# CDC 2A755

# Low Observable Aircraft Structural Maintenance Journeyman

## Volume 2. Metal Repair, Corrosion, and Protective Coatings

**Air Force Career Development Academy**

**The Air University**

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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

THIS IS the second volume of CDC 2A755, *Low Observable Aircraft Structural Maintenance Journeyman*. Unit 1 covers maintenance documentation and technical publication. In unit 2, we cover pre-repair procedures to include inspection techniques, then we go into damgeage removal, fabrication and installation of repair parts, and structural sealing. Unit 3 provides an overview of how to detect and determine whether corrosion is present, as well as the types of corrosion you may encounter in your job. It also discusses how to remove the various types of corrosion to ensure the reliability and integrity of the metals with which you will work. Unit 3 ends by discussing corrosion prevention procedures. In unit 4, we explore information on hazardous materials to include handling and disposal. Lastly, unit 5 gives you a look at protective coatings, equipment used to apply, and how to apply them.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

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This volume is valued at 18 hours and 6 points.

**NOTE:**

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

*Page*

# Unit 1. Maintenance Documentation and Publications



WHEN YOU BUY A new mechanical device, such as an appliance or car, you also receive a book of operating and maintenance instructions to help you get the greatest possible satisfaction from your purchase. The Air Force, like a manufacturer, provides printed and electronic instructions about the operation and maintenance of its equipment. These technical orders (TO) give you the procedures for inspecting, servicing, lubricating, removing, replacing, operationally checking, adjusting, repairing, and troubleshooting the equipment you work on. As its name implies, a TO is a military order, and like any other military order, it must be followed. Our weapons systems are complicated, state of the art devices; it is impossible for anyone to absorb and retain all of the knowledge required to operate and maintain this equipment. Therefore, you must depend upon written technical data. The Air Force also provides you with many different ways to document the maintenance you will be doing. Whether it is on aircraft, aircraft parts, or support equipment you will have to document what is wrong and how you fixed it.

## 1–1. Maintenance Documentation

Management of the maintenance effort requires documenting and reporting all maintenance actions. Not long after the first piece of shop equipment was placed into position someone realized there was a need for constant upkeep. The operating condition of your shop's equipment greatly impacts your unit's ability to realize its goals and meet the mission. Proper use and maintenance guarantees years of defect-free service. In this section, you will learn basic equipment inspection and maintenance techniques, cleaning and lubrication, and use of the Air Force Technical Order (AFTO) Form 244, Industrial/Support Equipment Record.

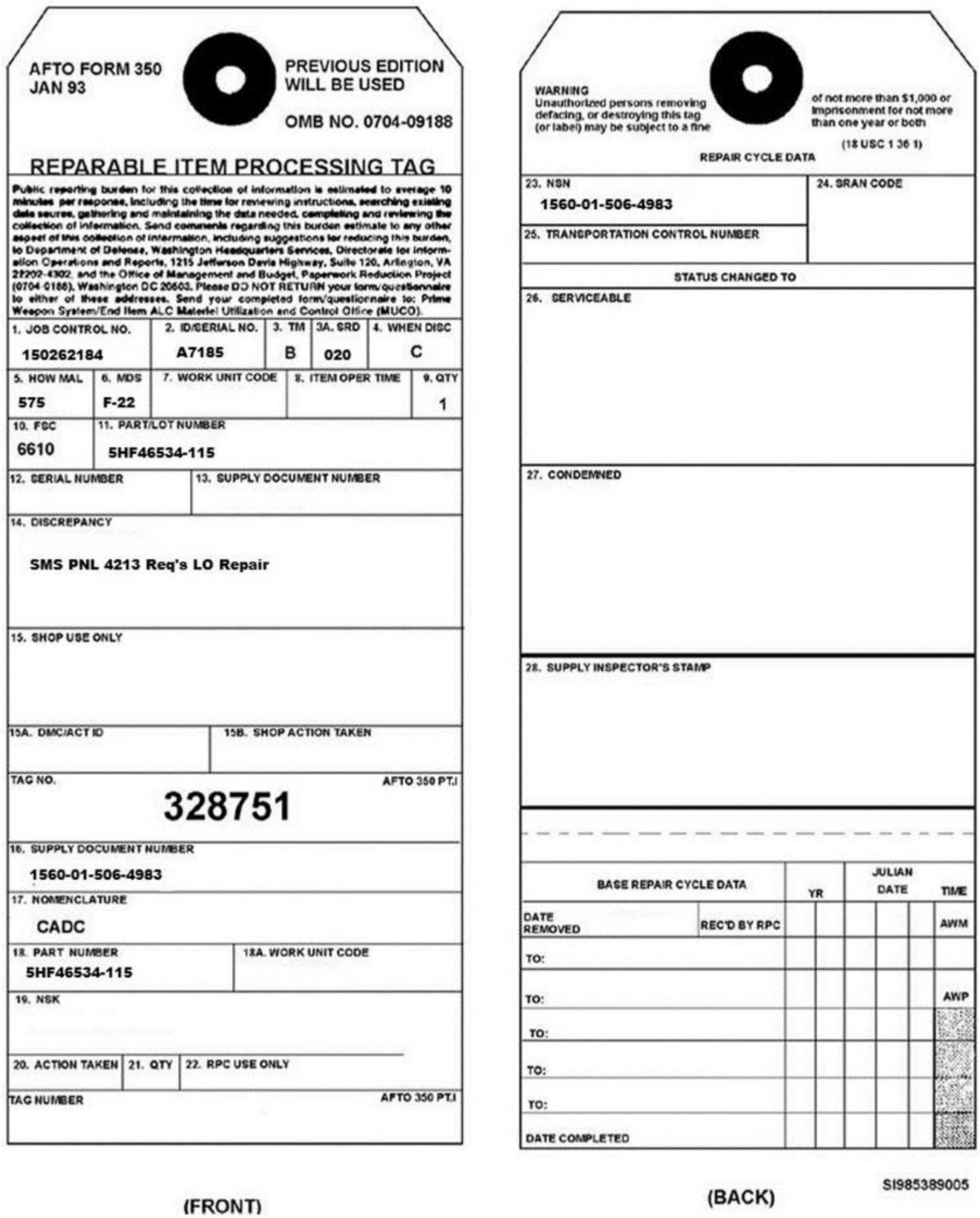
In addition to maintaining and documenting maintenance actions on support equipment, you will have to document all maintenance actions that you perform on an aircraft. The AFTO Form 781 series provides for a permanent record of these actions. In this section, you will study the entries made in AFTO Forms 781 and each type of form you will use.

### 201. Documenting AFTO Form 350, Repairable Item Processing Tag

It is critical that maintenance actions performed on aircraft components are properly documented to identify equipment failure trends and to aid in prompt repair. It is essential that you properly complete the associated paperwork for the maintenance actions you perform. One form you will be required to complete after removing a reparable component is the AFTO Form 350.

The AFTO Form 350 (fig. 1–1) is a two-part form attached to items requiring maintenance shop processing. These items include removed panels, removed end items, components removed from end items, and subassemblies removed from assemblies. A completed AFTO Form 350 identifies the origin of an item  and contains key data elements needed to document shop actions. Part I of the

AFTO Form 350 (the section located above the perforation) is the repair cycle processing tag. This part is attached to items determined to be reparable and being forwarded to other activities for repair. Part II (the section located below the perforation) serves as the production-scheduling document. TO 00–20–2, *Maintenance Data Documentation* gives a block-by-block explanation of how to document the AFTO Form 350 tag.



AFTO FORM 350 JAN 93

PREVIOUS EDITION WILL BE USED

OMB NO. 0704-09188

REPARABLE ITEM PROCESSING TAG

Public reporting burden for this collection of information is estimated to average 10 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, completing and reviewing the collection of information. Send comments regarding this burden estimate to any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 120, Arlington, VA 22202-4302, and the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington DC 20503. Please DO NOT RETURN your form/questionnaire to either of these addresses. Send your completed form/questionnaire to: Prime Weapon System/End Item ALC Materiel Utilization and Control Office (MUCO).

1. JOB CONTROL NO.: 150262184
2. ID/SERIAL NO.: A7185
3. TM: B
3A. SRD: 020
4. WHEN DISC: C
5. HOW MAL: 575
6. MDS: F-22
7. WORK UNIT CODE:
8. ITEM OPER TIME:
9. QTY: 1
10. FSC: 6610
11. PART/LOT NUMBER: 5HF46534-115
12. SERIAL NUMBER:
13. SUPPLY DOCUMENT NUMBER:
14. DISCREPANCY: SMS PNL 4213 Req's LO Repair
15. SHOP USE ONLY
15A. DMC/ACT ID
15B. SHOP ACTION TAKEN
TAG NO. 328751 — AFTO 350 PT.I
16. SUPPLY DOCUMENT NUMBER: 1560-01-506-4983
17. NOMENCLATURE: CADC
18. PART NUMBER: 5HF46534-115
18A. WORK UNIT CODE:
19. NSN
20. ACTION TAKEN | 21. QTY | 22. RPC USE ONLY
TAG NUMBER — AFTO 350 PT.I

(FRONT)

WARNING
Unauthorized persons removing, defacing, or destroying this tag (or label) may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both (18 USC 1 36 1)

REPAIR CYCLE DATA

23. NSN: 1560-01-506-4983
24. SRAN CODE
25. TRANSPORTATION CONTROL NUMBER

STATUS CHANGED TO

26. SERVICEABLE
27. CONDEMNED
28. SUPPLY INSPECTOR'S STAMP

| BASE REPAIR CYCLE DATA | | YR | JULIAN DATE | TIME |
|---|---|---|---|---|
| DATE REMOVED | REC'D BY RPC | | | AWM |
| TO: | | | | |
| TO: | | | | AWP |
| TO: | | | | |
| TO: | | | | |
| TO: | | | | |
| DATE COMPLETED | | | | |

(BACK)

SI985389005

**Figure 1–1. AFTO Form 350.**

**NOTE:** Automated AFTO Form 350s are authorized for use when produced by the automated Maintenance Data Documentation (MDD) system. Additional MDD data elements and discrepancy narratives may be included when such information may be helpful to the next repair activity. Equivalent AFTO Form 350 data may be used when shipping items to depot for repair.

The AFTO Form 350 tag uses special codes so the maintenance data can be entered into a computer database. To convert maintenance jargon into the special codes the database will accept, use the applicable –06, *Work Unit Code Manual* (i.e., TO 1B–2A–06). Refer to figure 1–1 as we discuss the specific block entries you are required to make.

## Front side, Part I

When an item is sent to a reparable processing center (RPC) or maintenance shop, blocks 1 through 14 and 15A are completed by the individual originating the form. Entries for blocks 1 through 12, 14, and 15A are completed at the time of the removal action. The supply document number (block 13) is obtained from the supply activity when a demand is made for a replacement item. The block entries you (the originator) are required to document on the front side of Part I are described in the following table:

| AFTO FORM 350—FRONT SIDE (PART I) | | |
|---|---|---|
| **Block Number** | **Block Title** | **Information Required** |
| 1 | JOB CONTROL NO. | Enter the job control number (JCN), as documented in the Interactive Electronic Technical Manual System (IMDS)/G081-Maintenance Data Record that reflects the JCN for the applicable reparable item. If more than one reparable component requiring an AFTO Form 350 is removed under the same JCN, each AFTO Form 350 initiated will have the same JCN entered in block 1. Document the JCN on the AFTO Form 350 prior to any maintenance action. |
| 2 | ID/SERIAL NO. | Enter the serial number of the end item or weapon system. Usually for flightline maintenance, the ID starts with an “A” followed by the last four digits of the aircraft tail number. |
| 3 | TM | Enter the applicable type maintenance (TM) code. This code is used to identify the type of work that was accomplished (i.e., scheduled or unscheduled maintenance). |
| 3A | SRD | Enter the applicable standard reporting designator (SRD) code. For AFTO Forms 350 prepared for engine items, enter the applicable engine SRD. |
| 4 | WHEN DISC | Enter the when discovered code. This one-digit code is used to identify when a defect or a maintenance requirement was discovered. |
| 5 | HOW MAL | Enter the how malfunctioned code. This code is used to identify the nature of the defect, not the cause of the discrepancy. |
| 6 | MDS | Enter the mission/design/series (MDS) (e.g., F–22, B-2, etc.) or end item work unit code (WUC). |
| 7 | WUC | Enter the WUC of the item to which the form is to be attached. If the item is a reparable subassembly that does not have a WUC, enter the WUC of the assembly from which the item (subassembly) was removed. |
| 8 | ITEM OPER TIME | If the item is a tracked item (identified by an asterisk in the WUC manual) for which time records are maintained, enter the calendar time or accrued operating time of the item. Calendar time is entered to the nearest whole month and operating time is entered to the nearest whole hour. |
| 9 | QTY | Enter the number of like items being forwarded for shop processing.<br>**NOTE:** The AFTO Form 350 may have a quantity of more than one only if the JCN, WUC, federal supply class (FSC), and part number are the same, and the components can be packaged or transported together for shop processing. Items identified by a tracked indicator (*) in the WUC manual require an individual AFTO Form 350. |

| AFTO FORM 350—FRONT SIDE (PART I) | | |
|---|---|---|
| **Block Number** | **Block Title** | **Information Required** |
| 10 | FSC | Enter the FSC of the removed item. The FSC equals the first four digits of the federal stock number/national stock number (FSN/NSN). |
| 11 | PART/LOT NUMBER | Enter the part number of the removed item, including dashes and slashes. First preference is the part number or complete identification as it appears on the data plate. For items that do not have a part number, enter the national item identification number (NIIN), including the dashes. The NIIN is the last nine characters of the NSN. |
| 12 | SERIAL NUMBER | Enter the serial number of the removed item. This entry is required for time-change, serially controlled, and warranty-tracked items. If the serial number exceeds 10 characters, enter only the last 10 characters. |
| 13 | SUPPLY DOCUMENT NUMBER | When a demand has been placed on the supply system, enter the supply document number for the replacement item. |
| 14 | DISCREPANCY | Enter a brief but specific description of the malfunction that caused the removal, or the reason for removal. Provide as much detail as possible to aid in failure trend analysis and to help speed up the repair. If the item was removed for off-equipment time compliance technical order (TCTO) compliance, enter the TCTO number. For electronic items that have sequential test procedures, also enter the TO reference step, and sequence number where the item failed to pass the test. If the item is a warranty item, enter the date of installation and the date of removal. For items removed from equipment involved in accidents, enter the words “INVOLVED IN ACCIDENT.” |
| 15A | DMC/ACT ID | If no ID number is entered in block 2 or for cryptologic equipment removed from an aircraft for shop processing, enter the owning command code. |

### Front side, Part II

Part II will be completed by the production scheduler, then detached and retained as a suspense document until the item is returned from the shop or is made serviceable. When an item is *not* sent to the RPC because of its size or for other reasons, blocks 16, 17, and 18 will be completed by the originator and Part II will be detached and forwarded to the production scheduler. Your required block entries for AFTO Form 350 front side, Part II are shown in the following table:

| AFTO FORM 350 — FRONT SIDE (PART II) | | |
|---|---|---|
| **Block Number** | **Block Title** | **Information Required** |
| 16 | SUPPLY DOCUMENT NUMBER | Enter the supply document number from block 13 of Part I. |
| 17 | NOMENCLATURE | Enter the nomenclature of the item. |
| 18 | PART NUMBER | Enter the identification of the item from block 11 of Part I. |

### Reverse side, Part I

Entries on this portion of the form are made by RPC, Base Supply, or the activity responsible for determining the status of the equipment (as applicable).

### Reverse side, Part II

The initiator of the AFTO Form 350 is responsible for entering (under block 29) the date the item was removed. The production scheduler is responsible for completing the remainder of block 29.

## 202. Maintaining and inspecting shop equipment

Many factors influence the operating condition of power and nonpowered shop machinery. First is the user. When equipment is maintained and used properly the natural outcome is a fully functioning machine. Local weather conditions (e.g., high humidity) can severely affect equipment serviceability. High humidity nearly always causes the machine to rust and cause breakdowns if not properly controlled. Finally, lack of proper maintenance and lubrication inevitably leads to equipment failure.

This lesson applies to general machinery and shop equipment maintenance and inspection. Specific maintenance requirements are determined by applicable technical data. Most shops have similar equipment, with slight variations. Basic shop equipment maintenance rarely changes from item to item. Each item requires thorough cleaning, lubrication, and daily observation to ensure it is serviceable at all times. The inspection equipment you use varies from inspection to inspection due to differences in aircraft and in specific problems. You need to be familiar with the function and use of each item.

As important as it is to know how to use your equipment, it is equally important to know how to maintain the equipment, and document the inspections and maintenance.

## Inspection and maintenance requirements

Preventative maintenance consists of scheduled maintenance, cleaning, lubrication, and minor adjustments. While each piece of equipment varies on specific requirements, all need the same basic care. *Specific* requirements are in the appropriate 34-series technical order.

### *Prior-to-use inspection*

Each piece of equipment requires a prior-to-use inspection, which must be completed before a machine is used for the first time on any given day. This inspection includes a visual inspection. While doing a visual inspection, you should be looking for anything that may be out of the ordinary or broken, and the overall machine condition. Look for loose or missing attachments, including latches and hinged parts. Pay special attention to glass or plastic shields. They should be free of cracks, breaks, chips, and scratches. Any of these defects could lead to breakage and possible injury.

Dials and pointers must be marked clearly and completely. Controls and switches must operate smoothly without binding. Inspect for leaks around gaskets and rubber parts. Terminals on plug-in type equipment must not have bent, loose, broken, or burned prongs.

Rubber hoses (including those used for painting and breathable air systems) must be examined for evidence of chaffing, dry rot, cracks, or excessive wear. Repair or replace any defective air hoses. Additionally, look closely at the quick disconnect fittings on the hose. They should operate freely and not require any force to operate.

### *Scheduled inspection*

Scheduled inspections are similar to prior-to-use inspections. It is during these inspections that *scheduled* actions (e.g., periodic lubrication, fluid level checks, and belt tension adjustments) are made.

### *Supervisory review*

A supervisory review consists of a quality control or supervisory review of the equipment forms to ensure proper documentation. The specific time between supervisor reviews may be determined by the major command (MAJCOM). This review is not used to document the inspection of completed maintenance.

### *Lubrication requirements*

Shop equipment is lubricated according to Air Force directives or approved commercial data. Lubrication points and frequency requirements are also found in these publications. There are as many types of lubricants available as there are pieces of machinery. Remember, only use lubricants authorized on an approved qualified products list (QPL).

Mechanically operated parts (e.g., gears, bearings, and hinges) must be lubricated to prevent binding or overheating.

### *Equipment cleaning*

Clean each piece of shop equipment on an as-needed basis or at least weekly. Systematic cleaning provides you another opportunity to conduct a thorough inspection. Cleaning doesn't mean simply wiping down the machinery. Look for metal in, around, and under all metalworking equipment. Empty all dust collection bins.

In a typical aircraft structural maintenance shop, the final step during weekly machine cleaning includes sanding down all bare surfaces and lightly oiling them. First, apply a few drops of lightweight oil to the surface, and then remove all rust and oxidation *using* 400-grit sandpaper. Finish by wiping the surface to remove any film or excess oil.

### *Painting*

On rare occasions, a piece of machinery may need to be painted or touched-up. Bare spots resulting from scraping or chipping should be sanded to a feathered edge and spot primed with lacquer-proof primer. Before painting, ensure the surface is chemically clean. This ensures a successful paint application.

Repainting of new machines or equipment solely for the purpose of matching shop color schemes is not authorized by TO 34–1–3, *Inspection and Maintenance—Machinery and Shop Equipment*. When complete painting is required, surfaces must be the original color when possible.

## Equipment maintenance forms

Equipment, such as shop machinery, maintenance stands, power units, and test stands, must have maintenance forms. The AFTO Form 244, *Industrial / Support Equipment Record* is used to document *all* recurring inspection and maintenance procedures.

Not only is this important to ensure Air Force equipment is properly maintained but it allows the operator and mechanic to ensure equipment is safe to operate. Consult figures 1–2 and 1–3 as you cover the information in this portion of the text.

