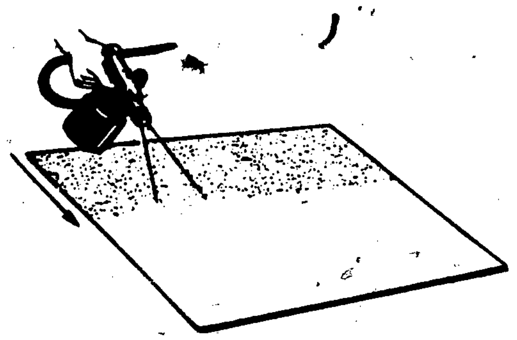


Figure 13. - Spraying flat surfaces.

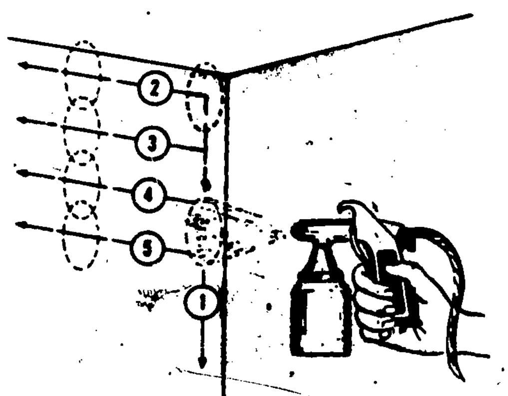


Figure 15. - Spraying an inside corner.

219

is heavy on each end. Insufficient atomizing pressure produces a pattern that is heavy in the middle and has an unatomized salt and pepper effect. Any condition that allows air to leak into the fluid passageway causes the spray gun to spit. Examples of these conditions are: dried out packing around the needle valve, dirt between the fluid nozzle seat and body, loose fluid nozzle, and a loose swivel nut on the siphon cup.

FILM THICKNESS MEASURING EQUIPMENT

To ensure adequate organic coating thickness, you can measure the thickness of the film if you have the necessary small measuring instruments. The two methods of measuring are the wet and dry methods.

Dry Film Gage

The dry gage, shown in figure 17, is manufactured in two models: one for lacquer and enamel with a range of 0 to 40 mils and one for galvanized coatings with a measuring range of 0 to 2 mils. All nonmagnetic dry coatings, including galvanized coatings, can be measured with the magnetic gage, if they are on a steel base. This highly accurate hand gage operates on the attraction power of a permanent magnet through a nonmagnetic coating to the steel base.

To use the gage, first turn the dial to maximum, then rest it on the surface to be gaged, as shown in figure 17. Make sure that the small pin in the handle is in the UP position. To check the film thickness, slowly rotate the dial downward (clockwise) until the magnetic contact breaks. Now read the dial, which is graduated in mils. The number in line with the small index mark on the face of the dial indicates the paint thickness.

Wet Film Gage

The wet gage, as shown in figure 18, is used to check wet coatings of paint, lacquer, enamel, or adhesive. Coatings to be checked must be on a smooth surface. These units come in two sizes, one with a range of 1/2 to 20 mils and the other with a range of 4 to 60 mils. Here's how to use the gage:

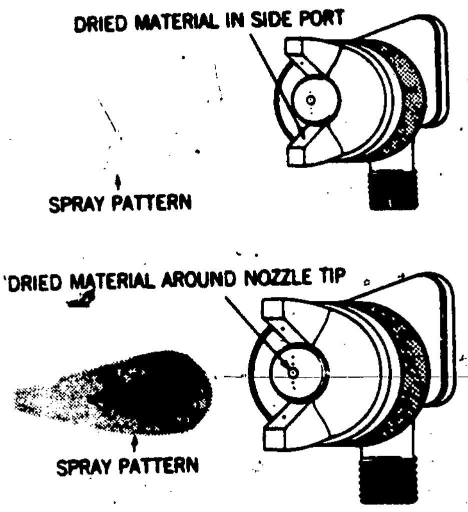


Figure 16. - Distorted spray patterns.

Figure 17. - Dry film gage.

1. Rotate the proper face to position. Use the highest number mil face for heavy coating, and the lowest number mil face for lightest coatings.

2. Before applying the gage to the film surface, make sure the face of the tester is clean and dry.

3. Place the gage face square on the wet film. Then withdraw the gage without allowing it to move on the wet surface.

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4. Look at the highest step coated by the wet film. If all four steps on the face are coated, then you must turn to the next higher gage face and repeat the test. The true wet film thickness lies between the highest step coated and the next higher step.