### *AFTO 244 application*

Step-by-step instructions for proper use can be found in TO 00–20–1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*. All powered and nonpowered aerospace ground equipment (AGE) and support equipment (SE), training equipment, test, measurement and diagnostic equipment (TMDE) which requires scheduled inspections, Vehicular SE, and all industrial machinery and industrial plant equipment will have an AFTO 244. Common and special hand tools do not require an AFTO 244.

| III. | SCHEDULED INSPECTION | | | | |
|---|---|---|---|---|---|
| INSPECTION REQUIREMENT | INTERVAL | DATE DUE | DATE COMPL | DATE DUE | DATE COMPL |
| WEEKLY LUBE | WEEKLY | 20150113 | 20150113 | 20150120 | 20150120 |
| | | 20150127 | 20150127 | 20150203 | 20150203 |
| | | 20150210 | 20150210 | 20150217 | |

| IV. | SUPERVISORY REVIEW | | | | |
|---|---|---|---|---|---|
| EMPLOY NO | DATE | EMPLOY NO | DATE | EMPLOY NO | DATE |
| 00147 | 20150113 | | | | |

**INDUSTRIAL/SUPPORT EQUIPMENT RECORD**

| I. ITEM IDENTIFICATION | | |
|---|---|---|
| 1. NOMENCLATURE/MODEL: PAINT SHAKER PACER 15 | 2. REGISTRATION/SERIAL NO.: 466 | |
| 3. ID NO.: LEELSE019 | 4. FIELD NO. (If applicable) | 5. WORK UNIT CODE: ZZ300 |
| 6. ORGN WC ASSIGNED: 1MXS/MXMFL | 7. PERIOD COVER: 20150106 TO | 8. |

| II. NON-SCHEDULED INSPECTION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | INSP INIT | TIME | INSP INIT | TIME | INSP INIT | TIME | INSP INIT | TIME | INSP INIT | TIME | INSP INIT |
| DATE | | DATE | | DATE | | DATE | | DATE | | DATE | |

AFTO FORM 244, 20130529 PREVIOUS EDITIONS ARE OBSOLETE

**Figure 1–2. AFTO Form 244 (front).**

| V. MAINTENANCE/DELAYED DISCREPANCY | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9. T.O. Owner's Manual | | 10. NSN 4940000227947 | | 11. | | 12. | |
| DATE DISCOVERED | DISCOVERED BY / SUP DOC NO. | SYMBOL | DISCREPANCY | JOB CON/ W.O. NO. | CORRECTIVE ACTION | DATE CORRECTED | CORRECTED BY / INSPECTED BY |
| 20150113 | T. Hutcherson / 02364 | H | Weekly lube due | 150136152 | Weekly lube c/w IAW Owners Manual | 20150113 | T. Hutch 02364 |
| 20150120 | AForrest / 03162 | F | weekly lube due | 150206152 | weekly lube c/w IAW O.M. | 20150120 | [illegible] 03162 |
| 20150127 | T Hutchison | H | weekly lube due | 150206153 | weekly lube c/w IAW Owners Manual | 20150127 | T. Hutch 02364 |
| 20150203 | AForrest 03162 | F | weekly lube due | 150206153 | weekly lube c/w IAW O.M. | 20150203 | [illegible] 03162 |

AFTO FORM 244, 20130529

**Figure 1–3. AFTO Form 244 (back).**

Let's examine parts I through V of AFTO Form 244.

### *Part I*

Part I is the identification portion of the equipment form.

| | Part I, AFTO Form 244 |
|---|---|
| **Block** | **Entry** |
| 1 | Name, nomenclature, NSN, or model of equipment |
| 2 | The assigned Air Force registration number or serial number; may be left blank. |
| 3 | Local ID. If the form is being used for a group of like items, enter a group ID number. |
| 4 | Enter the field number of the SE. |
| 5 | Enter the WUC if one is assigned; leave blank if not applicable. |
| 6 | Enter the designation of the organization/workcenter of the owning organization. |
| 7 | Enter the date the form was initiated to the "left" of the word TO. Once the form is closed out or the equipment is turned into supply/salvage, and a new form initiated, enter the date to the right of the word TO. Record all dates on the AFTO Form 244 by eight digits in the order of year, month, and day.<br>Example: YYYYMMDD, 20150226 for 26 February 2015. |
| 8 | Local option block, specified by group commander. |

### *Part II*

Part II provides a means to document servicing inspections. Prior to use, inspections are not documented unless required by the group commander or another publication.

| Part II, AFTO Form 244 | |
|---|---|
| **Block** | **Entry** |
| TIME | Enter the time (in 24-hour military time) the service/prior to use inspection was accomplished. If the unit is equipped with a running time meter, the metered time is entered in place of the time of day. For SE inspected at hourly intervals, enter the daily/accumulated time. |
| INSP INIT | Enter the assigned employee number of the person who completes the inspection. |
| DATE | Enter the date the inspection was accomplished. |

### *Part III*

Scheduled inspections or preventative maintenance requirements are recorded in Part III.

| Part III, AFTO Form 244 | |
|---|---|
| **Block** | **Entry** |
| INSPECTION REQUIREMENT | Enter the type of inspection due (e.g., periodic equipment [PE], special, etc.). |
| INTERVAL | Enter the scheduled inspection interval (e.g., 30-, 60-, and 180-day, or 500-hour, etc.) |
| DATE DUE | Enter the next inspection hour/date due in the next open date block. |
| DATE COMPLETED | Enter the hour/date inspection completed. |

### *Part IV*

This is the quality control block. It contains the supervisory review of the forms.

| Part IV, AFTO Form 244 | |
|---|---|
| **Block** | **Entry** |
| EMPLOYEE NUMBER | Enter the employee number (or first name initial, last name, and grade if no employee number). |

| Part IV, AFTO Form 244 | |
|---|---|
| **Block** | **Entry** |
| DATE | Enter the date the supervisor review was accomplished; use the same format as in Part II. |

### *Part V*

AFTO Form 244 Part V documents equipment discrepancies and corrective actions. The following conditions will be recorded on the AFTO Form 244 Part V.

1. Delayed discrepancies on equipment.
2. Overdue scheduled inspection.
3. Overdue time changes.
4. Discrepancies discovered during operation.
5. In shop environments, only delayed discrepancies need annotation, minor maintenance functions, such as check oil or water, don't need documentation.

| Part V, AFTO Form 244 | |
|---|---|
| **Block** | **Entry** |
| TO | Enter the TO number or manufacturer's manual that covers the equipment item. |
| NSN | Enter the NSN or part number for item identified in block 1. |
| Block 11 and 12 | Optional for major command use. |
| DATE DISCOVERED | Enter the date the discrepancy was discovered; use the format from Part II. |
| DISCOVERED BY | The individual who discovered the discrepancy will sign their first name initial, last name, grade, or employee number. |
| SUP DOC NO | Enter the base supply document number for items ordered to repair the equipment item. |
| SYMBOL | Whenever discrepancies are noted, promptly note them using the appropriate symbol. |
| DISCREPANCY | Enter the discrepancy or maintenance action required. Enter only one discrepancy in each block. |
| JOB CON/ W/O. NO. | Enter the job control number and work order number for the discrepancy. |
| CORRECTIVE ACTION | Enter the description of the corrective action taken. For Red X discrepancies, include a sufficient technical data reference to determine the work performed, (e.g. TO number and paragraph/figure number for conventional TOs, function number/fault code for MIS based TOs).<br>Industrial plant equipment (IPE) is excluded from this requirement since the TO reference is listed on the equipment. Group commanders may specify additional minimum TO reference. If more space is needed to make this entry, use the next open block. |
| DATE CORRECTED | Enter the date the discrepancy is corrected. Use the format from Part II. |
| CORRECTED BY | The individual who corrects the discrepancy fills in this block. They must use their first name initial, last name, grade, or employee number. |
| INSPECTED BY | Enter the first name initial, last name, and grade of the individual authorized to clear Red X symbols in this block. |

### ***Red symbols and their uses***

Red symbols are used to document equipment discrepancies on the Industrial/Support Equipment Record. A Red X indicates the equipment is *unsafe* or *unfit for use*, and the equipment *must not be used* until the unsatisfactory condition is corrected. The Red Dash (–) indicates a required special inspection or operational check is due, or a scheduled inspection is overdue, and the equipment is in an unknown condition. This condition must be corrected as soon as possible by complying with the required action. The Red Diagonal *(/)* indicates an unsatisfactory condition exists, but is not sufficiently urgent or dangerous to warrant not using the equipment.

#### *Clearing red symbol entries*

The last name initial entered in black over the symbol in the symbol block of the AFTO Form 244 indicates the individual has accomplished the required maintenance or has inspected the affected equipment. Upon initialing (clearing) the symbol, the individual closes out the discrepancy.

## 203. Entering information on aircraft forms

Your responsibility for the aircraft records varies with assignments and weapon systems. You'll maintain equipment and, eventually, train and supervise other personnel. A high percentage of maintenance tasks are documented on official forms. There are certain standard practices you must follow in using these forms. In this section, you'll study legibility, signature, dates, and abbreviations.

### Uniform entries

A more-than-ordinary effort should be made to make the entries on aircraft forms complete, correct, legible, and neat. These records are handled by different personnel who must file, extract information, and fill out other records and forms from them. It is, therefore, of the utmost importance that you make the entries proper and legible to reduce the possibility of errors caused by another person's misinterpretation. To ensure correct and legible entries, it is a good idea to enter the information in pencil so you can correct minor errors. Although discouraged, it is not wrong to make entries in ink.

#### *Signature*

The minimum signature used on most forms is the first name initial, complete last name, and employee number. These entries are always made in script by the actual person, and then printed if someone else transcribes it to other documents. There are exceptions to this policy, but they are rare. Record all dates on these forms by year, month, and day (i.e., yyyymmdd—20141130 for 30 November 2014).

**NOTE:** Every Red X requires two signatures. Because a Red X indicates a grounding condition, the work must be inspected by someone other than the person performing the maintenance. The person who actually performed the maintenance action signs only in the corrected by section. After the work is completed, it must be inspected before the aircraft is released from the grounding condition. The inspector checks the completed work than signs the inspected by section and will also sign off the Red X symbol.

#### *Abbreviations*

Standard abbreviations can help make a concise and readable form entry. Remember though, the key for using any shortened word form is, "Will the reader understand?" If you cannot answer this question in the affirmative, spell it out! For convenience and standardization, the first section of the TO indexes list common abbreviations to be used (e.g., DN for "document number" or IAW for "in accordance with").

### Symbols and their use

Specific symbols are used on maintenance documents to make certain notations instantly apparent. They indicate the mechanical condition; fitness for flight; or operation, servicing, inspection, and maintenance status of the system concerned. Of these, certain symbols are entered in red to make the important warning signals stand out clearly. Thus, the Red X represents the most serious possible condition: the Red Dash (–), the next most serious, and the Red Diagonal (/), the least serious condition. You must memorize the relative importance of these symbols to ensure proper entries on the aircraft forms. You enter these symbols on several of the AFTO 781-series forms. Remember, these symbols reflect the seriousness of the discrepancy in the opinion of the person making the entry.

### *Upgrade*

Any person who determines a discrepancy is more serious than previously entered may upgrade that symbol. To do this, the person draws a line through the minimum signature of the person who made the entry, and enters his/her own minimum signature above the "DISCOVERED BY" block.

When a Red Dash is upgraded to a Red X, close out the original Red Dash with the remark, "Symbol upgraded to a Red X, see page ____, item ____" in the "CORRECTIVE ACTION" block with a Red X using the "see page ____, item____" format.

### *Downgrade*

If any supervisory personnel believe the condition is less serious than represented by the symbol, the matter is brought to the attention of the commander, or designated representative. They can authorize a downgrade of the symbol entries if appropriate.

### *Error*

Once entered on an aircraft form, a symbol must never be erased, even if entered in error. This ensures the opinion of the person who made the entry is thoroughly evaluated before a symbol is changed. It also ensures that an erroneous symbol entry is cleared properly. In this way, no doubt is left about the integrity and validity of the symbol entered.

If an erroneous Red Dash or Diagonal is entered in the SYM block of the AFTO Form 781A, Maintenance Discrepancy and Work Document, the person making the entry enters this statement in the CORRECTIVE ACTION block: "Symbol entered in error, Item reentered on page ________, item ________." The person also enters his or her signature and employee number in the CORRECTED BY block and initials over the symbol. The discrepancy is then entered, with the correct symbol, in the next open discrepancy block (i.e., if the erroneous symbol is a Red X, an authorized person must initial over the symbol and sign the INSPECTED BY block).

Now that we have covered some basic information regarding special aspects of symbol entry, let's look at the different symbols and their meanings.

| **AFTO Form 781 Symbols** | |
|---|---|
| **Symbol** | **Description** |
| Red X | As we said, a Red X is the most serious symbol. It indicates the aircraft is considered unsafe or unfit for flight, and it must not be flown until this unsatisfactory condition has been remedied. No one may authorize or direct an aircraft be flown until the Red X has been properly cleared. After work has been done to clear the discrepancy, there must then be an audit of all related entries. They must be checked for completeness and accuracy. Each Red X symbol is always a separate AFTO Form 781A entry. Here are some typical situations that call for the Red X symbol:<br>• Immediately upon discovery of an unsatisfactory condition serious enough to warrant its use.<br>• Upon receipt of an immediate action TCTO.<br>• When work or inspections occur in or around the air intake areas of jet engines. The Red X is used for inspection of the intake ducts and areas forward of the intake ducts before engine start to ensure there are no objects that could be ingested by the engine.<br>• When maintenance is done on flight control systems or components.<br>• When maintainers or aircrew report defects or unsatisfactory conditions of systems or components that could affect safety of flight. Sometimes, defects or conditions cannot be physically located or can't be operationally duplicated.<br>• Upon removal of any component or assembly that affects the safety of flight or safe operation of the aircraft.<br>• When the affected aircraft fuel system requires maintenance. |

| AFTO Form 781 Symbols | |
|---|---|
| **Symbol** | **Description** |
| Red Dash<br>(—) | A Red Dash (–) symbol indicates the condition of the equipment is unknown. It means:<br>• An inspection is due and has not been completed.<br>• A functional check flight has not been made (such as the replacement of a repaired flight control).<br>• An accessory scheduled for replacement has not been replaced.<br>Red Dashes are often used in our career field to document cure checks on sealed repairs, bond nutplates or when your repair requires nondestructive inspection (NDI). |
| Red Diagonal<br>(/) | A Red Diagonal (/) indicates an unsatisfactory condition that may affect the flying safety or the flying efficiency of the aircraft, but is not urgent or dangerous enough to warrant grounding the aircraft.<br>The Red Diagonal is entered in the appropriate block, extending from the upper right hand corner to the lower left hand corner of the block. |

## 204. Using aircraft forms

We've already discussed form entries. Now, let's see how you make the entries on the three 781 forms you will come in contact with daily. 781-series forms are thoroughly discussed and proper procedures for their use are contained in TO 00–20–1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*. Be sure to review applicable TO supplements that affect your MAJCOM or base.

### AFTO Form 781A, Maintenance Discrepancy and Work Document

The AFTO Form 781A is designed so each individual deficiency and discrepancy reported by a pilot, aircrew member, or maintenance technician can be identified and documented for historical and filing purposes. The form's front and back are identical and each side contains spaces for noting different discrepancies. Each side is treated as a page when the completed forms are removed from the aircraft binder and forwarded to the records unit for filing. Figure 1–4 is an example of an AFTO Form 781A.

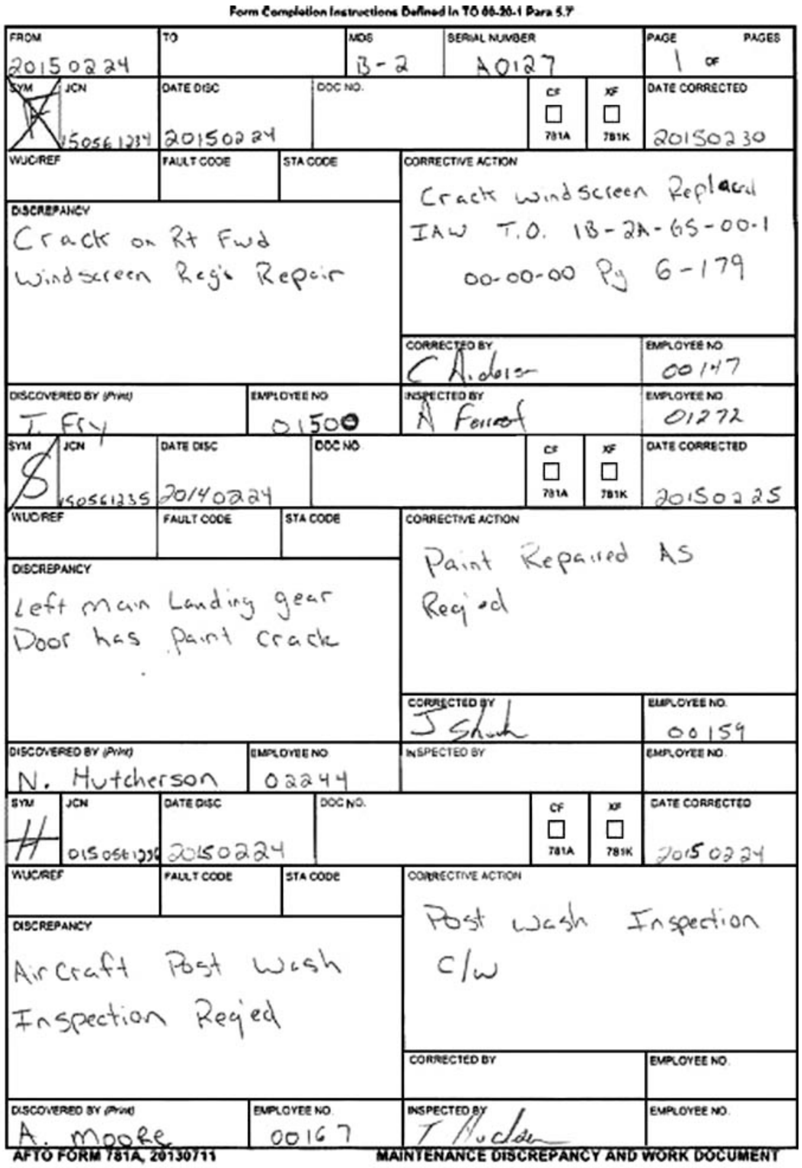
#### *Initial*

When a new AFTO Form 781A is initiated, any uncorrected discrepancies, other than Red X items, may be transferred to the AFTO Form 781K. The name of the person who makes the initial entry into the AFTO Form 781A need not be retained with the discrepancy when the entry is transferred to the AFTO Form 781K, or carried forward to a new AFTO Form 781A.

#### *New*

When a discrepancy is carried forward to a new AFTO Form 781A, the crew chief or alternate must enter the page number, item number, and date of the new form, and sign in the TRANSFERRED BY block. If the discrepancy is to be transferred to the AFTO Form 781K, the crew chief enters his or her employee number in the appropriate block. Do not place an initial over the symbol for discrepancies carried forward or transferred to another form; this only represents transcribing action and *does not* correct the reported condition.

When a discrepancy is carried forward to a new AFTO Form 781A or transferred to the AFTO Form 781K, the job control number (and, if applicable, the supply document number) and AFTO Form 350 tag number must be carried forward with the discrepancy.



Form Completion Instructions Defined In TO 00-20-1 Para 5.7

FROM 20150224 | TO | MDS B-2 | SERIAL NUMBER A0127 | PAGE 1 OF PAGES

SYM X | JCN 150561234 | DATE DISC 20150224 | DOC NO. | CF 781A | XF 781K | DATE CORRECTED 20150230

WUC/REF | FAULT CODE | STA CODE | CORRECTIVE ACTION: Crack windscreen Replaced IAW T.O. 1B-2A-65-00-1 00-00-00 Pg 6-179

DISCREPANCY: Crack on Rt Fwd Windscreen Req's Repair

CORRECTED BY C. A.dobs | EMPLOYEE NO 00147

DISCOVERED BY (Print) T. Fry | EMPLOYEE NO 01500 | INSPECTED BY A Forrest | EMPLOYEE NO 01272

SYM / | JCN 150561235 | DATE DISC 20140224 | DOC NO | CF 781A | XF 781K | DATE CORRECTED 20150225

WUC/REF | FAULT CODE | STA CODE | CORRECTIVE ACTION: Paint Repaired AS Req'ed

DISCREPANCY: Left main Landing gear Door has Paint crack

CORRECTED BY J Shah | EMPLOYEE NO 00159

DISCOVERED BY (Print) N. Hutcherson | EMPLOYEE NO 02244 | INSPECTED BY | EMPLOYEE NO

SYM H | JCN 0150561236 | DATE DISC 20150224 | DOC NO. | CF 781A | XF 781K | DATE CORRECTED 20150224

WUC/REF | FAULT CODE | STA CODE | CORRECTIVE ACTION: Post Wash Inspection C/W

DISCREPANCY: Aircraft Post Wash Inspection Req'ed

CORRECTED BY | EMPLOYEE NO

DISCOVERED BY (Print) A. Moore | EMPLOYEE NO 00167 | INSPECTED BY T Mulder | EMPLOYEE NO

AFTO FORM 781A, 20130711 — MAINTENANCE DISCREPANCY AND WORK DOCUMENT

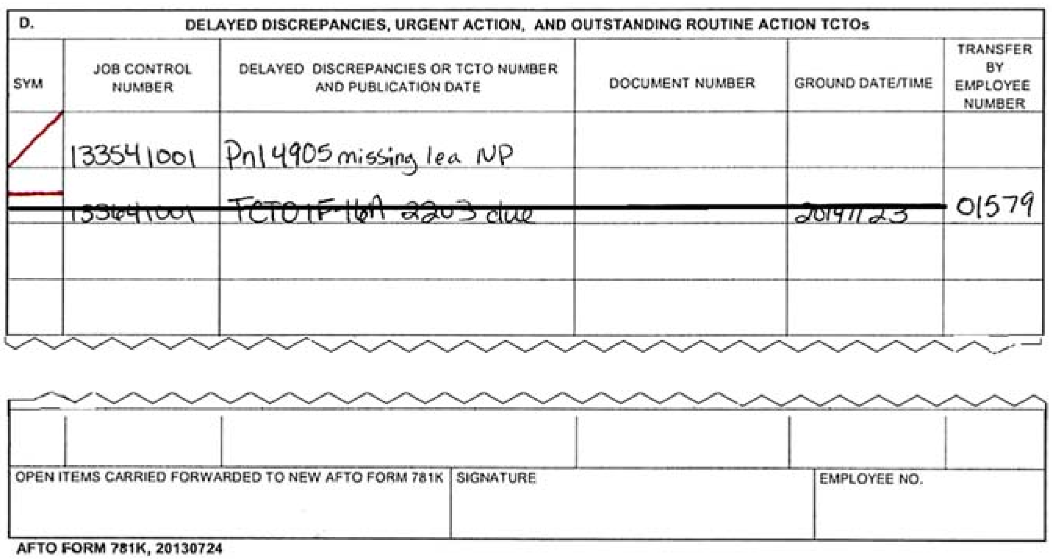
**Figure 1–4. AFTO Form 781A.**

## AFTO Form 781K

The AFTO Form 781K, Aerospace Vehicle Inspection, Engine Data, Calendar Inspection and Delayed Discrepancy Document encompasses every area covered on the form. Basically, AFTO Form 781K (fig. 1–5) is used to record and keep track of inspections due or completed. Delayed discrepancies may be transferred from the AFTO Form 781A or upon completion of scheduled maintenance. Red X entries *are not* entered on or transferred to the AFTO Form 781K. The most significant parts of the form are identified in the following table.

| Significant Parts of AFTO Form 781K | |
|---|---|
| **Part** | **Description** |
| Block A | Periodic, major, or phased inspections are recorded in block A, AIRCRAFT INSPECTION STATUS. This information includes type, frequency, and next due date. |
| Block B | Block B, ENGINE DATA, is used to record engine position, serial number, and engine change due time. |

| Significant Parts of AFTO Form 781K | |
|---|---|
| **Part** | **Description** |
| Block C | The CALENDAR AND HOURLY INSPECTION SCHEDULE is annotated in block C. This block is used to record calendar inspection items to be inspected or tested at a specified hourly or calendar period.<br>Items listed are primarily those short-term special inspection requirements that frequently become due, and are defined as those having an interval of less than six months or an hourly interval less than the periodic inspection interval.<br>Examples can include a requirement to inspect an area prone to failure every 25 hours or the condition of a temporary structural repair after every flight. |
| Block D | DELAYED DISCREPANCIES, URGENT ACTION, AND OUTSTANDING ROUTINE ACTION TCTOs are entered in block D. Delayed discrepancies may be transcribed from the AFTO Form 781A.<br>When a delayed discrepancy or TCTO entered on the AFTO Form 781K is to be corrected or accomplished during unscheduled maintenance, the entry must be transferred to the AFTO Form 781A so a brief description of the corrective action taken can be documented. |


D. DELAYED DISCREPANCIES, URGENT ACTION, AND OUTSTANDING ROUTINE ACTION TCTOs

| SYM | JOB CONTROL NUMBER | DELAYED DISCREPANCIES OR TCTO NUMBER AND PUBLICATION DATE | DOCUMENT NUMBER | GROUND DATE/TIME | TRANSFER BY EMPLOYEE NUMBER |
|---|---|---|---|---|---|
| / | 13354l001 | Pnl 4905 missing lea NP | | | |
| — | 13364l001 | TCTO 1F-16A 2203 due | | 2014l123 | 01579 |
| | | | | | |
| | | | | | |
| | | | | | |

| OPEN ITEMS CARRIED FORWARDED TO NEW AFTO FORM 781K | SIGNATURE | EMPLOYEE NO. |
|---|---|---|
| | | |

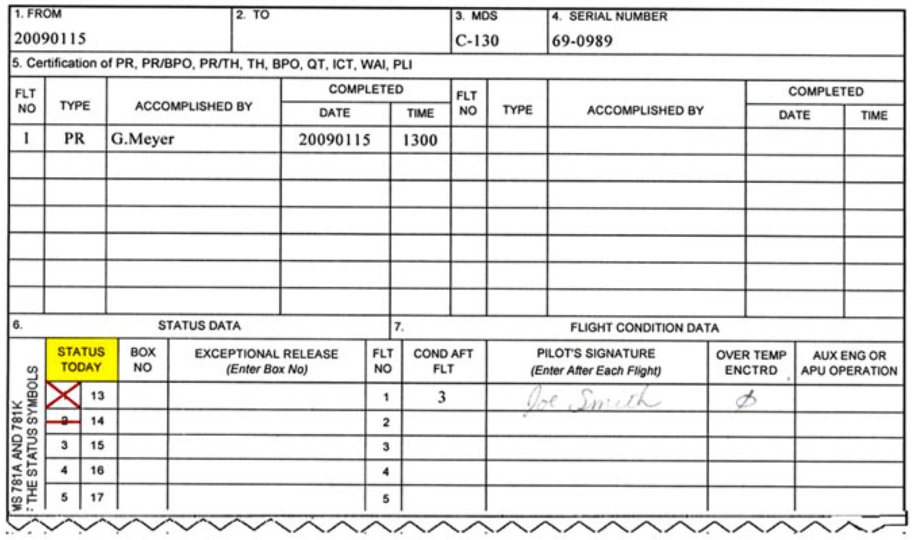
AFTO FORM 781K, 20130724

**Figure 1–5. AFTO Form 781K (Back).**

## AFTO Form 781H, Aerospace Vehicle Flight Status and Maintenance

The majority of AFTO 781 series entries are made on AFTO Forms 781A and K, or on AFTO Form 781H (fig. 1–6). Just as the title suggests, The AFTO Form 781H, *Aerospace Vehicle Flight Status and Maintenance,* shows the current status of the aircraft and serves as a ready reference to the servicing, maintenance, and inspection history.

This form also indicates the status and history of inspections specifically related to the daily activity or the day involved. The AFTO Form 781H is removed from the aircraft forms binder prior to the next flying period.



| 1. FROM | 2. TO | 3. MDS | 4. SERIAL NUMBER |
|---|---|---|---|
| 20090115 | | C-130 | 69-0989 |

5. Certification of PR, PR/BPO, PR/TH, TH, BPO, QT, ICT, WAI, PLI

| FLT NO | TYPE | ACCOMPLISHED BY | COMPLETED DATE | COMPLETED TIME | FLT NO | TYPE | ACCOMPLISHED BY | COMPLETED DATE | COMPLETED TIME |
|---|---|---|---|---|---|---|---|---|---|
| 1 | PR | G.Meyer | 20090115 | 1300 | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

6. STATUS DATA — 7. FLIGHT CONDITION DATA

MS 781A AND 781K / THE STATUS SYMBOLS

| STATUS TODAY | | BOX NO | EXCEPTIONAL RELEASE (Enter Box No) | FLT NO | COND AFT FLT | PILOT'S SIGNATURE (Enter After Each Flight) | OVER TEMP ENCTRD | AUX ENG OR APU OPERATION |
|---|---|---|---|---|---|---|---|---|
| X | 13 | | | 1 | 3 | Joe Smith | Ø | |
| 2 | 14 | | | 2 | | | | |
| 3 | 15 | | | 3 | | | | |
| 4 | 16 | | | 4 | | | | |
| 5 | 17 | | | 5 | | | | |

**Figure 1–6. AFTO Form 781H (front).**

## AFTO Form 95, Significant Historical Data

The AFTO Form 95, *Significant Historical Data*, is a document for maintaining a permanent history of significant maintenance actions on end items of SE, training equipment, and certain components designated by the item manager, MAJCOM, or group commander. Although specific information concerning maintenance actions is entered on other forms, these forms are temporary in nature.

The AFTO Form 95 is a permanent record of those significant actions that provide the maintenance organization with a lifetime profile of the item. As a minimum, this information should portray conditions that could have a bearing on future maintenance of the equipment. There are some major structural maintenance actions that may require AFTO Form 95 entries. These may be radome repairs, repairs to control surfaces, aircraft paint, and major structural repairs. This list is not all-inclusive and varies from base to base.

## Integrated Maintenance Information System/Autonomous Logistics Information System

While most military aircraft are documenting aircraft maintenance with a combination of the Integrated Maintenance Delivery System (IMDS) and 781 series forms, the new high-tech, low-observable (LO) platforms are using automated systems. The F–22 platform uses a system called the Integrated Maintenance Delivery System (IMIS) and the F–35 platform uses a system called the Autonomous Logistics Information System (ALIS). Both IMIS and ALIS serve as an automated system for aircraft maintenance documentation and tech data.

When using IMIS and ALIS to document aircraft maintenance, the symbols and entry requirements are the same as those for the 781 series paper forms except they are input digitally. Figure 1–7 shows an example of typical LO maintenance documented in IMIS.

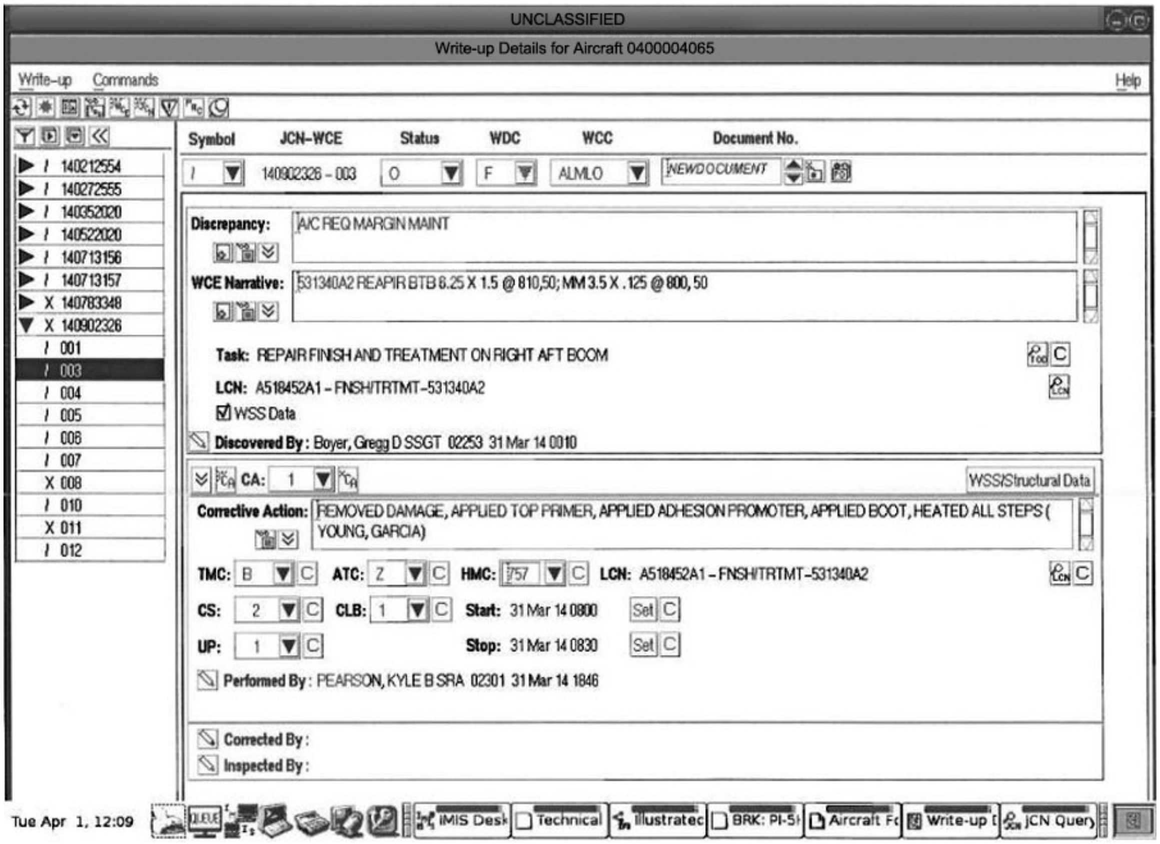



Figure 1–7. IMIS Forms.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 201. Documenting AFTO Form 350, Repairable Item Processing Tag

1. What is Part I of the AFTO Form 350 known as and what is it used for?

2. Where is Part II of the AFTO Form 350 located and what purpose does it serve?

3. Where can you find a block-by-block explanation of how to document the AFTO Form 350 tag?

4. When an item is sent to RPC, which blocks (both front and back) are required to be completed by the individual (originator) initiating the 350 tag?

5. When an item is *not* sent to the RPC because of its size or for other reasons, which additional blocks must be completed by the originator?

### 202. Maintaining and inspecting shop equipment

1. When *must* a prior-to-use inspection be completed?

2. What should you look for when inspecting rubber hoses?

3. What guidance is used to determine equipment lubrication requirements?

4. What grit of sandpaper is used when removing oxidation from bare metal equipment surfaces?

5. What form is used to document equipment maintenance?

6. What section of the Industrial/Support Equipment Record documents scheduled inspections?

7. What symbol would you use to document an unsafe or unfit for use condition?

8. When documenting equipment discrepancies on the Industrial/Support Equipment Record, how do you document a scheduled inspection is overdue?

### 203. Entering information on aircraft forms

1. Why is it important to make form entries complete, legible, and neat?

2. What is the minimum signature on most aircraft forms?

3. In order to sign off a Red X entry, how many signatures are required?

4. Who may change a symbol if a condition is believed to be more serious than represented by the current symbol?

5. What does the Red X indicate?

6. How is a Red Diagonal entered in the forms?

### 204. Using aircraft forms

1. What AFTO 781-series form is used for a record and for keeping track of all inspections?

2. What type of form entries are not transferred from the AFTO Form 781A to the AFTO Form 781K?

3. What information is recorded in the CALENDAR AND HOURLY INSPECTION SCHEDULE block?

4. What AFTO 781-series form is titled Aerospace Vehicle Flight Status and Maintenance?

5. What purpose does the AFTO Form 781H serve?

6. When is the AFTO Form 781H removed from the aircraft forms binder?

7. What is the purpose of the AFTO Form 95?

## 1–2. Technical Publications

The TO system is the official means used to distribute military orders of a technical nature to the using activity. TOs are official directives from Headquarters USAF that contain information, instructions, and procedures pertaining to Air Force equipment and material. Since you are a low observable aircraft structural maintenance (LOASM) journeyman, you'll be doing research in many different types of publications dealing with maintenance and material. In this section, you will learn the various types of TOs and their purposes. Afterwards, you'll be better able to decide which one is most likely to have the information you need at a particular time and for a particular purpose.

### 205. Using different types of technical orders

The Air Force ensures that everyone has a full set of operating and maintenance (O&M) instructions to perform his or her assigned duties. These instructions are in the form of TOs. TOs are official US Air Force directives and *their use is mandatory when maintaining aircraft and aircraft components;* therefore, maintenance will not be performed unless a technical order is in use. Accidents and malfunctions on aircraft and ground equipment can often be traced to failure to observe all requirements in the pertinent TO. Such negligence not only endangers the lives of others and impairs the achievement of our mission but also represents a grave breach of military discipline.

Most TOs tell you how to inspect, operate, maintain, modify, and overhaul Air Force equipment. You will research and use them daily to perform your duties. There are many types of TOs used by the Air Force and each type fills a certain need. Operational libraries are authorized to provide personnel quick access to the TOs required for the most efficient and effective performance of assigned duties. This kind of library is most commonly found in the work area; however, as LOASM, a majority of the TOs you will be using have transitioned to an electronic format. Nevertheless, whether they are paper or digital, all TOs fall into one of five major types of TOs authorized for use (fig. 1–8).

1. Index type TOs.
2. O&M TOs.
3. Methods and procedures technical orders (MPTO).
4. Abbreviated TOs.
5. TCTOs.

#### Enhanced Technical Information Management System

Enhanced Technical Information Management System (ETIMS) is a secure Web, Global Combat Support System (GCSS)-AF application accessible via the AF Portal with the TO catalog, ordering, and account management functions.

ETIMS also features an electronic TO (eTO) content repository, a paper TO Distribute and Print Service (TODPS), an eTO publisher/transformer, and an eTO viewer with online, connected and portable, disconnected modes. Primary users are TO managers, TO Distribution Office (TODO) personnel, TO Distribution Account (TODA) personnel, TO library custodians, eTool administrators and TO users.

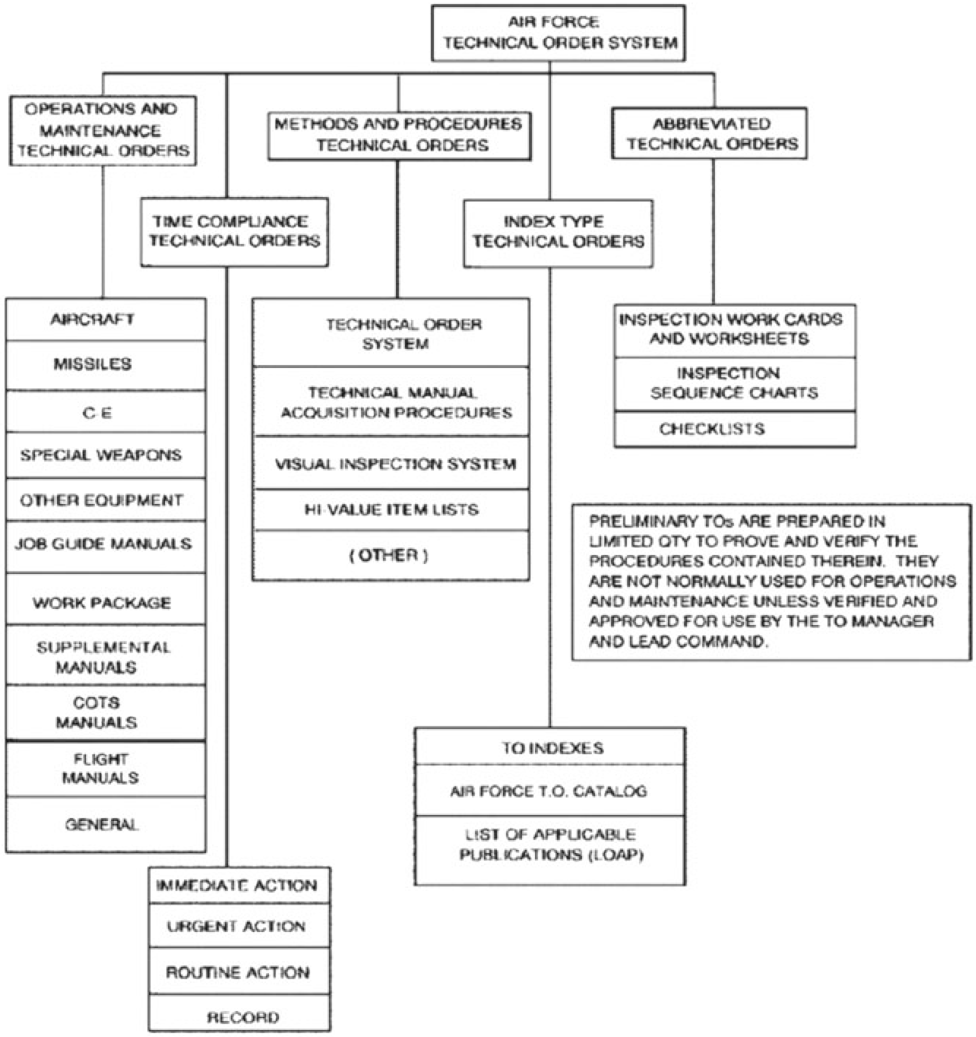



**Figure 1–8. Breakdown of the technical order system.**

## Index technical orders

Indexes provide a means of identifying needed TOs, grouping TOs pertaining to specific items of equipment, and showing the status of all TOs. The following table describes some indexes you will use.

### *TO Catalog*

The TO Catalog is located in ETIMS and provides up-to date information on all active AF TOs. It is updated daily with information for newly assigned TOs, TO increments (revisions, changes or supplements), and TCTOs. It also includes information for TOs that were rescinded or reinstated, superseded/distributed and/or renumbered. You can use the TO catalog to ensure you are using the most current copy of a TO and that you have all the required supplements and current changes.

### *List of Applicable Publications*

The List of Applicable Publications (LOAP) contain a complete list of the TOs required for a specific weapons system or piece of equipment. The purpose of this TO is to help you become familiar with the TOs needed for a system you will be working on. If you need a TO for a piece of equipment, look it up in the LOAP. When you are establishing a TO file, the LOAPs provide the minimum TO requirements. When –01 appears at the end of a TO number (except TO 0–1–01), that TO is a LOAP TO. Again, remember that the LOAP is not to be used to determine the currency of TOs or to order TOs.

### Operations & maintenance technical orders

O&M TOs cover installation procedures, operation, troubleshooting, repairing, calibration, servicing or handling of Air Force military systems and end items. O&M TOs must be available and used at the job site. Job site may be defined by the using command for specific situations or may be delegated to group level or equivalent commanders. Now we discuss some examples of these:

#### *Flight manual program publications*

These contain information on an aircraft, aircraft equipment, aircraft operation and characteristics. They include flight manuals like the –1 series.

#### *On-equipment organizational maintenance manual sets*

On-equipment organizational maintenance manual sets provide detailed procedures in step-by-step form for operational checkout, test repair, adjustment, and removal and replacement of accessories. These TOs include Job Guides (JG) which are TOs designed to lead you through a specific maintenance task. These TOs contain such information as general maintenance procedures, operational checkout procedures, and a step-by-step component removal and installation procedure.

At the beginning of each task listed in the JG, you can find a complete listing of input conditions that tell you how many people are required, references to the applicable TOs, and what equipment you need. Make sure you read and understand these conditions before you start any job. By failing to read the input conditions, you could cause yourself or others a lot of unnecessary work or lost time.

#### *Work package technical orders*

Work package TOs are depot and intermediate maintenance manual sets that contain individual work packages (WP) that provide detailed procedures, in step-by-step form, to accomplish specific maintenance tasks. The depot or intermediate maintenance set contains all applicable WPs.

#### *Calibration technical orders*

These 33K-series manuals provide instructions for off-equipment calibration of TMDE.