5. Always wipe the gage face clean immediately after use. Clean the gage carefully with solvent, then dry and oil it lightly before you put it in the case.

SAFETY PRECAUTIONS

The application of organic coatings presents many hazards that must be rigidly controlled. The mists and vapors produced by spraying may be easily ignited. Repeated exposure to the coating materials may produce dermatitis. Many coating materials also contain toxic substances which are harmful when inhaled. In the interest of safety, it is essential that all coatings be applied according to accepted safety standards.

We cannot overstress the health hazard to personnel caused by polyurethane paint. The paint can produce irritation of the skin, eyes, and respiratory tract during mixing and application. Allergic sensitization of personnel exposed to the vapors and mists produced during spray application may occur and cause difficulty in breathing, dry cough, and shortness of breath. Individual susceptibility appears to be a controlling factor. Once sensitized, many workers cannot tolerate even a minimum subsequent exposure and must thereafter avoid work areas where such exposure could occur.

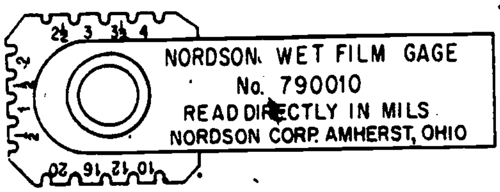

Figure 18. - Wet film gage.

When you are mixing, painting, or working with polyurethane paint in confined areas, use adequate ventilation and appropriate face-mask breathing protection to minimize toxicity effects. For adequate protection while painting with an air spray gun, you must wear a well-fitted, double cartridge organic vapor respirator with fresh cartridges, solvent-resistant gauntlet style gloves, and safety goggles. Painters should be fully clothed with collars buttoned and sleeves taped at the wrist. Personnel engaged in mixing or applying polyurethane paint should have medical surveillance.

HEALTH PROMOTION

Education of all personnel is necessary if injuries and illnesses are to be kept low. Each person must be fully aware of the hazards involved in his job and the protective measures that are prescribed for his safety. Supervisors must make certain that all safety regulations and precautions are strictly observed.

Ventilation

Forced air ventilation must be provided to all spray booths to prevent accumulation of dangerous vapors. The air velocity across the face of the booth must not be below 150 feet per minute. Spraying should always be done with the spray gun pointed toward the spray booth waterfall. When forced air ventilation is impracticable, such as when doing minor touch-up, you should wear a suitable respirator.

Fire Hazards

All potential sources of ignition should be removed from the shop area. All electrical equipment and fixtures must be explosion-proof and grounded. All objects that could produce static electricity must be grounded before spray painting. Rags and other waste materials saturated with paint must be placed in covered metal cans and emptied daily.

Touch-up painting is permissible, but spray painting of an entire aircraft is prohibited in operational, maintenance, or storage hangars. Touch-up spray painting during regular maintenance is defined as:

1. Spray painting of disassembled parts.
2. Stenciling data, insignia, identification marks, etc.
3. Painting surface areas less than 50 square feet.

Cleanliness

We must emphasize keeping the shop area clean. Use caution to prevent unnecessary spillage, accumulation, or evaporation of coating materials. Clean up spills and other contaminants immediately, and provide suitable receptacles for the disposal of the waste products.

Personal Protective Equipment

Whenever other means of hazard control fail to provide complete protection, personal protective clothing and equipment should be worn. A respirator must be worn when the ventilation is not adequate. When you are not wearing a respirator, wear some form of filtering device to prevent inhalation of paint overspray. While painting, wear clothing that completely covers the body, as continuous contact with coating materials may cause detmatitis.

Personal Hygiene

Personal cleanliness is essential when working with coating materials. Always wash your hands upon completion of any coating operation. Clean protective clothing frequently and, when not in use, keep it outside the spray room. Do not hang it in confined lockers that may induce spontaneous combustion.

If hand creams are available, apply them before any coating operation. This prevents dermatitis and permits easy removal of the coating products. If desired, you may also apply hand cream to your face. One application will give several hours of protection unless the hands have been wetted with water. Upon completion of the coating operation, you can easily remove the hand cream with skin cleanser and water.