### General technical orders

If the number 1 is used in lieu of a specific equipment identifier (e.g. 1–1–690, 1–1–694) the TO is a general technical order (category general, system general, or equipment-series general TO). General TOs apply to more than one type of aircraft, missile or engine or to more than one equipment system in the category. System general TOs apply to a system installed on more than one type of aircraft, missile or engine. Equipment-series general TOs apply to more than one subseries.

**NOTE:** In case of a conflict between procedures in general TOs and Air Force Occupational Safety and Health (AFOSH) Standards, follow the more restrictive requirement.

#### *Methods and procedures technical orders*

MPTOs establish policies and prescribe procedures relating to such subjects as the TO system, preventive maintenance, scheduled inspections of equipment, maintenance management information, historical status, and configuration accounting documentation. The MPTOs are general in content and are not issued against specific weapons systems or equipment. They tell the what, when, why, and how of general subjects. Most MPTOs begin with the number 00. Two of the more commonly used MPTO series are listed:

- 00–5 series TOs—provide basic information about TOs, their distribution, TCTOs, and the TO numbering system.

- 00–20 series TOs—provide maintenance management information concerning general maintenance policies and procedures, maintenance data documentation, repair cycle assets, and aircraft forms documentation.

### *Abbreviated technical orders*

Abbreviated TOs are primarily work simplification devices. Obviously, it is difficult to carry around a bulky TO for instructions on various tasks such as inspecting or lubricating equipment. For this purpose, inspection workcards, checklists, and lubrication charts have been developed in condensed form as an abbreviated TO to simplify handling. (**NOTE:** In the event of a conflict between the basic TO and abbreviated TO, the basic TO takes precedence.)

#### *Inspection workcards*

Workcards (WC) are developed in sets by type of inspection, and work area or zone being inspected. They provide the required guidance; including applicable safety warnings, cautions and notes as well as specific accept/reject criteria for performing and inspection.

#### *Checklists*

Checklists (CL) provide abbreviated step-by-step procedures for operation and maintenance of system and equipment in the sequence deemed most practical, or to ascertain operational readiness or equipment and minimum serviceable condition.

### *Time compliance technical orders*

TCTOs are the authorized method of directing and providing instructions for modifying military systems and end items (other than temporary modifications), and performing or initially establishing one-time inspections. Depending upon the urgency of the inspections, TCTOs are grouped into one of the following types: immediate action, urgent action, and routine action. The type of urgency determines how quickly TCTO compliance is to be completed. Detailed instructions on TCTOs are provided in TO 00–5–15, *Air Force Time Compliance Technical Order Process*.

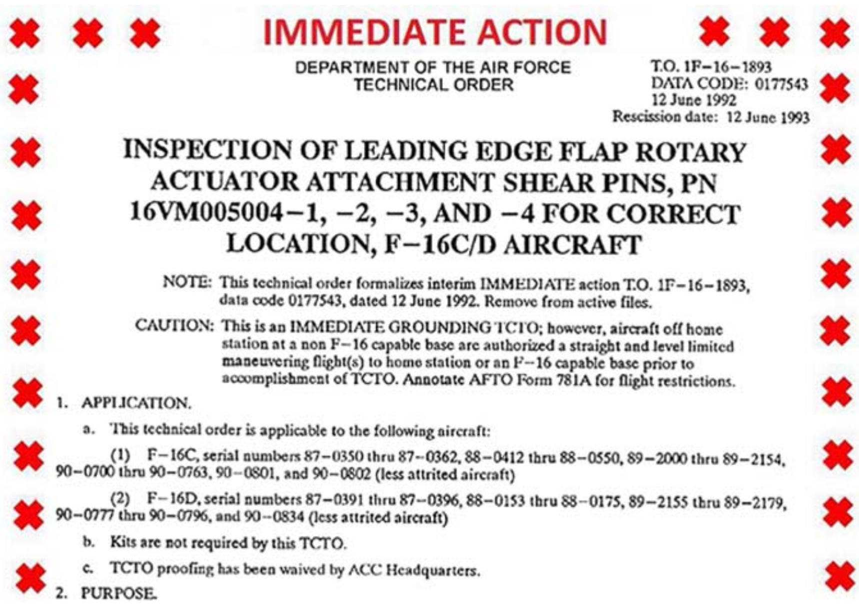
#### *Immediate action*

Immediate action TCTOs (fig. 1–9) are issued under the governing factors of safety conditions, the uncorrected existence of which could result in fatality or serious injury to personnel or extensive damage to or destruction of valuables. The words IMMEDIATE ACTION are printed in red at the top center of the first page and a series of red Xs (XXXX) are printed around the border of the first page.

The urgency of these TCTOs requires immediate action to remove the aircraft from service (grounding), prevent launch of missiles, discontinue operation of ground communication-electronic (G-E) systems, or use of related support equipment, personal equipment, or munitions. When possible, corrective actions are included in immediate action TCTOs. Commanders shall ensure distribution to all affected personnel within four hours after receipt because of the TCTO’s critical nature.

#### *Urgent action*

Urgent action TCTOs are issued under the governing factors of combat necessity or potentially hazardous conditions which could result in injury to personnel, damage to property, or unacceptable reductions in combat efficiency. The urgency of these TCTOs requires compliance within specified time limits. If compliance is not accomplished by expiration of the time limit, these TCTOs require action to remove aircraft from service (grounding), discontinue use of air-launched missiles, prevent launch of missiles, discontinue operation of AGE, or use of SE, personal equipment, materials or munitions. On formal TCTOs, the words URGENT ACTION are printed in red at the top center of the first page and a series of red diagonals alternately spaced with red Xs (/ X / X / X) are printed around the border of the first page. Commanders shall ensure distribution is made to all affected personnel within 24 hours of receipt.



IMMEDIATE ACTION

DEPARTMENT OF THE AIR FORCE
TECHNICAL ORDER

T.O. 1F–16–1893
DATA CODE: 0177543
12 June 1992
Rescission date: 12 June 1993

INSPECTION OF LEADING EDGE FLAP ROTARY ACTUATOR ATTACHMENT SHEAR PINS, PN 16VM005004–1, –2, –3, AND –4 FOR CORRECT LOCATION, F–16C/D AIRCRAFT

NOTE: This technical order formalizes interim IMMEDIATE action T.O. 1F–16–1893, data code 0177543, dated 12 June 1992. Remove from active files.

CAUTION: This is an IMMEDIATE GROUNDING TCTO; however, aircraft off home station at a non F–16 capable base are authorized a straight and level limited maneuvering flight(s) to home station or an F–16 capable base prior to accomplishment of TCTO. Annotate AFTO Form 781A for flight restrictions.

1. APPLICATION.

a. This technical order is applicable to the following aircraft:

(1) F–16C, serial numbers 87–0350 thru 87–0362, 88–0412 thru 88–0550, 89–2000 thru 89–2154, 90–0700 thru 90–0763, 90–0801, and 90–0802 (less attrited aircraft)

(2) F–16D, serial numbers 87–0391 thru 87–0396, 88–0153 thru 88–0175, 89–2155 thru 89–2179, 90–0777 thru 90–0796, and 90–0834 (less attrited aircraft)

b. Kits are not required by this TCTO.

c. TCTO proofing has been waived by ACC Headquarters.

2. PURPOSE.

**Figure 1–9. Immediate action time compliance technical order.**

*Routine action*

Routine action TCTOs are issued for any condition not covered under immediate or urgent action TCTOs. Governing factors are equipment or procedural deficiencies of a material, mechanical, operational, or tactical nature, the uncorrected existence of which could create a hazard through prolonged usage, have a negative effect on operational efficiency, reduce tactical or support utility, or reduce operational life or general service utilization of systems or commodities. Routine action TCTOs may also provide enhancements to equipment or system capabilities. The procuring activity is authorized to withhold the release of non-safety routine action TCTOs for a maximum of 90 days to permit simultaneous release of two or more TCTOs requiring work in the same general area. This procedure is authorized for all systems and commodities to reduce access and button-up maintenance man-hours when subsequent TCTOs are known to be approved and in process.

*Interim*

When circumstances preclude the timely publication of emergency instructions as formal TCTOs, they are issued by electronic means. This is called an interim TCTO or ITCTO. This method can be used with immediate action, urgent action, and routine safety TCTOs.

## 206. Using the technical order numbering system

Technical orders cover a large number of subjects; therefore, a good numbering and filing system is needed so that information can be located quickly and easily. TO numbers are composed of groups separated by dashes, and each group is further divided into parts (fig.1–10) and are used to categorize TO data, provide a sequence for filing, and determine and order what is needed in a particular TO library. Each grouping is made up of a numerical or numerical/alphabetical (alphanumeric) combination separated by a dash.

Sufficient flexibility exists within the total numbering system to allow for expansion or contraction within numbering parameters, yet still maintain standard application of numbering patterns within each category. In this lesson, we will use the category reserved for aircraft (category 1) to further explain TO numbering.

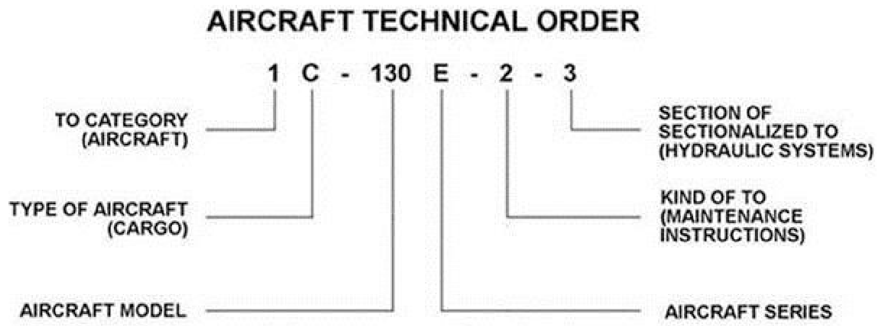



**Figure 1–10. Technical order numbering.**

A total of seven groups may be used in the TO numbering pattern. The number of parts within any group varies according to the TO data being numbered in a specific category. Each part of a group consists of one or more numeric characters or one or more alpha characters separated by a dash. The numbering patterns used to identify TO data in each category are outlined in TO 00–5–18, *USAF Technical Order Numbering System*. TO data is identified, in most categories, by using only the first three or four basic groups. The first grouping has two parts. In part one of the first grouping Part one (1) identifies the TO category and part two (2) identifies the aircraft mission., the numerical character 1 identifies the category reserved for aircraft. Part two is an alpha character that identifies the aircraft basic mission and type of equipment. For example, Category 1 is Aircraft TOs; with the addition of a basic mission symbol (as in the letter F) after the 1, it becomes 1F–Aircraft and identifies a general TO on cargo aircraft. The following table lists a few of the basic mission alpha identifiers:

| Alpha Identifier | Basic Mission |
|---|---|
| 1B | Bomber aircraft |
| 1C | Cargo aircraft |
| 1F | Fighter aircraft |
| 1U | Utility aircraft |

### Group two

The second group of TO numbers identifies the specific model and production series aircraft that pertain to the TO. This grouping may consist of two or three parts. The first part contains one or more numeric characters identifying the aircraft model. The first series manufactured is identified with the alpha A, second series with the alpha B, and continuing through the alphabet. So continuing on with our example 1F identifies a general TO for a fighter aircraft, continuing on with a 22 narrows it to a specific model fighter and finally by adding an A to the second group it becomes 1F–22A.

### Remainder

The third grouping of numbers is located after the second dash in the TO number. In category 1 (aircraft) TOs, group three primarily identifies the type of TO, instruction, or procedure. This can be accomplished by using one or two parts. Part one consists of one or more numeric characters reserved to indicate the specific type of TO. The following table lists some of the numbers reserved to identify the TOs in category 1:

| Number | Explanation |
|---|---|
| –06 | WUC manual |
| –3 | Structural repair instructions |
| –2 | Maintenance instructions |
| –4 | Illustrated parts breakdown (IPB) |

### Letters

The last part you should know is there are some instances when the numeric characters in part one are followed by one or more alpha characters indicating a series of CLs, WCs, supplements, or other types of functions. So in our example 1F–22A–2-GV–1, the –2 means a maintenance instruction, GV indicates a general vehicle TO and the last –1 is the first book in this series. Some of the authorized alpha characters are listed in the following table:

| Alpha Characters | Meaning |
|---|---|
| GA | General aircraft |
| GS | General system |
| GV | General vehicle |
| JG | Job guide |

### Maintenance Integrated Data Access System

The Maintenance Integrated Data Access System (MIDAS) TO number is a six-digit numbering system expressed by three elements of two digits each. Refer to figure 1–11to see what each element stands for. Consider this example 51–40–00. The first two digits represent the major system, in the case the Standard Practices Structures TO. The third digit (4) indicates the typical composite repair section, which is a subsystem of the structures. The fourth digit (0) indicates a sub-subsystem. The last two digits (00) represent the function number that is tied to the JG manuals and are used for operational checks or repair of the aircraft system. The MIDAS number appears on the lower outer corner of every page of the pertinent manuals. This provides a ready reference index number. For instance, using MIDAS number 51–40–00, you would refer to JG 1B–2A–2–51GS–40–1 to work on the fuel indicating subsystem with the fuel system.

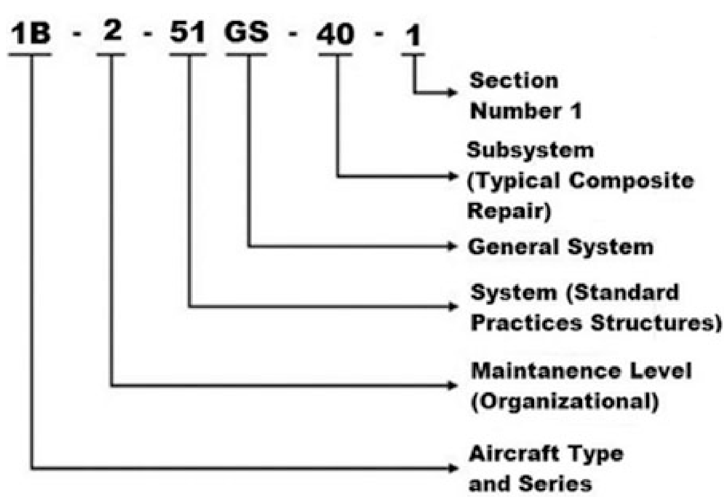



Figure 1–11. MIDAS TO number.

## 207. Using the illustrated parts breakdown

Another valuable source of research information is the –4, Illustrated Parts Breakdown. The IPB allows you to identify most procurable parts for a specific aircraft. Besides being able to help you identify parts, it can also help you save time, manpower, and materials. The –4 IPB gives you the following information:

- If a damaged part is a procurable item or if it is designated as requiring local manufacture.
- If a damaged part is authorized to be repaired at your level of maintenance.

- If a damaged part can be condemned or sent to an overhaul facility.
- Fastener requirements, such as number required, grip lengths, and diameters.

The –4 IPB consists of a number of volumes. Do not let the size or the number of volumes keep you from using the IPB. If you can locate information in the system specific TO, you can easily find it in the IPB. The IPB is a simple arrangement of three sections: (1) introduction, (2) group assembly parts list, and (3) numerical index. Take a brief look at these sections and notice what information each provides.

### Section I, introduction

The introduction section is the heart of the IPB; it provides you with the keys to locating and interpreting the information contained in the other two sections. This section should be your first stop if you are unfamiliar with the –4 IPB. Within section I, you will find a short explanation of each individual section of the TO, different types of research procedures, listings of source, maintenance, and recoverability (SMR) codes, and related IPB technical manuals. Additionally, you will find vendor codes, incorporated TCTOs, and a major assembly breakdown illustration of the entire aircraft. Each of these areas is interrelated to each other in one way or another. Each plays an important part in the repair decision you will make.

### Section II, group assembly parts list

Section II contains illustrations and corresponding numbered parts lists of replaceable parts. The illustrations and parts lists are arranged in main groups corresponding to the major assembly breakdown. You'll obtain most of the information needed to order a replacement part from this section. At the end of section II, there is a functional system parts list that contains a breakdown of the installations and assemblies within a specific system. These breakdowns provide a means of pinpointing the exact locations of parts within a system as well as the required part number you'll need to order a particular replacement part.

### Section III, numerical index

Finally, section III is the numerical index. It is an alphabetically and numerically arranged listing of the part numbers found in section II. The figure and index numbers are given for reference to section II in which each part number appears. Parts appearing in section II with no part number are alphabetically listed in section III by the identifying noun (item name) listed in the part number column. Also given are the SMR codes and the number of like parts used throughout the aircraft.

## 208. Updating and improving technical orders

You should always strive to improve your equipment and methods of doing things. To do this, your technical publications must also keep pace. TO changes, revisions, supplements, and rescissions keep these publications up to date. We all have the responsibility to ensure that the TOs we use are current and correct. As a result, you may find the need to change and update the information in these publications from time to time. The AFTO 22, *Technical Manual (TM) Change Recommendation and Reply*, is the tool you use to recommend changes in your TOs. If your TOs are not kept current, serious mishaps involving aircraft, support equipment, and personnel could occur. Let's discuss the different ways of updating your TOs to include revisions, changes, supplements, and rescissions.

### Revisions

A revision is a second or subsequent edition of a TO that supersedes (replaces) the preceding edition. A revision incorporates all previous changes, supplements and new data that would normally have required a separate update into the basic TO. A revision is normally issued when changed pages total 80 percent or more of the basic TO.

## Changes

Changes are issued when only parts of existing TOs are affected. The changed pages replace the corresponding numbered pages. Remove all replaced pages and discard them in accordance with the handling and destruction notice. When changes are received, check the complete change against the new listing on the List of Effective Pages (LOEP). This list is on the back of the title page, as shown in figure 1–12. Notice here that it says: “The portion of the text affected by the changes is indicated by a vertical line in the outer margins of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas.” Notice also that this location gives a code key to distinguish the original pages from the change pages and, in addition, gives the total number of pages in the TO. Just below there are two columns: Page No. and Change No. Look at page i-iii under the Page No. column; then follow the dotted lines across to the # Change No. column. You can see that those pages are original pages (change 0). Page 1–43 is not an original page because it was replaced by change 33.

**T.O. 1C-135(K)A-3-1**

**INSERT LATEST CHANGED PAGES. DESTROY SUPERSEDED PAGES.**

**LIST OF EFFECTIVE PAGES**

NOTE: The portion of the text affected by the changes is indicated by a vertical line in the outer margins of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas.

**Dates of issue for original and changed pages are:**

| | | | |
|---|---|---|---|
| Original ... 0 ... 30 Jan 87 | Change ... 16 ... 6 Jun 89 | Change ... 32 ... 27 Sep 91 | Change ... 48 ... 1 Feb 94 |
| Change ... 1 ... 19 Mar 87 | Change ... 17 ... 8 Aug 89 | Change ... 33 ... 22 Nov 91 | Change ... 49 ... 1 Apr 94 |
| Change ... 2 ... 1 Jun 87 | Change ... 18 ... 5 Oct 89 | Change ... 34 ... 14 Jan 92 | Change ... 50 ... 9 Jun 94 |
| Change ... 3 ... 20 Jul 87 | Change ... 19 ... 22 Dec 89 | Change ... 35 ... 5 Mar 92 | Change ... 51 ... 15 Jun 94 |
| Change ... 4 ... 7 Oct 87 | Change ... 20 ... 19 Jan 90 | Change ... 36 ... 30 Apr 92 | Change ... 52 ... 6 Jul 94 |
| Change ... 5 ... 2 Nov 87 | Change ... 21 ... 15 Feb 90 | Change ... 37 ... 1 Jun 92 | Change ... 53 ... 22 Dec 94 |
| Change ... 6 ... 9 Jan 88 | Change ... 22 ... 5 Apr 90 | Change ... 38 ... 3 Aug 92 | Change ... 54 ... 22 Feb 95 |
| Change ... 7 ... 13 Feb 88 | Change ... 23 ... 14 May 90 | Change ... 39 ... 14 Sep 92 | Change ... 55 ... 18 May 95 |
| Change ... 8 ... 22 Apr 88 | Change ... 24 ... 20 Jul 90 | Change ... 40 ... 16 Nov 92 | Change ... 56 ... 30 Jun 95 |
| Change ... 9 ... 17 Jun 88 | Change ... 25 ... 14 Sep 90 | Change ... 41 ... 5 Jan 93 | Change ... 57 ... 28 Aug 95 |
| Change ... 10 ... 22 Aug 88 | Change ... 26 ... 26 Oct 90 | Change ... 42 ... 1 Feb 93 | Change ... 58 ... 20 Sep 95 |
| Change ... 11 ... 23 Sep 88 | Change ... 27 ... 28 Feb 91 | Change ... 43 ... 15 Mar 93 | Change ... 59 ... 8 Nov 95 |
| Change ... 12 ... 9 Nov 88 | Change ... 28 ... 3 Apr 91 | Change ... 44 ... 15 May 93 | Change ... 60 ... 26 Feb 96 |
| Change ... 13 ... 6 Jan 89 | Change ... 29 ... 1 May 91 | Change ... 45 ... 18 Jun 93 | Change ... 61 ... 10 Apr 96 |
| Change ... 14 ... 24 Feb 89 | Change ... 30 ... 7 Jun 91 | Change ... 46 ... 31 Aug 93 | Change ... 62 ... 12 Jun 96 |
| Change ... 15 ... 20 Apr 89 | Change ... 31 ... 19 Jul 91 | Change ... 47 ... 15 Nov 93 | Change ... 63 ... 28 Aug 96 |

**TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 2172 CONSISTING OF THE FOLLOWING:**

| Page No. | *Change No. | Page No. | *Change No. | Page No. | *Change No. | Page No. | *Change No. |
|---|---|---|---|---|---|---|---|
| Title | 63 | 1-3 – 1-4 | 51 | 1-42 Blank | 13 | 1-72 | 62 |
| A – E | 63 | 1-4.1 | 61 | 1-43 | 33 | 1-72.1 | 62 |
| i – iii | 0 | 1-4.2 – 1-4.8 | 63 | 1-44 – 1-45 | 63 | 1-72.2 Blank Added | 14 |
| iv | 55 | 1-4.9 Added | 63 | 1-46 – 1-48 | 44 | 1-73 | 14 |

**Figure 1–12. Technical order list of effective pages.**

## Supplements

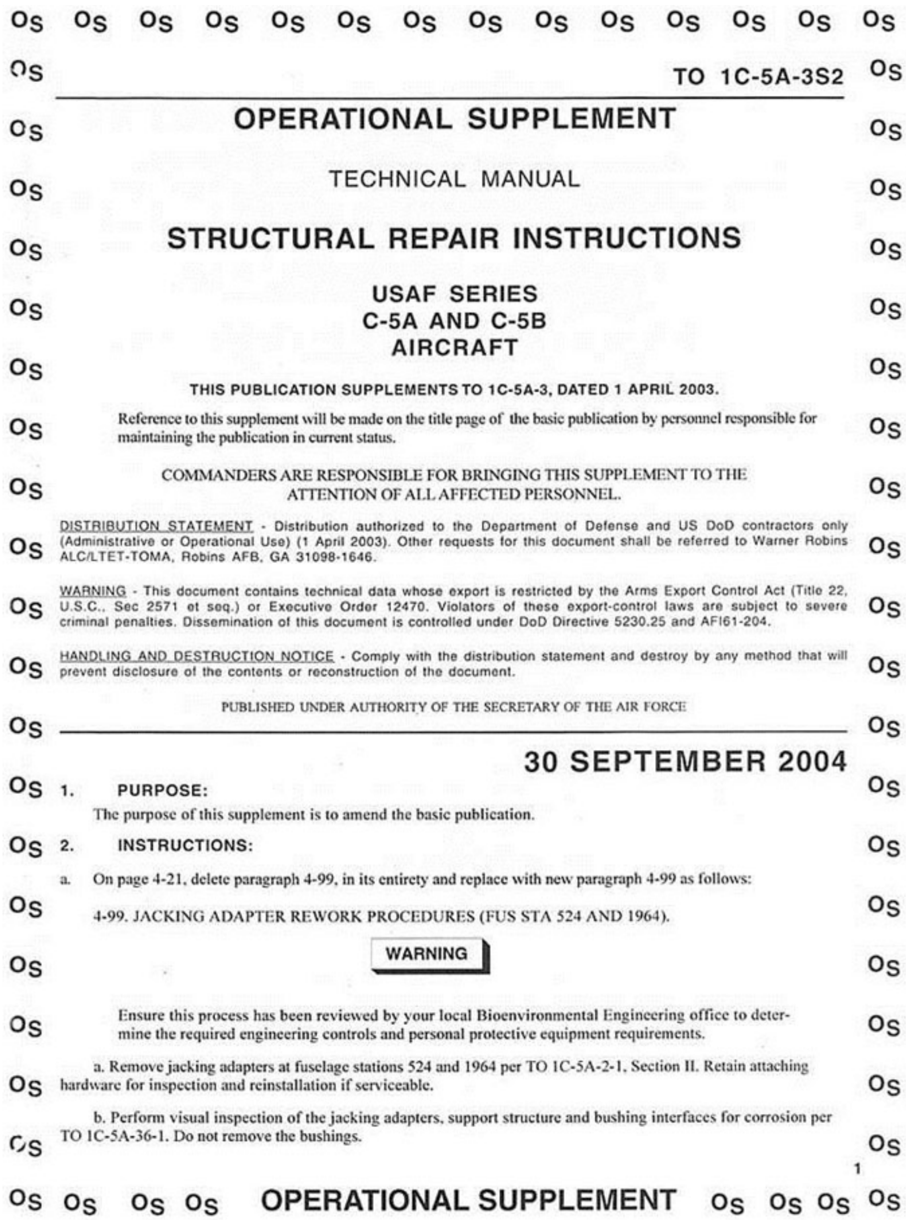
Supplements are issued as separate TOs to augment or change data in basic TOs when the added material may not fit into the basic TO very well. The types of supplements include routine, operational, and safety. Depending upon which type of supplement it is will also determine whether it will get filed either in front of the basic TO or behind it.

### *Routine*

Routine supplements are identified by the word “supplement” and an alphabetical suffix to the basic publication number. The first supplement normally begins with the suffix letter C. These are filed to the rear of the basic publication in alphabetical order. Also, the supplement letter that can be found on the supplement title page is written on the title page of the basic TO.

### *Operational*

The same format used in routine supplements also applies to operational supplements, except that the first (title) page is printed with a border of black “OS”s, with the words operational supplement at the top and bottom of the page, and with all other information appearing in black. The supplement number contains a single digit (fig. 1–13).



TO 1C-5A-3S2

OPERATIONAL SUPPLEMENT

TECHNICAL MANUAL

STRUCTURAL REPAIR INSTRUCTIONS

USAF SERIES
C-5A AND C-5B
AIRCRAFT

THIS PUBLICATION SUPPLEMENTS TO 1C-5A-3, DATED 1 APRIL 2003.

Reference to this supplement will be made on the title page of the basic publication by personnel responsible for maintaining the publication in current status.

COMMANDERS ARE RESPONSIBLE FOR BRINGING THIS SUPPLEMENT TO THE ATTENTION OF ALL AFFECTED PERSONNEL.

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PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

30 SEPTEMBER 2004

1. PURPOSE:

The purpose of this supplement is to amend the basic publication.

2. INSTRUCTIONS:

a. On page 4-21, delete paragraph 4-99, in its entirety and replace with new paragraph 4-99 as follows:

4-99. JACKING ADAPTER REWORK PROCEDURES (FUS STA 524 AND 1964).

WARNING

Ensure this process has been reviewed by your local Bioenvironmental Engineering office to determine the required engineering controls and personal protective equipment requirements.

a. Remove jacking adapters at fuselage stations 524 and 1964 per TO 1C-5A-2-1, Section II. Retain attaching hardware for inspection and reinstallation if serviceable.

b. Perform visual inspection of the jacking adapters, support structure and bushing interfaces for corrosion per TO 1C-5A-36-1. Do not remove the bushings.

1

OPERATIONAL SUPPLEMENT

**Figure 1–13. Operational supplement.**

### *Safety*

Safety supplements are identified by the first (title) page printed with a border of red “SS”s and with other important information in red. The words SAFETY SUPPLEMENT appears at the top and bottom of the title page. The supplement number will contain two “S”s, as shown in figure 1–14. Safety and operational supplements are both filed in *reverse numerical sequence* and placed in front of the basic TO. When safety and operational supplements have the same date, the safety supplement is filed in front.

TO 00-105E-9SS-1

**SAFETY SUPPLEMENT**

TECHNICAL MANUAL

**AEROSPACE EMERGENCY RESCUE AND MISHAP RESPONSE INFORMATION (EMERGENCY SERVICES)**

THIS PUBLICATION SUPPLEMENTS TO 00-105E-9 REVISION 10, DATED 1 MAY 2005, LOCATED AT WEB SITE: **http://www.robins.af.mil/logistics/LGEDA/Documents/to00-105e-9.htm**.

DISTRIBUTION STATEMENT - Approved for public release; distribution unlimited.

COMMANDERS ARE RESPONSIBLE FOR BRINGING THIS SUPPLEMENT TO THE ATTENTION OF ALL AFFECTED AIR FORCE PERSONNEL.

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

**19 MAY 2005**

1. PURPOSE.
This supplement provides instructions for update of TO 00-105E-9 Revision 10, dated 1 May 2005, affecting Chapter 8, Fighter Aircraft. This supplement is an updated file for the latest information regarding the F-117A aircraft procedures.

2. INSTRUCTIONS.
a. This information, formated in PDF, can be downloaded and printed from this web site by the end user. Use the most current Adobe Reader for this function, available free from Adobe.com.

b. This supplement to Chapter 8 updates information based on newly researched source data information regarding this aircraft. The new file update should be added to Chapter 8 in TO 00-105E-9 Revison 10. The end user should save this file and print the affected pages, if applicable to the user's operation. File a copy of this Safety Supplement with the main Technical Order according to current regulations.

NOTE

This information should also be included in mobility boxes where applicable. If your unit or a part of your unit is serving elsewhere, they should be informed of this Safety Supplement and how to obtain it. See TO 00-5-2 paragraphs 1-1.4, 1-1.4.1, and 1-1.6 for Local Reproduction of TOs and Digital Media guidance.

THE END

1

**SAFETY SUPPLEMENT**

**Figure 1–14. Safety supplement.**

## Rescissions

TOs are rescinded (canceled) when the information is no longer required. The material may have been incorporated in other publications or it may no longer be needed. A good example is a TCTO with an automatic rescission date. Do not remove publications from the files until they are listed as rescinded in the TO indexes.

## Technical order improvement

The AFTO 22, *Technical Manual (TM) Change Recommendation and Reply,* is the form used to recommend improvements and correct errors to technical orders. Mistakes will occasionally be found in these publications. As you gain expertise with using the equipment (and with the TOs relating to the equipment), you may very likely discover areas for improvements in the applicable TOs. Any person discovering a condition requiring a change to a TO can (and should) submit an improvement recommendation. The result of an approved recommendation can correct an error, insert an omitted technical fact, or standardize improved procedures for all personnel Air Force wide.

TO 00–5–1, *Air Force Technical Order System*, provides detailed instructions for preparing and submitting an AFTO 22. Read the section about the form and follow the instructions step-by-step when you prepare a report, particularly the first few you prepare. After you submit a report or two, preparing them will be a simple matter.

If you find yourself making a correction to IMIS or ALIS, the steps and procedures listed below are essentially the same. The difference is that instead of using an AFTO form 22 you will us your IMIS terminal and follow the links and steps to fill out a Technical Order Data Correction Request (TODCR) as shown in figure 1–15. If you use ALIS, follow the links to submit an action request.

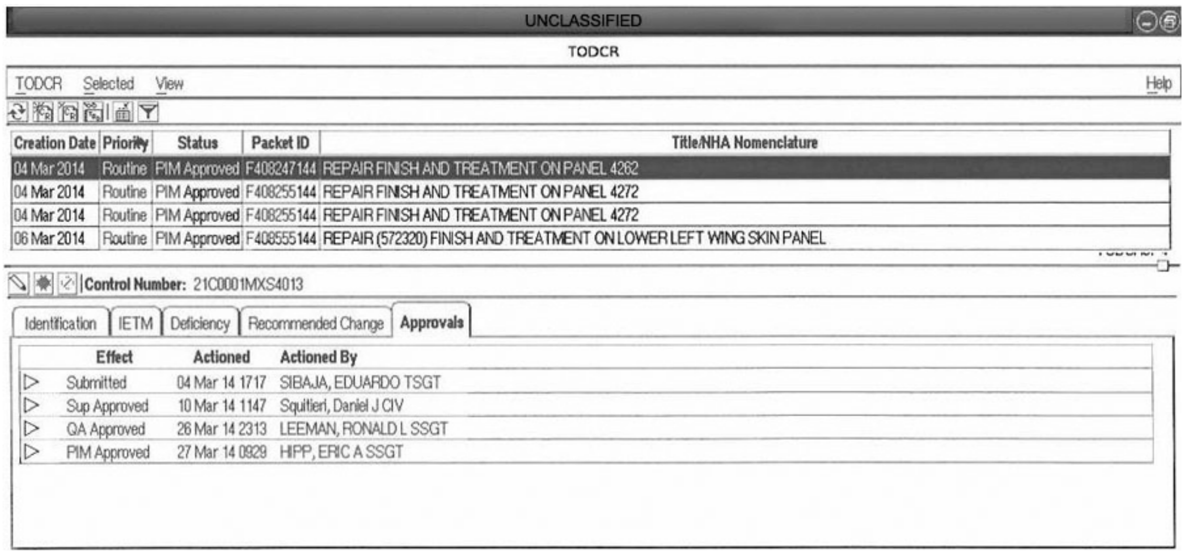


**Figure 1–15. IMIS TODCR.**

### *Criteria for submission*

There are specific types of publications and problems that are not approved topics for an AFTO IMT 22. Do not submit an AFTO 22 if the discrepancies are found in any of the following:

- New types of TOs.
- Computer system hardware or software problems.
- Preliminary TOs.
- Flight manual program publications.
- SMR code changes.
- Calibration responsibility determination.
- Contractor data.
- Classification recommendations.

After determining the recommendation is applicable to the TO improvement reporting system, the recommendation must be evaluated. Prior to submittal, the recommended change will be assessed in terms of the following criteria:

- Mission impact.
- Personnel and aerospace system safety.

- Damage to equipment.
- Work simplification.
- Urgency of need for change.
- Manpower savings.

### *Submission requirements*

The supervisor of the person submitting an improvement report must make sure the report is valid and warrants submittal. Both the initiator and the initiator's supervisor must be listed on the form. Copies of all reports that are determined valid must be sent to the local product improvement (PI) office, Quality Assurance (QA) office, or other responsible organization for review and approval. The reviewing activity will forward approved recommendations to the command control point. There are several categories of recommendations in which a report can be submitted according to the seriousness and urgency of the report.

#### *Emergency recommendations*

Emergency recommendations require immediate action on a TO deficiency which, if not corrected, *would* result in a fatality or serious injury to people, extensive damage, destruction of equipment or property, or inability to achieve or maintain operational posture (*MISSION ESSENTIAL*) including field-level work stoppage.

#### *Urgent recommendations*

Urgent reports are submitted for TO deficiencies that, if not corrected, *could* cause one or more of the following: personnel injury, damage to equipment or property, reduced operational efficiency, and/or could jeopardize the safety or success of mission accomplishment. Submit changes that could result in over $25,000 or 1,000 man-hours annual savings as urgent. Also, all technical TCTO deficiencies are submitted as urgent.

#### *Routine recommendations*

Routine recommendations require action on TO deficiencies, which do not fall into the emergency or urgent categories.

### *Method of submission*

The AFTO IMT 22 requires entries at each office or organization that handles the form. This list shows the major stopping points from the time a discrepancy is reported until a system manager for evaluation receives an AFTO IMT 22. Stopping point action includes the following:

- Initiator or person who finds the discrepancy.
- Supervisor validates the form.
- PI office responsible for review and approval for the organization to which the initiator is assigned.
- MAJCOM to which initiator is assigned (AMC, ACC, etc.).
- ALC Air Logistics Center (TO manager) listed in the TO Catalog.

### *Technical order data correction request*

TODCRs are automated forms used correct the tech date. The form is filled out similarly to Form 22 but the data is all in IMIS or ALIS.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 205. Using different types of technical orders

1. What are the five major TO types that you will use most?

2. Where would you look to get a complete list of the technical orders required for a specific weapons system or piece of equipment?

3. What type of information is found in O&M TOs?

4. What do you do in case of a conflict between procedures in general TOs and AFOSH standards?

5. What is the function of MPTOs?

6. Which TO category includes the inspection WC and CL?

7. What are the three main types of TCTOs?

8. When is an immediate action TCTO issued?

### 206. Using the technical order numbering system

1. What are TO numbers used for?

2. What does the first group of numbers in the basic technical order numbering system identify?

### 207. Using the illustrated parts breakdown

1. What are the three sections of the IPB?

2. What section of the IPB contains a breakdown list of equipment major assemblies?

### 208. Updating and improving technical orders

1. What are the four methods used to keep TOs current?

2. On what page do you check for changes to a TO?

3. What are the three types of TO supplements?

4. How are operational and safety supplements filed?

5. What form do you use to recommend improvements to TOs?

6. What type of TO improvement report would you submit for TO deficiencies that, if not corrected, *could* cause personnel injury, damage to equipment or property, reduced operational efficiency, and/or could jeopardize the safety or success of mission accomplishment?

## Answers to Self-Test Questions

**201**

1. It is known as the repair cycle processing tag; it is attached to items that are determined to be reparable and are being forwarded to other activities for repair.
2. It is the section located below the perforation; it is used as a production scheduling document.
3. TO 00–20–2.
4. Blocks 1 through 14, and 15A.
5. Blocks 16, 17, and 18.

**202**

1. Before the machine is used for the first time on any given day.
2. Chaffing, dry-rot, cracks, or excessive wear.
3. Air Force directives or approved commercial data.
4. 400.
5. AFTO Form 244.
6. III.
7. Red X,
8. By placing a Red Dash (–) in the symbol block.

**203**

1. To reduce the possibility of errors caused by someone's misinterpretation.
2. First name initial, complete last name, and employee number.
3. Two signatures are required.
4. Any person who determines the discrepancy is more serious.
5. The aircraft is considered unsafe or unfit for flight, and it must not be flown until this unsatisfactory condition has been remedied.
6. From the upper right hand corner to the lower left hand corner of the appropriate block.

**204**

1. 781K.
2. Red Xs.
3. Calendar inspection items to be inspected or tested at a specified hourly or calendar period.
4. 781H.
5. Serves as a ready reference to the servicing, maintenance, and inspection history.
6. Prior to the next flying period.
7. It serves as a document for maintaining a permanent history of significant maintenance actions on end items of SE, training equipment, and certain components designated by the item manager, MAJCOM, or group commander.

**205**

1. (1) Index type.
   (2) O&M.
   (3) MPTO.
   (4) Abbreviated.
   (5) TCTO.
2. LOAP.
3. Installation procedures, operation, troubleshooting, repairing, calibration, servicing or handling of Air Force military systems and end items.
4. Follow the more restrictive requirement.

5. To establish policies and prescribe procedures relating to such subjects as the TO system, preventive maintenance, scheduled inspections of equipment, maintenance management information, historical status, and configuration accounting documentation.
6. Abbreviated TOs.
7. Immediate action, urgent action, and routine action.
8. Under governing factors of safety conditions, the uncorrected existence of which could result in fatality or serious injury to personnel or extensive damage to or destruction of valuables.

**206**

1. To categorize TO data, provide a sequence for filing, and determine and order what is needed in a particular TO library.
2. The number identifies the category, and the letter identifies the basic mission or type of equipment.

**207**

1. Introduction, group assembly parts list, and numerical index.
2. Section II.

**208**

1. Changes, revisions, supplements and rescissions.
2. LOEP.
3. Routine, operational, and safety.
4. In reverse numerical sequence and placed in front of the basic TO. When safety and operational supplements have the same date, the safety supplement is filed in front.
5. AFTO Form 22.
6. An Urgent report.

**Do the unit review exercises before going to the next unit.**

## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

**Do not return your answer sheet to Air Force Career Development Academy (AFCDA).**

1. (201) To find a block-by-block explanation of how to document the Air Force Technical Order (AFTO) Form 350, you would use
   a. Air Force Manual (AFMAN) 23–110 Basis USAF Supply Manual.
   b. Technical Order (TO) 00–20–2 Aerospace Equipment Maintenance Inspection Documentation, Policies and Procedures.
   c. Air Force Instruction (AFI) 21–101Aircraft and Equipment maintenance Management.
   d. TO 00–5–1AF Technical Order System.

2. (201) Blocks 1 through 14 of the Air Force Technical Order (AFTO) 350 tag are completed by the
   a. originator.
   b. production scheduler.
   c. base supply technician.
   d. repair processing center.

3. (202) When is periodic equipment lubrication completed?
   a. Daily.
   b. During supervisory review.
   c. During scheduled inspection.
   d. During prior-to-use inspection.

4. (202) What section of the Air Force Technical Order Form 244 do you use to document *equipment discrepancies*?
   a. I.
   b. III.
   c. IV.
   d. V.

5. (202) When documenting equipment discrepancies, what does a *Red X* denote on an Air Force Technical Order (AFTO) Form 244, Industrial/Support Equipment Record?
   a. Unsafe condition.
   b. Unknown condition.
   c. Safe for use condition.
   d. Unsatisfactory condition.

6. (202) You need to denote an unsatisfactory, but useable, equipment condition. Which symbol on an Air Force Technical Order (AFTO) Form 244, Industrial/Support Equipment Record will you use?
   a. Red X.
   b. Red Dash (–).
   c. Red Diagonal (/).
   d. Black, last name initial.

7. (203) To sign an entry on most aircraft forms, the minimum signature that you would give is
   a. last name initial, and employee number.
   b. complete last name, and employee number.
   c. complete first name, last name initial, and employee number.
   d. first name initial, complete last name, and employee number.

8. (203) A symbol entered on an aircraft maintenance form reflects the opinion of the
   a. shop supervisor.
   b. maintenance officer.
   c. squadron commander.
   d. individual making the entry.

9. (204) If a discrepancy is carried forward to a new Air Force Technical Order (AFTO) Form 781A, who enters the page number, item number, and date of the new form, and signs in the TRANSFERRED BY block?
   a. Crew chief.
   b. Flight chief.
   c. Superintendent.
   d. Commander.

10. (204) What Air Force Technical Order (AFTO) Form is titled Aerospace Vehicle Inspection, Engine Data, Calendar Inspection and Delayed Discrepancy Document?
    a. 781A.
    b. 781H.
    c. 781J.
    d. 781K.