STORAGE OF COATING MATERIALS

These items should be stored, whenever possible, in dry, fire-resistant, well-drained, and well-ventilated structures, preferably separated from other buildings, and under automatic sprinkler protection. You should not use space heaters and other direct-fired heaters to heat storage areas. Floors should be concrete and drained to one point. The drain should run to a sump or detached cistern and have a deep trap. The storage structure should be ventilated with screened inlet air vents 6 inches above the floor and screened outlet vents through the roof. This will allow paint fumes to escape. You should provide protection for paint containers against wetting by rain, snow, steam leaks, or other sources of water. Coating materials must be stored separately from greases, oil, rags, wood, and other similar combustible materials.

To avoid direct heat on the materials, do not store them near steam lines or other sources of heat. It is recommended that steam heat be used with heating coils above the stock, with the coils screened to prevent them from contacting the containers. You should not store paint on floor below grade (ground level). In any case, you should lay the first tier of containers at least 2 inches above the floor level to allow suitable ventilation and drainage.

Paints and paint thinner packaged in 55-gallon steel drums may be stored outdoors, provided the containers are protected against rusting. To protect the containers, paint the bare metal areas and set the drums on scrap lumber so as to provide approximately 2 inches clearance above the ground.

Containers of paint may develop internal pressure from high temperatures. This condition is apparent as a bulging of the light gage "tin" containers but is not evident in the heavier gage steel drums. Therefore, you must open containers with care to allow the pressure to dissipate slowly before the seal is completely removed. Failure to observe this precaution may result in your being spattered by the material exploding because of the sudden release of pressure. If a container is sealed with a bung, open it by turning out the bung slowly until you hear a hissing sound. When the hissing ceases, indicating equalization of pressure with the atmosphere, you can completely remove the bung.

Containers should be readily accessible at all times. Do not stack other materials on top of coating materials. Store containers and issue them in the order of the dates of manufacture shown on the respective labels. Use material bearing the oldest date first. In the event of date of manufacture is not shown on the container, use the date of receipt as the approximate date of manufacture for purposes of storage and issue.

ERIC

215

LOGBOOK RECORD ENTRIES FOR AIRCRAFT PAINTING

A logbook or record entry must be made anytime an aircraft is completely painted or if 15 percent of the aircraft is painted. An entry is also required if a major subassembly, such as a wing, tail group, or tail cone is painted. The entry must include the aircraft type and serial number, activity doing the painting. location of the activity, and the date the painting was completed. Complete identifying information for all materials used for painting, such as paints, thinners, activators, and strippers, must be entered. The identifying information must include the specification number, manufacturer, batch number, and brand or trade name of the paint material. The above information must be entered on the aircraft AFTO Form 95.

The painting information must be recorded so that there will be a record of the latest painting information for all surfaces of the aircraft. Previous painting information which is no longer applicable should be removed or made obsolete.

223

LESSON QUIZ

QUESTIONS

13. The primary objective of any paint finish is ____________.

14. When painting or touching-up aircraft, what directive must you comply with?

15. In surface preparation for painting, before applying the cleaner-brightener, you should wipe down all sanded surfaces and bare metal with ________.

16. After applying the epoxy primer coating, you should allow it to dry for ____ hours.

17. If polyurethane paint is not properly thinned, what will result?

18. When should you remove masking tape from a polyurethane painted surface?

19. How can you improve the retention capability of decals on polyurethane coatings ?

20. When using an internal-mixing spray gun, where are the paint and air mixed?

21. When spray painting, air pressure that is too high will cause ________.

22. When spray painting, how can you reduce overspray at the right and left ends of a panel?

23. How should you clean clogged side ports on a paint spray gun mixing cap?

24. What are the two methods of measuring paint film thickness?

25. Cans containing rags and waste materials saturated with paint must be emptied ____________.

26. A bulge in a paint can of light gage "tin" indicates ____________.

27. When is a logbook entry required for painting an aircraft?

ANSWERS

13. The protection of exposed surfaces against deterioration (Page 13)

14. CGTO 42A-1-2 (Page 15)

15. A 1 to 1 mixture of xylene and acetone (Page 15)

16. 1 - 2 (Page 16)

17. Chipping will occur, especially around fastener holes. (Page 17)

18. Before the paint is allowed to dry. (Page 18)

19. Lightly sand or roughen the surface. (Page 19)

20. Inside the spray cap (Page 20)

21. thin center of the spray pattern (Page 23)

22. Use a banding technique (Page 23)

23. Dissolve the dried material with thinner or solvent (Page 23)

24. Wet and dry methods (Page 25)

25. daily (Page 26)

26. Internal pressure from high temperatures (Page 27)

27. Anytime an aircraft is completely painted or if 15 percent of the aircraft is painted (Page 28)

PAMPHLET REVIEW QUIZ

Directions: Cover the answers to the questions with the enclosed Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any question incorrectly, refer to the text material.