11. (204) Who is authorized to sign the *EXCEPTIONAL RELEASE* block of the Air Force Technical Order (AFTO) Form 781H?
    a. Crew chief.
    b. Shop chief.
    c. Senior NCO.
    d. Shift supervisor.

12. (205) Which is *not* one of the five major types of technical orders (TO) authorized for use in the Air Force?
    a. Operations and methods technical order.
    b. Time compliance technical order.
    c. Abbreviated technical order.
    d. Index type technical order.

13. (205) Which technical order (TO) category includes the inspection workcard and checklist?
    a. Operations and maintenance.
    b. Time compliance.
    c. Abbreviated.
    d. Index type.

14. (205) Which type of time compliance technical order (TCTO) is signified by a series of red Xs printed around the border of the first page?
    a. Urgent.
    b. Routine.
    c. Inspection.
    d. Immediate.

15. (206) What type of technical order (TO) does the number 1F–16C–06 represent?
    a. List of affected pages.
    b. Work unit code manual.
    c. Maintenance instructions.
    d. Illustrated parts breakdown.

16. (207) In what part of the illustrated parts breakdown (IPB) would you look if you wanted to find a list of equipment broken down into major assemblies and subassemblies?
    a. Introduction.
    b. Numerical index.
    c. Group assembly parts list.
    d. Reference designation index.

17. (208) A revision to a publication is normally issued when the changes exceed at least what percentage of the basic technical order (TO)?
    a. 50 percent.
    b. 60 percent.
    c. 70 percent.
    d. 80 percent.

**Please read the unit menu for unit 2 and continue ➔**

# Unit 2. Airframe Assessment



IN THE FIRST PART OF THIS UNIT, we discuss aircraft construction. When you're familiar with aircraft construction features, you know how and where to inspect for damage. In this unit we will discuss damage inspections and in a later volume we will discuss another very important type of inspection, the corrosion inspection. In the second half of this unit we will discuss damage and repair classifications and finish up with how to determine repair procedures.

## 2–1. Inspections

Determining which of the different aircraft inspections and techniques are required depends on many factors. The information in this section will provide you with knowledge you will need to conduct a thorough and effective inspection. The lessons include aircraft construction features and damage inspections.

### 209. Aircraft structural design

The structural design of an aircraft is determined by aerodynamic factors in combination with the planned use of the aircraft. This lesson includes information about major assemblies, flight controls, structural components, and reference lines. This information is an integral part of your "tool set" for accomplishing your structural maintenance responsibilities.

#### Major assemblies

No matter how the aircraft is designed or used, all load stresses during flight and at rest are absorbed by the aircraft structure or frame. The major assemblies are the fuselage, wings, engines, landing gear, and empennage (fig. 2–1).

##### *Fuselage*

The word "fuselage" originated during aviation development in France and is still used to designate the "body portion" of an aircraft. This is the main structural assembly to which the other assemblies are directly or indirectly attached.

The mission design, or the purpose for which the aircraft was built, determines the size, shape, and accommodations of the fuselage. For example, the fuselage of a bomber is built to carry and discharge a load of bombs. The fuselage of a cargo/transport aircraft is designed to carry various types of cargo or is furnished for the comfort of passengers. The fuselage of a fighter aircraft houses the crew, armament, and other equipment. It may or may not house the engines.

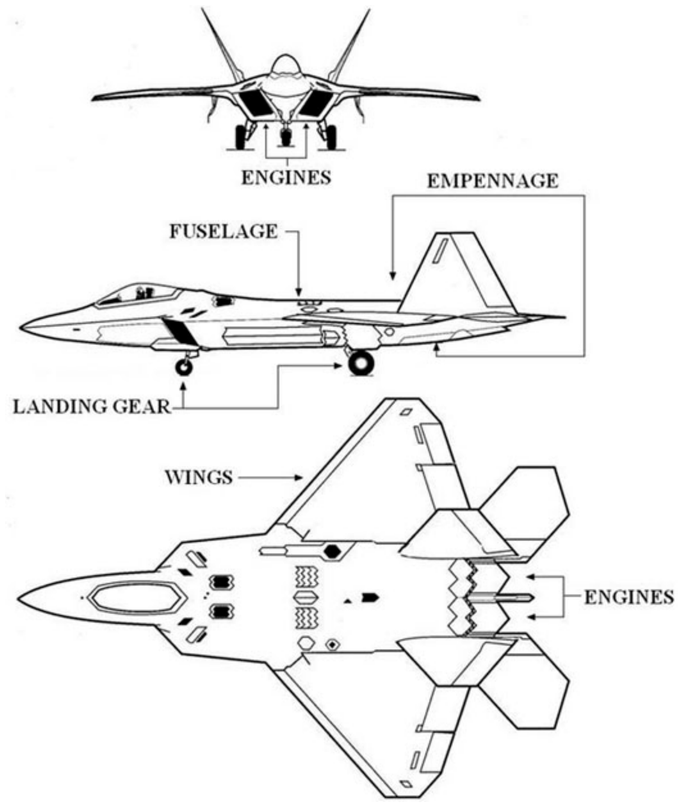


**Figure 2–1. Major assemblies of aircraft.**

### *Wings*

Aircraft wings are primarily designed to provide lift to the aircraft, but they also stabilize it along its longitudinal axis and support it during flight. Wings are described as high, low, and midwing, depending on the point of their attachment to the fuselage. A remarkable development in wing structure design is the ability of a wing to be moved back and forth during flight (i.e., the wings on the B–1B can be swept back, or streamlined, to reduce drag and, thus, increase aircraft speed). Another recent development in wing structure design is used on the CV–22 Osprey aircraft, where the wing and attached turboprop engines can be tilted upward for vertical takeoff, and then moved into a horizontal position for forward flying.

### *Engines*

Engines provide the power for the forward thrust of the aircraft. The different types of engines are reciprocating, turbojet, and turboprop. In reciprocating and turboprop engines, thrust is achieved by a propeller. In turbojet (and turbofan) engines, the compression of intake gases and the expansion of exhaust gases produce thrust.

The design of the aircraft will determine where the engines are located. On large cargo type and bomber aircraft the engines are mounted to the wings in what are called nacelles. Nacelles are separate enclosures or housings that streamline and protect parts of the engine. The engine nacelles on jet aircraft are sometimes called pods. On fighter aircraft such as the F–15 and F–16 the engines are attached to the fuselage.

With the development of low observable aircraft came the “burying” of the engines to minimize any detectable signature source as much as possible. Cavities such as engine inlets, engine exhaust or auxiliary power unit exhaust ports can be significant radar scattering sources. This scattering may be reduced, as on the B–2, by masking the cavities by other parts of the aircraft structure. The cavity may also be lined with radar absorbent material (RAM) to absorb energy as it bounces, or by snaking the duct, so that the radar energy bounces more and therefore deteriorates.

### *Landing gear*

The landing gear (fig. 2–2) provides a means for the aircraft to take off and land, and provides support and directional control of the aircraft while on the ground. During landing and taxiing, the gear also provides a cushioning effect that absorbs shock. The forward gear is referred to as the "nose landing gear", while the aft gear is called the "main landing gear." Most aircraft have retractable landing gear to prevent excessive drag friction during flight. However, some aircraft still have fixed landing gear. Examples of this are some helicopters and unmanned aircraft systems (UAS).

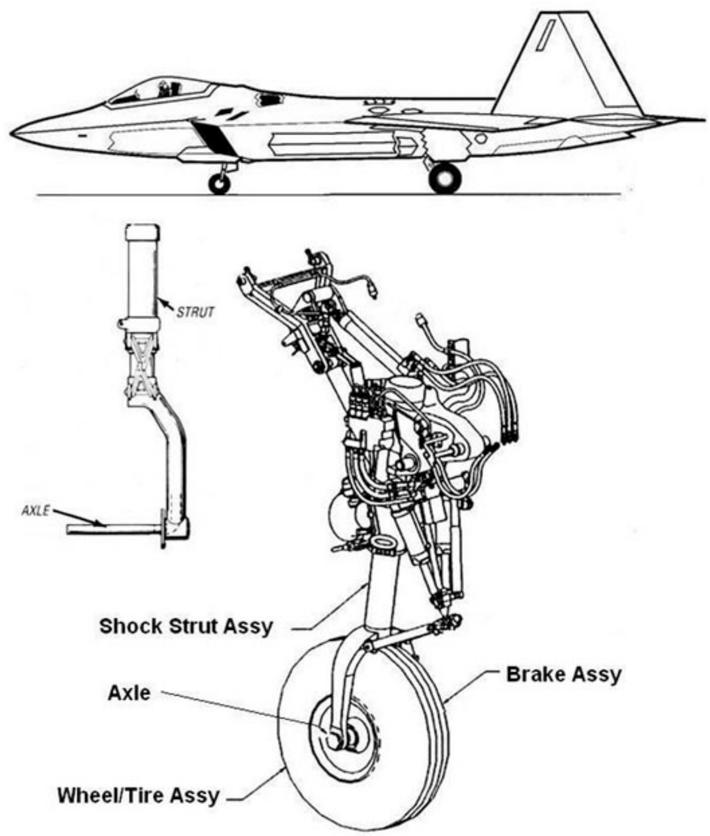


**Figure 2–2. F–22 landing gear.**

### *Empennage*

The empennage is the aircraft's aft section or tail. It is usually composed of vertical and horizontal stabilizers with attaching control surfaces. The *vertical stabilizer* is a fixed wing-like structure attached in a vertical position at the aft end of the fuselage. Its purpose is to reduce the swaying motion (yaw) about the vertical axis of the aircraft.

The *horizontal stabilizer* is usually a fixed wing-like structure also attached to the aft section of the fuselage. It extends horizontally to the right and left to reduce the up and down motions (pitch) of the empennage about the lateral axis of the aircraft.

You will notice that the empennage sections of low observable aircraft are somewhat different compared to those of traditional legacy aircraft. These design modifications were necessary to reduce the overall radar signature of the aircraft by reducing the amount of radar reflective surfaces. Certain shapes present bigger radar cross sections (RCS) than others; the ones that give off the biggest are corner reflectors. Corner reflectors are flat surfaces that make 90° corners. In most aircraft, the empennage (tail section) and wings form corner reflectors with the fuselage. This is why the "vertical" stabilizers of the F–22 and F–35 are slanted and the designers of the B–2 just did away with the vertical stabilizer all together.

## Aircraft flight controls

The classification of a flight control surface depends on the aircraft for which it was designed. Aircraft flight control systems consist of primary and secondary systems. The ailerons, elevator (or stabilator), and rudder constitute the primary control system and are required to control an aircraft safely during flight. Wing flaps, leading edge devices, spoilers, and trim tabs constitute the secondary control system and improve the performance characteristics of the airplane or relieve the pilot of excessive control forces.

### *Primary flight controls*

Movement of any of the three primary flight control surfaces (ailerons, elevator or stabilator, or rudder), changes the airflow and pressure distribution over and around the airfoil. These changes affect the lift and drag produced by the airfoil/control surface combination, and allow a pilot to control the aircraft about its three axes of rotation.

#### *Ailerons*

Ailerons (fig. 2–3) are attached to the outboard trailing edge of the wing and are hinged so they can move up or down. The up and down movement of the ailerons is what controls the roll of the aircraft. Lowering the aileron on one wing automatically raises the aileron on the opposing wing. As the cockpit control is moved to the right, the right aileron moves up and the left aileron moves down. The right wing (with the raised aileron) moves down because of the decreased lift, and the opposite wing (with the lowered aileron) moves up because of the increased lift. The aircraft rolls to the right around the longitudinal axis. For a roll to the left, the left aileron moves up and the right aileron moves down.

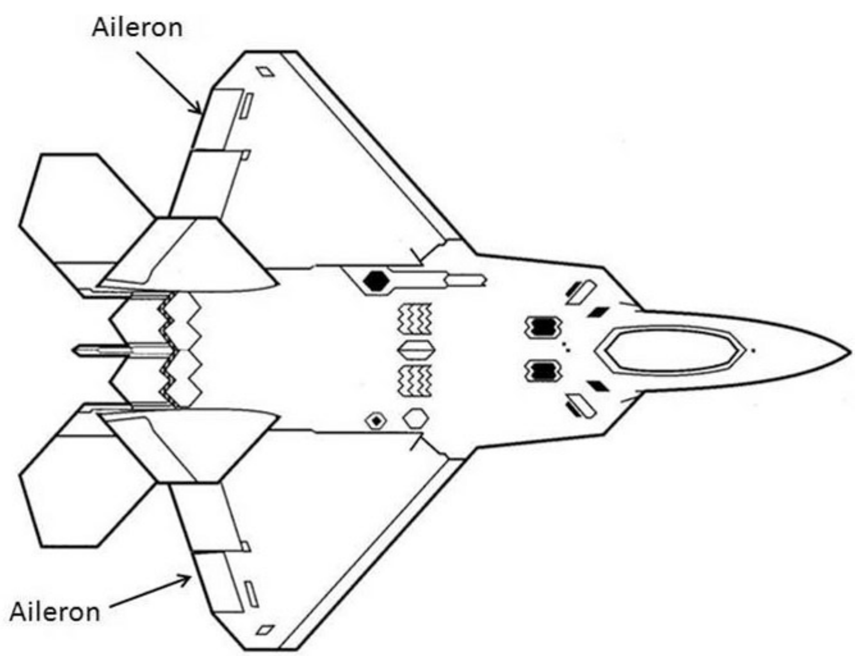


**Figure 2–3. Ailerons.**

### *Elevators*

Elevators are attached to the trailing edge of the horizontal stabilizer and are hinged to move up and down. Elevators control pitch. Pushing the cockpit control forward moves the elevator down; if the control is pulled back, the elevator moves up. With the elevator up, there's less lift because of an increase in drag. As a result, the tail of the aircraft is forced downward and the aircraft climbs. To nose the aircraft down, the opposite actions take place. Pushing the control forward moves the elevator down. This forces the aircraft tail up, resulting in a nose-down position.

### *Stabilators*

A stabilator is a horizontal stabilizer and elevator built as one piece. The stabilator controls pitch just like an elevator, but the whole stabilizer moves instead of just the trailing edge. Figure 2–4 shows a stabilator on an F–22 aircraft.

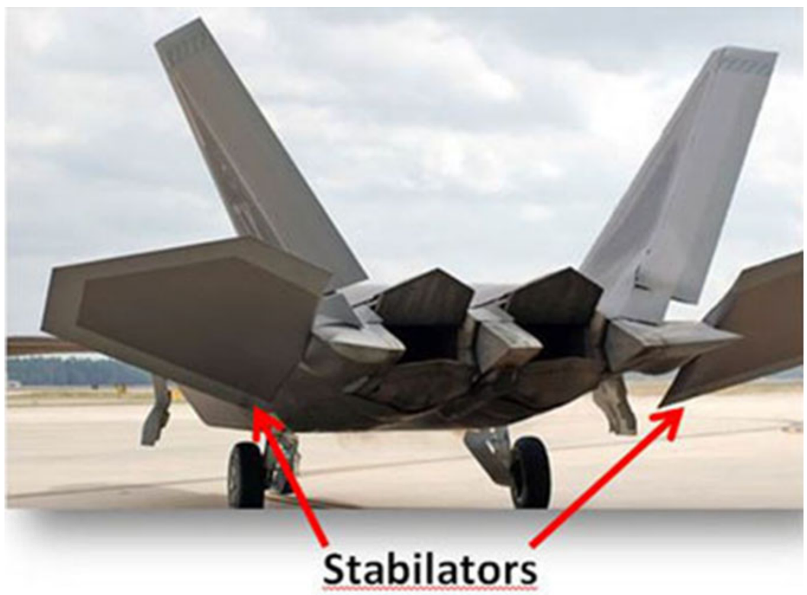


**Figure 2–4. F–22 stabilator.**

### *Rudders*

Rudders (fig. 2–5) are attached to the trailing edge of the vertical stabilizer to provide movement (yaw) around the vertical axis. The pilot controls the rudders by depressing the rudder pedals. Depressing the right rudder pedal makes the rudder deflect to the right and moves the tail section to the left around the vertical axis in a turn to the right. To make a left turn, the pilot depresses the left pedal.

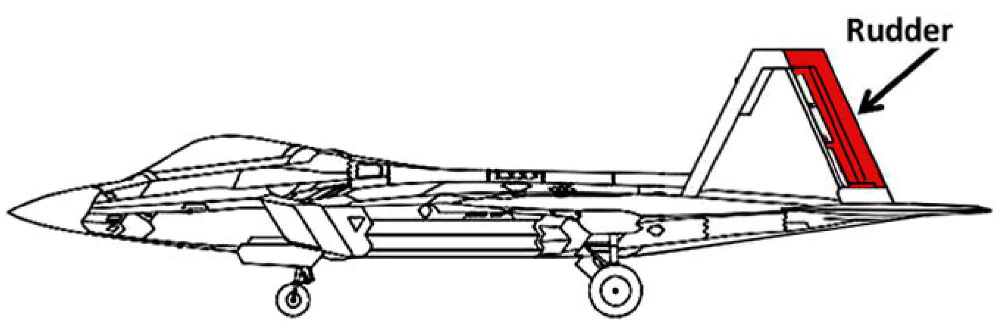


**Figure 2–5. F–22 rudder.**

### *Secondary flight controls*

Other control surfaces used on some aircraft are called *secondary surfaces*. Some of these are flaps, tabs, spoilers, and slats.

| **Auxiliary Flight Controls** | |
|---|---|
| **Assembly** | **Description** |
| Flaps | Flaps are part of the inboard trailing edge of the aircraft wing. They're hinged or pivoted so they can be lowered to control the lift and drag of the wings, letting the airplane dive or glide at a steeper angle and at lower airspeeds than would otherwise be possible. Thus, the airplane's landing approach and landing run are effectively shortened. The increased lift is also used for taking off, if it's necessary to shorten the takeoff run. |
| Tabs | Tabs are small airfoils in the trailing edge of the control surfaces that aid and position these surfaces in flight. Tabs are usually controlled electrically or mechanically from the cockpit. The most common tabs on today's aircraft are trim tab and servo-tab types. |
| Spoilers | On some aircraft, spoilers serve as airbrakes by raising an equal amount of spoiler surface on each wing, thus increasing drag and slowing the aircraft. They're also used to kill (spoil) the lifting force when the aircraft is on the ground in a high wind. |
| Slats | The wing slats used on some aircraft are airfoils attached to the leading edge of each wing by tracks and rollers. They operate automatically to reduce the aircraft's stalling speed as a result of the air pressure on them. At high speed, they're fully retracted with the leading edge of the wing; but as the aircraft approaches stalling speed, they move forward and create an opening between themselves and the wing. This increases wing lift, and the airplane can operate at a lower airspeed before stalling. |

### Structural components

Your job as an aircraft structural maintainer requires you to know and be familiar with the structural components of the aircraft. Figure 2–6 illustrates underneath the skin where you will find the frame work, or substructure, of the aircraft and each component is important to the structural integrity. The structural components of the fuselage and the wings vary slightly so we will cover them separately.

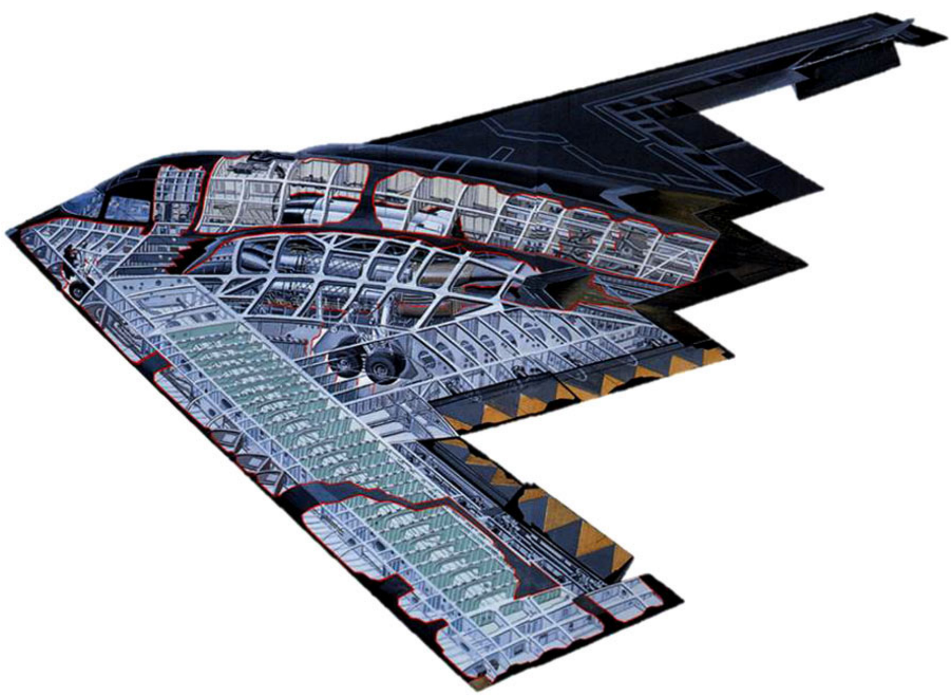

**Figure 2–6. Substructural components.**

### *Fuselage*

The structural components found in the fuselage are longerons, stringer, bulkheads (to include formers and rings), and the skin.

| Fuselage Structural Components | |
|---|---|
| **Assembly** | **Description** |
| Longerons | Longerons (fig. 2–7) are the main lengthwise members of the fuselage. They're the *longest and strongest* structural members of the fuselage, and are primarily designed to add strength. They run from the nose of the fuselage to the empennage. |
| Stringers | Stringers (fig. 2–7) are found throughout the aircraft, mainly as lengthwise members that are smaller and lighter than longerons and serve as fill-ins. They provide some rigidity, but their chief use is to *give shape* to the aircraft and provide a means for attaching the skin to the structure. Stringers are also found in the wing. |
| Bulkheads | Bulkheads (fig. 2–8), are circular members that give cross-sectional shape to the fuselage, and add strength and rigidity to the structure. Bulkheads that separate one area from another are solid and sometimes are equipped with doors for access. |
| Formers | Formers (fig. 2–8) resemble incomplete bulkheads or ribs, and are the most numerous structural units. They help to keep the shape of the fuselage, give attachment points for the skin, and add rigidity to the aircraft. |
| Rings | Rings (fig. 2–8) are lighter than bulkheads and formers and are positioned in between formers to aid in the load carrying ability of the airframe. |
| Skin | The skin is the outside covering of an aircraft. The metals used vary for different aircraft. Some skins, especially on fighter aircraft, are a stressed, load-carrying part of the aircraft frame. Most aircraft have an aluminum alloy skin, but titanium and corrosion-resistant steel (CRES) are used on some sections.<br>Honeycomb panels are also used in aircraft construction (fig. 2–9). A honeycomb panel is a sandwich panel with a honeycomb core. The upper and lower surfaces are metal sheets thermobonded to the core. This type of structure gives maximum strength at minimum weight.<br>Today's high-performance aircraft use more nonmetallic skins, called composites, made of high-strength fiber and resin combinations. The most common composites are epoxy/graphite, epoxy/boron, and epoxy/aramid structures. Used correctly, composites result in a lighter than metal skin with greater strength properties. Again, there are numerous types of composites.<br>TO 1–1–690, *General Advanced Composite Repair Manual,* has more information on composite design and use. |

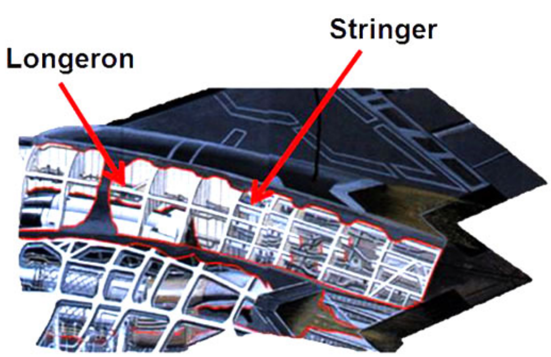


**Figure 2–7. B–2 Substructural components - longeron.**

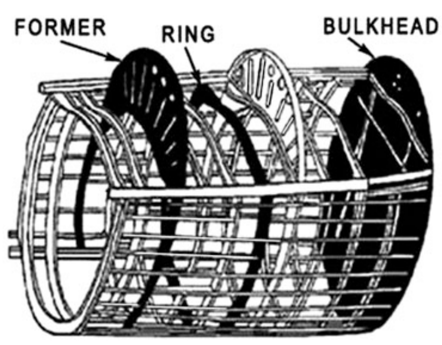


**Figure 2–8. Substructural components - bulkhead.**

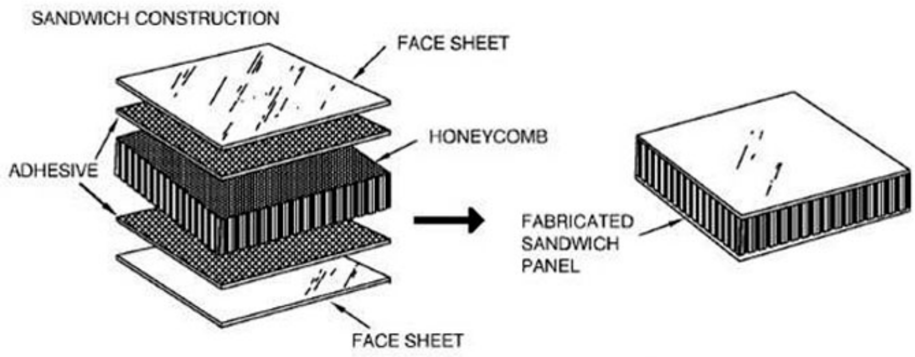


Figure 2–9. Construction of honeycomb skin

### *Wings*

The wings also have stringers and skin, but have spars and ribs instead of longerons and bulkheads. Figure 2–10 shows the different structural components of the wing.

| Wing Structural Components | |
|---|---|
| **Assembly** | **Description** |
| Spars | Spars (fig. 2–10) are the main lengthwise structural members of the wings, providing a high degree of strength. They can also be found in the empennage. |
| Stringers | Stringers (fig. 2–10) are lengthwise members that are smaller and lighter than the spars and serve as fill-ins. They perform the same functions as the stringers in the fuselage. |
| Ribs | Ribs (fig. 2–10) serve a dual purpose: providing contour or shape to the wing, and adding rigidity and cross sectional strength to the structure. |
| Skin | Wing skins (fig. 2–10) are made from the same materials and serve the same purpose as the skin on the fuselage. |

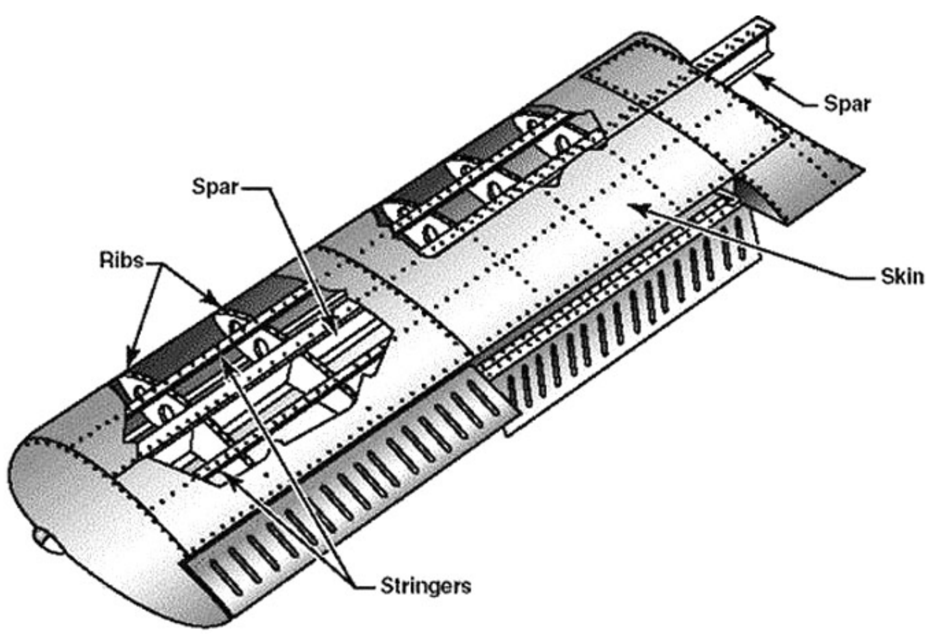


Figure 2–10. Wing construction components.

## Reference lines

Reference lines (fig. 2–11) are used to locate an area on an aircraft. Reference lines represent a plane cutting the aircraft at a particular location. A reference line's number represents its distance in inches from a zero point. Particular aircraft may require other reference lines, but the main ones are described in the following table.

| Reference Lines | |
|---|---|
| **Nomenclature** | **Description** |
| Fuselage Station (FS) | FS lines indicate the longitudinal position of vertical planes perpendicular to the plane of symmetry. They are measured in inches forward and aft of station zero. |
| Waterlines (WL) | WL indicate horizontal planes parallel to the ground line. Waterlines measured above WL 0.000 are positive, while those measured below are negative. |
| Buttock Lines (BL) | BL indicate vertical planes parallel to the plane of symmetry. The plane of symmetry is a vertical plane through the longitudinal centerline of the aircraft. |
| Wing Stations (WS) | WS represent vertical planes perpendicular to a predetermined wing reference plane. |
| **NOTE:** The same reference lines are not common to all aircraft. | |

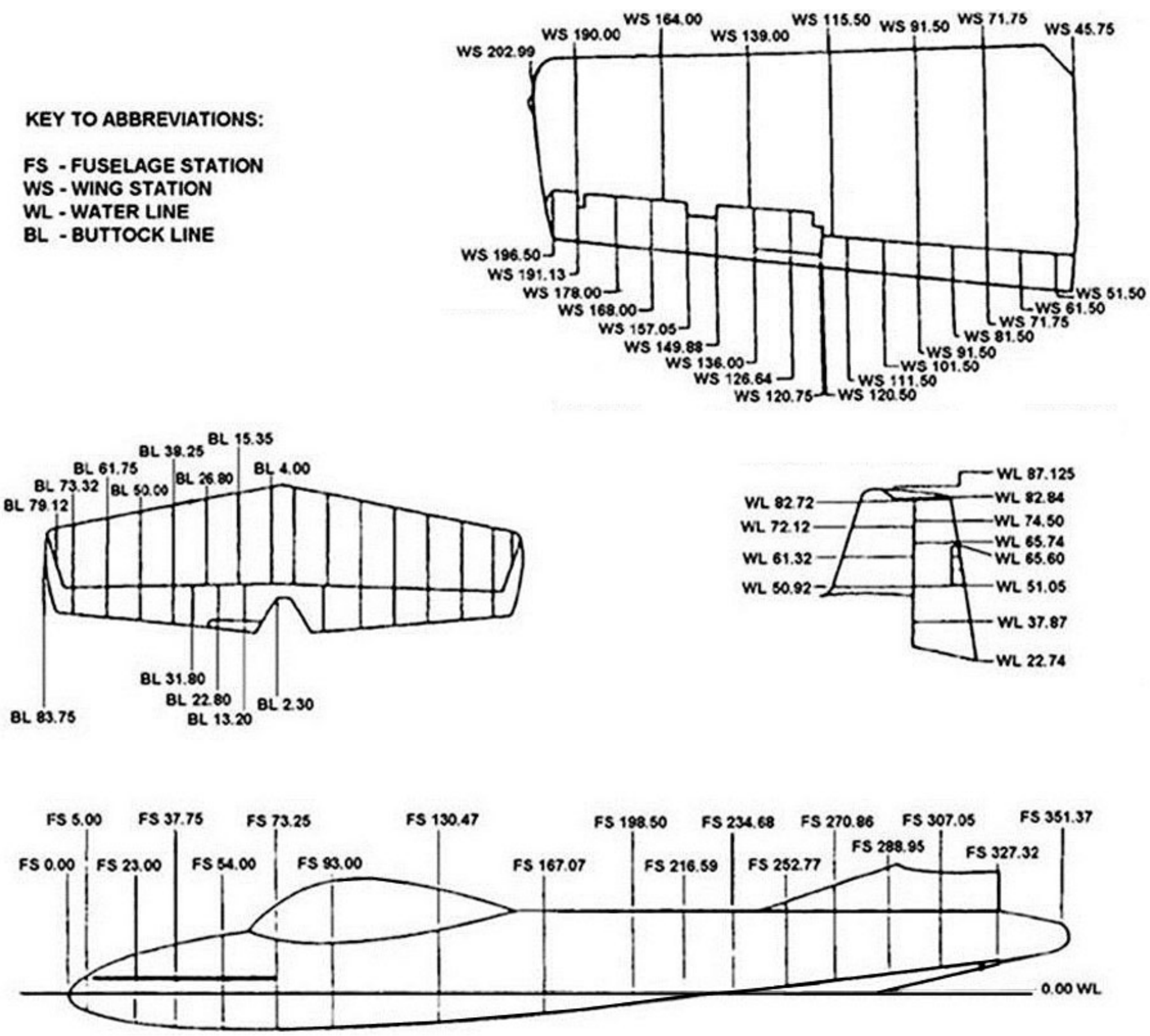


**Figure 2–11. Station diagram.**

## 210. Inspection techniques

When you visually inspect damage, you must remember to consider the supporting substructural members. The actual damage to the part might extend further than the evident damage on the external surface, inspect all rivets, bolts, and attaching structures along the complete member for evidence of additional damage. In this lesson, we describe the critical factors you need to examine when you're making a detailed visual inspection for damage on metal, composite, and plastic structures. Damage inspection for LO coatings will be covered in a later volume.

### Metal component inspection methods

There are two methods for inspecting metal components: visual and NDI. You will use the visual method to inspect the exterior surfaces and when there is suspected internal damage, or you need to verify the ends of a crack you will call NDI.

The external surfaces of the aircraft, such as the skin, doors, panels, and landing gear, should be inspected carefully for damage. If you're inspecting damaged skin panels, ensure you also inspect the substructural components for damage as well. Inspect all rivets, bolts, and attaching structures along the damaged component for evidence of additional damage. The following table lists some specific areas to inspect and types of damage you should look for.

| Specific Inspection Types | |
|---|---|
| **Type** | **Description** |
| Fasteners | Thoroughly inspect riveted and bolted joints in damaged areas for loose, sheared, or tilted heads. If the head of a fastener is tilted or loose, remove it and inspect for deformation of the fastener and elongation of the hole. Inspect the complete row or pattern of fasteners. On painted surfaces, you can detect rivet tilt by looking for cracks in the paint around the rivet. |
| Cracks, dents, and gouges | Inspect for dents that appear as hollows or depressions in the skins and panels. You can see cracks in forgings, castings, and extrusions, but use fluorescent penetrant to inspect suspicious areas. Dents can also be detected by shadowed effects on the skins. Gouges appear as scraped areas on painted and unpainted surfaces where metal is removed. |
| Corrosion | Inspect the inside surface of skin panels and supporting structures along with pockets and corners where moisture may accumulate. Corrosion can be recognized by white deposits or spots. In some cases, corrosion can be detected by dulling and, in severe cases, pitting or blistering of the metal. |
| Landing gear | Landing gear assemblies are particularly sensitive to damage. The main support structures of the gear are manufactured from steel alloys that have been heat-treated to achieve high strengths. These materials, while strong, are brittle. A surface flaw (e.g., scratch, pit, or dent) on one of the highly stressed areas of a landing gear strut could easily lead to the formation of cracks. When you're inspecting landing gear support structures, look for cracks, deformation, and misalignment. |
| Doors | Doors are also susceptible to damage because of their frequent use. Pay close attention to the entire area around the door as you perform your inspection. Inspect such critical points as hinges for misalignment, cracks, and broken or missing tangs. Also, inspect the door latches for binding, deformed or broken hooks, and proper rigging. Then, inspect the door fasteners and holes for deformation and elongation. |

### Composite component inspection methods

Unlike metal structures, composites can be a little more difficult to inspect. There are two primary methods of inspecting laminates: visual and tapping. Nondestructive inspection is also used to check for internal damage and moisture in bonded honeycomb parts.

### *Visual method*

Visual inspection is inexpensive and easy, but internal flaws such as disbonds can be hard to detect with this method. When visually inspecting composites, check for damage such as punctures, dents, scratches, and cracks. Also while inspecting, make special note of any previously accomplished repairs as to number, location, and distance from the damaged areas. This is important because certain components have weight limitations and specific restrictions on how close patches can be together in certain areas. These facts, plus the estimated amount of damage, play an important role during the damage classification procedure.

### *Tapping method*

Tap testing is used to evaluate conditions on laminated and bonded structures. The only equipment necessary for this test is a light (1-ounce) aluminum hammer that can be manufactured locally (fig. 2–12). The tapping method is satisfactory for detecting delaminations as long as the facings are not firmly attached to the core. If the delaminated facing and core are still in close contact, it is difficult to detect any difference between the tapping tone produced by delaminated and well-bonded areas. Poorly bonded areas cannot always be identified from well-bonded areas by tapping.

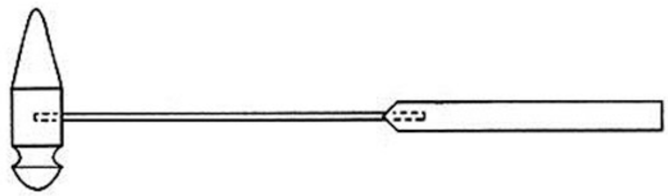

**Figure 2–12. Tap hammer.**

When using the tapping method, clean the panel by wiping the surface with a clean cheesecloth moistened with a cleaning solvent. When using a tap hammer, inspect the head for burrs, nicks, indentations, and so forth that could damage the panel surface. Use a fine grit cloth to remove blemishes from the hammerhead. Mark the panel to be inspected in approximately 1-square-foot grids to ensure complete coverage of the panel during inspection. In a smaller area, reduce the grid sizes as necessary. Once the area is marked, lightly tap the surface. A well-bonded area produces a clear tone; a poorly-bonded area produces a lower tone or a dull thud. If you are unsure, you can compare the results to a tap test of other like parts that are known to be good.

## Bonded honeycomb inspection

Inspection for damage is more critical for bonded honeycomb assemblies than for conventional structures; honeycomb structures can have extensive hidden damage not easily seen during routine visual checks. Structural parts must be carefully inspected for proper bonding between facings and core. Nondestructive inspection techniques are effective in detecting internal damages, such as delaminations, crushed core, and moisture. If you suspect a part has internal damage, coordinate with the NDI shop for further inspection. You will also want to check for edge crushing; it is similar to dents but the damage may extend beyond the obviously crushed area. When a crushed edge is discovered, a more in-depth inspection must be conducted by using the tapping or NDI inspection methods. Edge crushing usually breaks the edge seal, allowing moisture to enter the panel; therefore, you must also perform a *moisture inspection*.

## Plastic inspection methods

You must visually inspect plastic for mechanical and material defects. These defects include scratches, nicks (chipping), cracks, bubbles, delaminations, fractures, crazing and optical distortion. Some defects, such as scratches, are easy to detect so we will discuss the more difficult defects to inspect.

### *Nicks*

Nicks (chips) are layers or flakes of glass broken from the surface by excessive stresses in areas where the strength of the bond between the core and the glass is greater than the surface strength of the glass.

- A chipped area has a rough or grained appearance readily detectable in reflected light.
- White powdered glass is often seen in a chipped area.
- Visibility through the chipped area is poor and badly distorted.

### *Delaminations*

This is a separation of the outer or inner face ply and the vinyl core. Delaminated windows are sometimes confused with chipped windows. To avoid confusion, you can identify a delaminated window by the following characteristics:

- The delaminated area is smooth in appearance in direct and indirect light.
- Visual distortion through the delaminated area is slight, except along the edges of the delaminated area.
- Delamination generally begins near the edge and spreads inward toward the center and along the edge.
- A milky (cloudy) appearance anywhere around the edge of the inner or outer glass is an indication of actual or imminent delamination as a result of moisture penetration.

### *Crazing*

Crazing is a pattern or area of tiny fissures or splits in the plastic resembling the cracking of glaze in pottery or surface splits on weathered wood. Crazing having fissures of discernible width are considered as cracks. They are difficult to detect since and can be best seen by moving the piece to be inspected under an overhanging light and looking at the surface of the plastic in front of a dark background. You can do this on an aircraft by using a light (flashlight or extension light) while looking on the outside surface and having a dark surface

### *Distortion*

Visual distortion is a visual imperfection caused by the use of harmful cleaning materials or chemical vapors, improper cleaning practices, excessive heat, or accumulation of surface damage through use. Excellent lighting is imperative to recognizing distortion. Use bright sunlight when possible. A check for distortion of acrylic plastic panels can be made by viewing horizontal and vertical lines through the panel at a distance of at least 30 feet from the panel. A grid manufactured for this purpose or the crossed frame of a window readily detects distortion in any direction. If the plastic panel has been removed, place it on a table and view the grid while simulating the position and movements of a pilot in the aircraft. The horizontal and vertical lines should retain their shape and position during all movements. A straight object should not curve or break pattern.

## 211. Classify damage

In classification, you determine the extent of your damage, what your technical data allows, and resources needed to do the repairs.