QUESTIONS

1. To properly use a power sander, you should keep the sanding disc tilted to an angle of ______ degrees against the work.

   A. 5
   B. 10
   C. 15
   D. 20

2. When you are grinding on a metal surface, excessive heating can alter the grain structure and can result in ________.

   A. fatigue cracks
   B. warpage
   C. work hardening
   D. severe corrosion

3. Which part of a vacu-blaster will trap oversized debris that is picked up by the vacuum hose?

   A. Dust collector
   B. Dust tray
   C. Abrasive reclaimer
   D. Vibrating screen

4. The entire vacu-blaster unit operates on an air supply of ________.

   A. 50 cfm at 100 psi
   B. 75 cfm at 150 psi
   C. 100 cfm at 100 psi
   D. 150 cfm at 150 psi

5. The corrosion removing compound, MIL-C-38334, is used to chemically remove corrosion from _____ and its alloys.

   A. aluminum
   B. magnesium
   C. plated steel
   D. titanium

ANSWERS

1. B - You should keep the sanding disc tilted to approximately a 10-degree angle so that only one side of the disc is in contact with the metal surface. (Page 2)

2. D - When you are grinding, excessive metal heating alters the granular structure, which can result in severe corrosion. (Page 2)

3. D- Oversized debris is trapped by the vibrating screen, which must be periodically cleaned. (Page 4)

4. C - The entire vacu-blaster unit operates on an air supply of 100 cfm at 100 psi. (Page 5)

5. A - The corrosion removing compound, MIL-C-38334, is used to chemically remove corrosion from aluminum and its alloys. (Page 5)

ERIC

219

6. How should you remove heavy corrosion on small removable aluminum parts?

A. Use a stainless steel powered brush
B. Use a carbide tipped scraper
C. Immerse in an alkaline remover
D. Immerse in a phosphoric-chromic acid solution

6. D - Table 1. (Page 4)

7. What chemical should you use to condition a corrosion resistant steel surface before painting?

A. Nitric-hydrofluoric acid
B. Phosphoric acid base rust remover
C. Chromic acid pickle solution
D. Pasa-Jell 101

7. B - Phosphoric acid base rust remover is used to condition steel, corrosion resistant steel, and copper surfaces before painting. (Page 7)

8. If acid is used to remove corrosion from high strength steel, the acid will cause ________.

A. hydrogen embrittlement
B. case hardening
C. intergranular corrosion
D. inclusions

8. A - Never use an acid solution to remove corrosion from high-strength steel parts; acid causes hydrogen embrittlement of the steel. (Page 7)

9. The alkaline corrosion remover is used for removing corrosion from ____ alloys.

A. aluminum
B. magnesium
C. ferrous
D. titanium

9. C - Use the alkaline corrosion removing compound to remove corrosion from ferrous and copper alloys. (Page 7)

10. The metal plating process is a method of producing a metallic coating on the surface of a metal by ______ means.

A. electrochemical
B. mechanical
C. magnetic
D. dielectric

10. A - Plating is a method of producing a metallic coating by electrochemical means. (Page 8)

11. An oxide film formed on a metal surface as the result of a chemical treatment is more corrosion and ______ resistant than a natural film.

A. heat
B. fatigue
C. contaminant
D. wear

11. D - Oxide films are more corrosion and wear resistant than natural films and give the parts greater service life. (Page 8)

12. Where should you store toxic materials?

A. In the paint locker
B. In a completely enclosed and locked area
C. In the grease and oil locker
D. In the battery shop

12. B - Areas in which toxic materials are stored and mixed should be completely enclosed and locked to prevent the materials falling into the hands of unauthorized personnel. (Page 9)

13. Complete aircraft refinishing under field conditions should be attempted ONLY if the existing finish ________.

A. is faded
B. is stained
C. fails to protect
D. fails to reduce heat absorption

13. C - Complete refinishing under field conditions should be restricted to those areas where existing paint finishes fail to perform their protective function. (Page 13)

14. Aircraft "Painting and Marking Details" drawings are maintained and furnished to operating units by ________.

A. Commandant G-EAE
B. the prime unit
C. AR&SC
D. the aircraft manufacturer

14. C - AR&SC maintains current drawings for all Coast Guard aircraft models, and applicable copies are finished to operating units initially, upon revision of a drawing, and upon request. (Page 15)

15. The standardized Coast Guard aircraft paint system consists of an improved epoxy primer and a ______ coating.

A. polyurethane
B. lacquer
C. epoxy
D. enamel

15. A - The Coast Guard standardized paint system consists of an improved epoxy primer, MIL-P-23377B, and a polyurethane coating, MIL-C-81773(AS) or MIL-C-83286 (USAF). (Page 16)

16. After thinning, stirring, and straining epoxy primer, MIL-P-23377B, you should allow the primer to stand for a MINIMUM of ______ minutes before use.

A. 15
B. 30
C. 45
D. 60

16. D - The thinned primer should be stirred thoroughly, strained, and allowed to stand 1 hour before use. (Page 16)

17. Depending on the temperature, the air pressure for spraying polyurethane paint with the conventional hand pot spray gun is ______ psi.

A. 40-45
B. 50-55
C. 60-65
D. 70-75

17. C - For the conventional hand pot spray gun, the air pressure should be 60-65 psi, dependent on the temperature. (Page 17)

ERIC

221

18. When sprayed, unthinned polyurethane paint appears ________.

A. gritty
B. unsmooth
C. dull
D. lustrous

18. B - If no thinner is mixed with the paint, its application will not be smooth and will have an orange-peel effect. (Page 17)

19. When you measure paint viscosity with a Zahn cup, the viscosity is expressed in ________ through the cup.

A. seconds
B. minutes
C. liters
D. ounces

19. A - Viscosity is expressed in seconds through the cup. (Page 17)

20. How should you prepare a painted fiberglass surface for repainting?

A. Sand lightly with 320-400 wet or dry sandpaper
B. Soften the old paint with acetone
C. Remove the old paint with paint remover
D. Remove the old paint with a metallic scraper

20. A - The approved Coast Guard method for touch-up of fiberglass surfaces is to use lacquer thinner to thoroughly clean the area to be repainted and sand lightly with 320-400 wet or dry sandpaper. (Page 18)

21. What type of paint finish is required for radomes?

A. Polyurethane
B. Lacquer
C. Epoxy
D. Enamel

21. C - Two epoxy systems are approved as the paint finish for radomes. (Page 19)

22. A suction-feed spray gun can be identified by the ________.

A. two hoses attached to the gun
B. internal-mixing spray cap
C. absence of an air vent hole in the paint cup cover
D. presence of an air vent hole in the paint cup cover

22. D - A suction-feed spray gun can be identified by the presence of an air vent hole in the paint cup cover. (Page 20)

23. When you are spray painting, holding the spray gun too far from the work causes a ________.

A. weak center spray pattern
B. heavy wet coat
C. dry spray
D. coarse, spattered effect

23. C - Generally, the distance varies from 6 to 10 inches. Holding the spray gun at a greater distance causes a dry spray and excessive spray dust. (Page 23)

228

24. When you are spray painting, a distorted spray pattern is caused by a/an ___.

A. clogged air valve
B. clogged side port
C. weak trigger spring
D. improperly adjusted air control screw

25. Which instrument for measuring paint thickness operates on the principle of magnetism?

A. Depth micrometer
B. Dial indicator
C. Wet film gage
D. Dry film gage

26. While painting, you should wear clothing that completely covers the body to prevent ________.

A. psoriasis
B. chemical burns
C. dermatitis
D. hepatitis

27. Aircraft painting information should be entered in the aircraft logbook on AFTO Form ________.

A. 44
B. 95
C. 103
D. 781

24. B - Paint can clog the side ports of the mixing cap and restrict the passage of air so that the full air pressure from the clean side port forces the fan pattern in the direction of the clogged side, causing a distorted spray pattern. (Page 23)

25. D - The dry film gage operates on the attraction power of a permanent magnet through a nonmagnetic coating to the steel base. (Page 25)

26. C - While painting you should wear clothing that completely covers the body, as continuous contact with coating materials may cause dermatitis. (Page 29)

27. B - Aircraft painting information must be entered on the aircraft AFTO Form 95. (Page 30)