### Metals

Damages you find during your inspection are grouped into four general classes. The availability or lack of repair materials, and time are some of the most important factors that determine whether a part is repaired or replaced. Each description is brief and is covered in more depth later in this career development course (CDC):

| Classification of Metal Damage | |
|---|---|
| **Classification** | **Description** |
| Negligible | Negligible damage is damage that does not affect the structural integrity of the aircraft. It is small dents, scratches, cracks, or holes that can be repaired by smoothing, sanding, stop drilling, or hammering out, or otherwise repaired without the use of additional materials. |
| Repairable by Patching | Damage repairable by patching is any damage exceeding negligible damage limits that can be repaired by bridging the damaged area or component with a splice material. |
| Repairable by Insertion | Damage repairable by insertion is any damage that can be repaired by cutting away a damaged section, replacing the removed portion with a like section of the damaged component, and securing the insertion with splices at each end. |
| Necessitating Replacement | Damage necessitating replacement of parts (replacement of an entire part) is considered when damage is not cost effective to repair or it exceeds TO limitations. |

## Composites

To help you classify the damage on composite components, many manufacturers include a damage evaluation chart in the TO by which you can determine the types of damage and where to find the repair procedures. The chart gives you a type allowable, repairable damage, and the paragraph number for repair procedures. Let's quickly look at information on the classes of damage for composites.

| Damage Classes for Composites | |
|---|---|
| **Fiberglass** | |
| **Class** | **Repair Description** |
| I | A scar, scratch, surface abrasion, or minor damage not penetrating through the first facing. |
| II | Damage extending through two plies of the plastic facing, or completely through one facing and possibly into the core. |
| III | When the facings and core of fiberglass components have been damaged. |
| | **Classifications** |
| Kevlar, graphite, and boron | These are classified as either *negligible* or *repairable*. The dividing line between these categories is whether or not broken filaments are part of the damage. |

Use TO 1–1A–12, to determine which of two types of damage classifications to use on plastics: mechanical or material defects.

| Mechanical Defects | |
|---|---|
| **Defect** | **Description** |
| Scratches | The length, depth, number of scratches in a given area, and location determine whether to replace the enclosure or plastic panel. Scratches are acceptable if they can be sanded or buffed out without reducing the panel thickness to less than prescribed (for visual concerns) by the applicable TO. |
| Nicks (chipping) | They are similar to scratches; and may be removed by sanding. However, this is not done if the removal of the material reduces the panel thickness to less than prescribed by the applicable TO, or if the removal impairs vision.<br>Surface imperfections (orange peel, pits, pimples, and mark-off) caused by lint impression are acceptable, provided these conditions do not impair vision or cause localized distortion. |
| Cracks | Cracks and fractures are *not* acceptable in plastic enclosures. However, a temporary repair for a crack is given in TO 1–1A–12. Use this repair only under extreme emergency conditions. |

| Mechanical Defects | |
|---|---|
| **Defect** | **Description** |
| Material | Delaminations are found in glass and laminated plastics. This is a separation of the outer or inner face ply and the vinyl core. The strength of the window is not seriously affected by delamination, but visibility can be reduced and window heating impaired because of a damaged conductive coating. When visibility or window heating is impaired, the delaminated window is replaced.<br>Delaminated windows are sometimes confused with chipped windows, which is a cause for immediate removal. To avoid confusion, you can identify a delaminated window by the following characteristics of the material:<br>• The delaminated area is smooth in appearance in direct and indirect light.<br>• Visual distortion through the delaminated area is slight, except along the edges of the delaminated area.<br>• Delamination generally begins near the edge of the glass and spreads inward toward the center and along the edge.<br>• Unless viewed at an angle, the delaminated area may be difficult to detect.<br>• A milky (cloudy) appearance anywhere around the edge of the inner or outer glass is an indication of actual or imminent delamination as a result of moisture penetration.<br>• Large bubbles between layers or plies of glass are found mostly in laminated plastics. They are acceptable if well scattered, provided they do not impair vision. The applicable TO gives you the acceptable number, diameter, and spacing for each area on the enclosures, panels, and windows. |
| **Material Defects** | |
| **Defect** | **Description** |
| Delaminations | The strength of the window is not seriously affected by delamination, but visibility can be reduced and window heating impaired because of a damaged conductive coating. When visibility or window heating is impaired, the delaminated window is replaced. |
| Bubbles | Large bubbles between layers or plies of glass are found mostly in laminated plastics. They are acceptable if well scattered, provided they do not impair vision. The applicable TO gives you the acceptable number, diameter, and spacing for each area on the enclosures, panels, and windows. |

## Self-Test Questions

### 209. Aircraft structural design

1. What are the major assemblies of an aircraft?

2. What is the main structural assembly to which the other assemblies are directly or indirectly attached called?

3. What major assembly is designed to give lift to the aircraft and stabilize it along the longitudinal axis?

4. What is the purpose of the engines?

5. What is the purpose of the landing gear?

6. Match the control surface in column B with its function in column A. Column B items are used only once.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Serve as an airbrake. | a. Ailerons. |
| ____ (2) Control wing lift and drag. | b. Rudders. |
| ____ (3) Control roll. | c. Flaps. |
| ____ (4) Reduce stalling speed. | d. Tabs. |
| ____ (5) Control yaw. | e. Spoilers. |
| ____ (6) Aid and position control surfaces in flight. | f. Slats. |

7. Match each component in column B with its description or function in column A. Column B items are used only once.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Small, lightweight, lengthwise members. | a. Longerons. |
| ____ (2) Like bulkheads, but in wings and empennage. | b. Bulkheads. |
| ____ (3) Fairly heavy, lengthwise members of fuselage. | c. Stringers. |
| ____ (4) Outside covering of the aircraft. | d. Spars. |
| ____ (5) Main lengthwise structural member of wing. | e. Ribs. |
| ____ (6) Provide shape to the fuselage; add strength and rigidity to the structure. | f. Skin. |

8. Match each reference line in column B with its description or function in column A. Column B items are used only once.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Indicates vertical planes parallel with the plane of symmetry. | a. FS. |
| ____ (2) Represents a vertical plane perpendicular to a wing reference plane. | b. WL. |
| ____ (3) Indicates horizontal planes parallel to the ground line. | c. BL. |
| ____ (4) Indicates longitudinal positions of vertical planes perpendicular to the plane of symmetry. | d. WS. |

## 210. Inspection techniques

1. When inspecting for damage, how should you inspect fasteners?

2. When should you make note of previously accomplished repairs?

3. What steps should you take if you are unsure of the results of a tap test?

4. How do you inspect for damage on plastic parts?

### 211. Classify damage

1. In metal classification of damage, what are the four general classes of damage?

2. When classifying damage to a metal structure, how would you classify when the damage is excessive and the amount of material required to repair will exceed the cost of a new component?

3. When evaluating a scratch on a fiberglass component what classification would it be if the scratch extends through three plies?

4. Why would you classify a scratch on a graphite panel as repairable instead of negligible?

5. When evaluating a plastic, what would you look for to verify that a delamination is not a chip?

## 2–2. Damage Removal

In this unit, we cover damage removal procedures and the techniques you can use for the layout of fastener patterns. The skill and workmanship you exhibit while performing repairs has a direct influence on the outcome of the repair. The old saying "haste makes waste" is very true when you're removing damage and developing rivet patterns. Here's some friendly advice that will last a lifetime: Always take a little extra time to work out the details of a repair before getting started. If you do, it pays off in quality work.

### 212. Damage removal procedures

A fundamental principle of removing damaged areas is this—do not cause additional damage. To not cause additional damage, you must use the correct procedure and tools, based on the location of the damage. Removal procedures (e.g., chain drilling, use of the skin knife, and use of specific types of power tools) are covered in this lesson. Other factors to take into consideration when removing damaged areas are also covered in detail.

#### How to lay out a damaged cutout

Your first step in removing a damaged area is to decide how much of the undamaged area should be removed along with the damaged area. After calculating this, develop a layout for the cutout of the damaged area. This layout serves as a guideline during damage removal. You must also consider whether the damage is in an open area or near a substructural member. Also, don't lose sight of the final size of the patch, including the complete fastener layout, when you're developing the layout for the cutout. There are two other important factors that come into play when deciding how to lay out a damage cutout—open areas and substructural areas.

##### *Open areas*

An open area is an area where there's no substructural member (i.e., a stringer) within the damaged area. When you're working in an open area, your prime concern is removing the damage. As you develop the layout for the cutout, it's important to make the cutout the correct size and to relieve stress concentrations. These requirements are discussed in more detail in the following table.

| Open Area Cutout Requirements | |
|---|---|
| **Requirement** | **Description** |
| Correct cutout size | The cutout must be large enough to encompass any damage that has changed the configuration of the structure. The size of the cutout should also be practical and allow you to develop a proper size patch. Don't make your cutout so small that it is difficult to fabricate a filler plate. However, don't cut away an excessive amount of undamaged skin. When determining the size of a particular cutout, base your decision on your experience and observation of the damaged area.<br>**NOTE:** The general rule is to keep the repair as small as possible. |
| Stress relief | When making damage cutouts (other than circular cutouts), it's necessary to have a radius on the inside corners. This prevents the creation of high-stressed areas. The size of the corner radius is normally the same as the edge distance used for the fastener layouts, unless a specific size corner radius is stated in the TO. |

### *Substructural areas*

When making a cutout near or over a substructural member, there are two important factors to consider:

1. Edge distance from the cutout to the nearest fastener.
2. Allowances for the fastener spacing required in the filler and doubler.

#### *Cutout edge distance*

The outer edges of the cutout must be the proper edge distance from existing fasteners (fig. 2–13). This allows you to maintain the proper edge distance from the existing fastener to the edge of the cutout after the cutout is made. So in other words, after removing the cutout material, existing rivets are in proper edge distance to the edges of the cutout. At the same time, you establish the location of the first row of fasteners needed for the doubler.

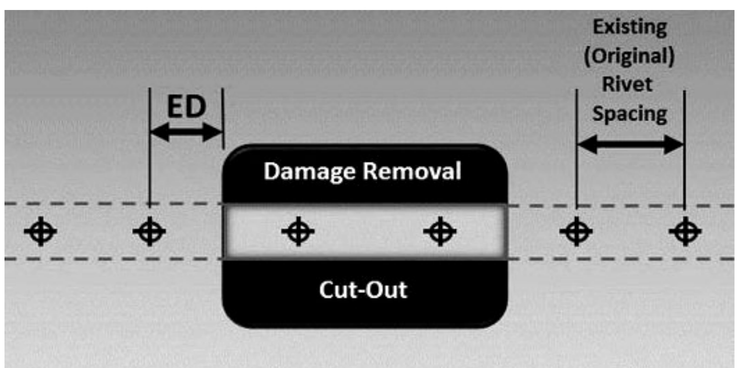


**Figure 2–13. Cutout area—edge distance location.**

#### *Rivet spacing allowance*

When the cutout area is near a substructural member you must allow for rivet spacing. The lower section of figure 2–14 illustrates the space required on both sides of the cutout area for the fastener layout. In some cases, the cutout area may need to be even larger. You may have to extend the cutout over the substructural member to the opposite side in order to have enough space for the required fastener layout in the filler and doubler. As you develop a layout for the cutout, remember to consider the total area required for the repair parts.

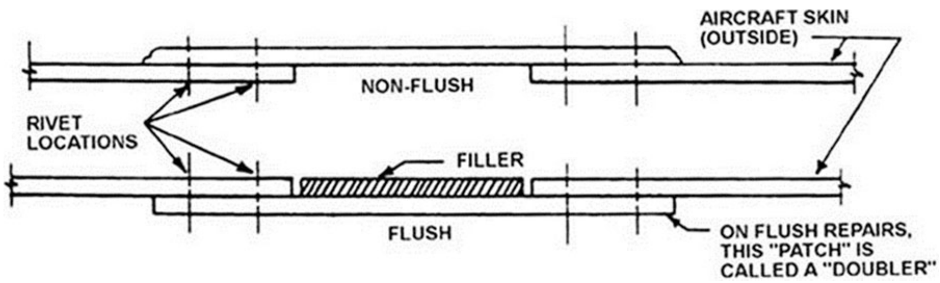


**Figure 2–14. Cross section of total patch requirements.**

## How to remove skin damage

Many methods for removing damaged materials are available for your use. The specific method you select depends on several factors:

- The damaged material.
- The damage location.
- The equipment located behind the damaged area (i.e., tubing, wiring, substructure, etc.).

Keep these factors in mind as we discuss the procedures and techniques for removing damaged skin areas.

### *Chain drilling procedures*

Chain drilling is the process of removing damaged material by drilling a series of closely spaced holes inside a cut line. When finished the holes resemble a chain, thus the name “chain drilling” (fig. 2–15). Removing damaged material by chain drilling requires caution. When chain drilling over a substructural member or other vital aircraft components (tubing or wiring), it is difficult not to drill into the substructural member. You can resolve this problem in a number of ways.

One way is to position a thin piece of scrap metal between the skin and the substructural member. Removing a number of fasteners on both sides of the cutout area loosens the skin enough so the metal can be inserted. This piece of metal serves as a stop when drilling over the substructural member. Drill only through the top skin until you reach the scrap piece of metal. Once you’ve removed the cutout area, leave the scrap metal in place over the substructural member in preparation for rotary file operation.

In areas where it’s impossible to insert a scrap piece of metal between the members, be extremely cautious and drill into the top skin only until the twist drill starts to break through the back side. This procedure is easier said than done, so be extra careful. Once the cutout has been removed, the remaining material can be rotary filed away. Insert a scrap piece of metal between the members when rotary-filing.

### *Filing procedures*

Next you will file the cutout to the final dimensions of the layout. Do this, in part, with a rotary file. Use the rotary file with a pneumatic drill to smooth down the burrs and rough edges left after you’ve chain drilled the cutout. Figure 2–16 shows the shapes of rotary files available. Like chain drilling, rotary filing requires careful use because of the speed with which it removes metal. One careless slip and the repair could be ruined. Therefore, use extreme care and always exercise caution when using this type of file. When used correctly, rotary filing can make a difficult job easier. As you’d expect, using a rotary file is much faster than hand filing; however, this operation doesn’t leave the edges in a finished condition. Consequently, you must finish the edges with a hand file and sandpaper.

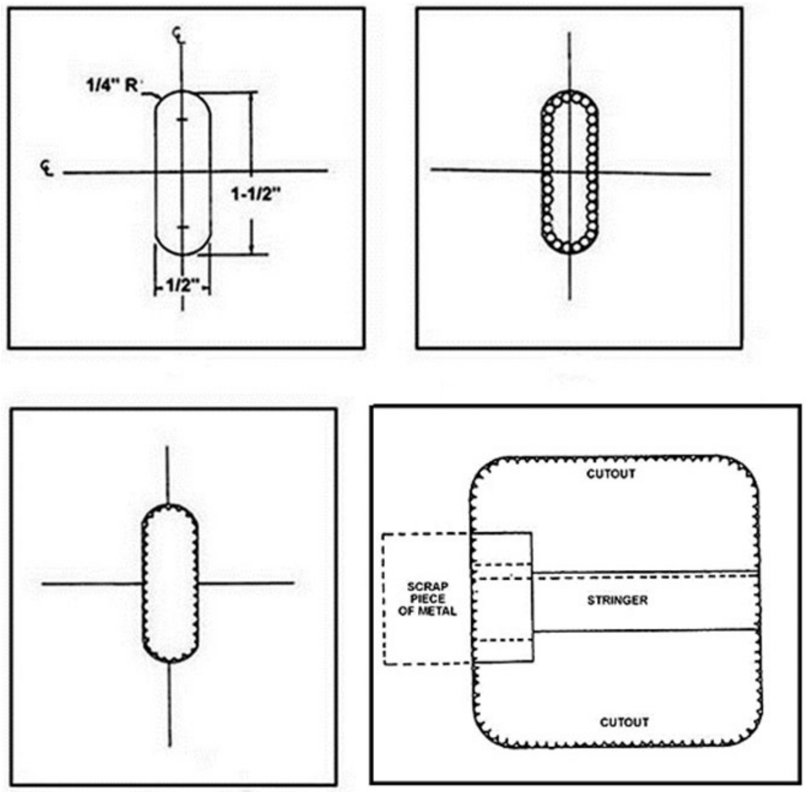


Figure 2–15. Chain-drilling techniques

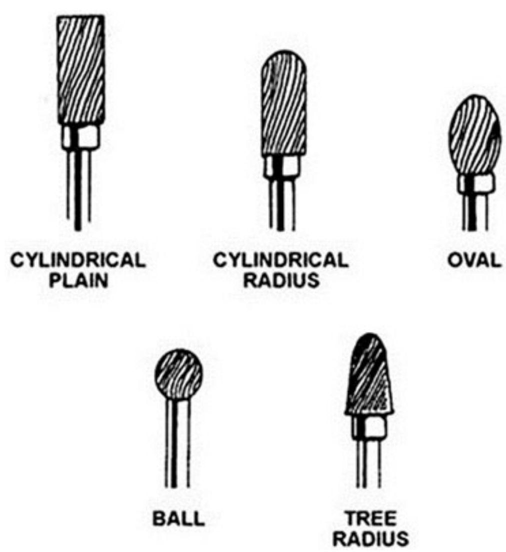


Figure 2–16. Rotary files.

## How to remove parts of damaged substructural members

We’ll now turn our attention to the procedures used to remove a damaged substructural member. For a representative example, we’ll use removing part of a damaged stringer. The procedures and consideration factors for removing a damaged part of a stringer can be applied to other substructural members. Always keep in mind that whenever you remove a damaged area you must be careful not to damage surrounding structural members or equipment.

### *Cutout size*

Along with removing the damaged portion, you must consider the location of existing fasteners in the stringer when you're determining the overall size of the cutout. Also, be sure to maintain the proper edge distance from the edge of the cutout to the first fastener on both sides of the cutout. Where damage requires skin and stringer cutouts, the size of the cutouts should be the same. This is the case unless the damage to the skin or stringer makes it impractical. Sometimes, the underlying structure has more damage than the skin. For example, a mishandled support stand may puncture the skin and the substructure may be bent or cracked beyond the external damage. In this case, separate cutouts are needed, each with the proper edge distance requirements.

### *Removal techniques*

When the stringer cutout is the same as the skin cutout, ensure the sides of the stringer cutout are perpendicular (90 degrees) from the skin cutout to ensure a proper fit of the stringer filler section when you're installing the repair parts.

In areas where the stringer cutout is larger than the skin cutout, insert a scrap piece of metal between the skin and stringer so you don't damage the skin (fig. 2–17). You may need to use an angle drill to chain drill the horizontal flange of the stringer because of limited space, or location of the stringer and adjacent internal structures.

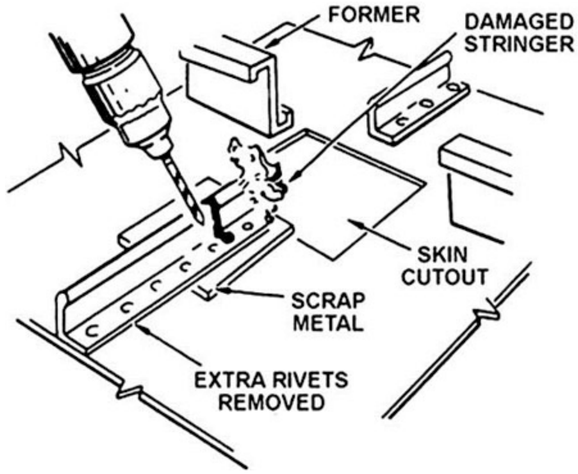


**Figure 2–17. Stringer damage removal.**

**NOTE:** Be sure you keep all bits and pieces of the damaged area you remove until you complete the repair. You may need to refer to them for additional repair information (i.e., the alignment of parts, overall dimensions, location of fastener holes, etc.).

## Blending negligible damage

There are going to be times that the damage you locate is going to be minor scratches or nicks. Even though they may be negligible, some work will still need to be performed. One way to repair minor scratches and nicks is by blending.

When blending negligible damage, a saucer shaped depression is formed to eliminate stress concentrations in the metal (fig. 2–18). As you blend the material, ensure that you blend the surfaces of the reworked area smoothly and evenly with the surrounding original surface. Nicks, scratches, gouges and corroded areas should be blended out as follows:

- Use a 240-grit abrasive mat to remove all rough edges.
- Smooth the area with a 320-grit abrasive mat.

- Have NDI perform an inspection to confirm all damage has been removed.
- If a sign of a crack exists, remove more of the material by abrading, but do not allow blended area to exceed maximum allowable damage limits.
- Repeat NDI check.
- If a crack still exists, make a patch repair in accordance with applicable repair procedures.
- If no crack shows after first or second NDI check, polish the area with a 400-grit abrasive mat.
- Finally, treat area for corrosion control in accordance with the applicable –23 technical order.

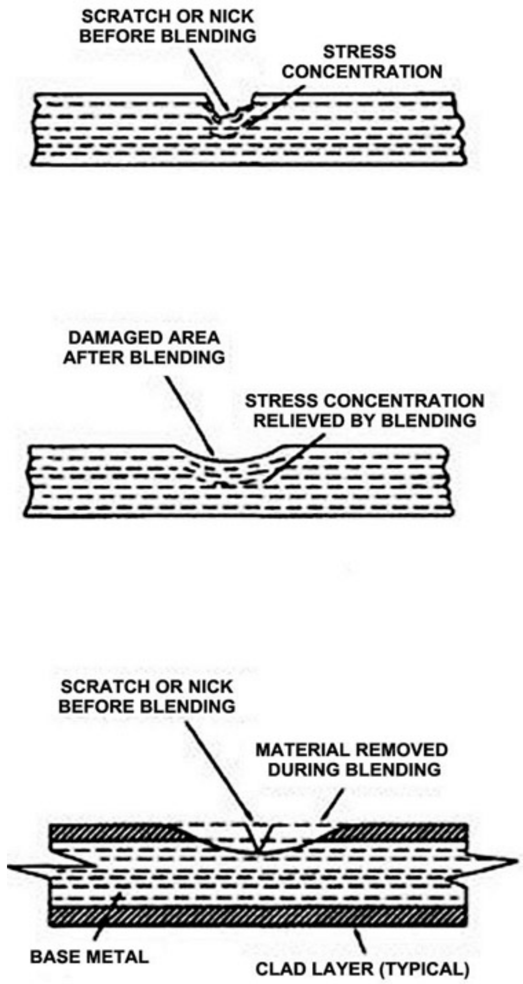


**Figure 2–18. Blending of damage.**

## 213. Stopping drill cracks

Cracks may be caused by nicks, scratches, corrosion, vibrations, or metal fatigue. Stop-drilling a crack is a matter of drilling a hole to prevent the crack from spreading.

### Crack evaluation

Metal fatigue results from repeated loads and some of the items most often affected are skins, fairings, formers, frames, and fittings. During your inspection make sure to carefully inspect these items, particularly around cutouts, formed areas, fastener locations, and adjoining parts of varying thickness. Some cracks may not be visible so any indications or suspected locations of cracks should be carefully examined, using an appropriate nondestructive inspection method.

The severity of a crack can be determined by assessing the length and geometry of the crack, the area in which the crack occurs, the rate of propagation, and the depth. Cracks must be repaired according to weapon system-specific TO. These TOs generally include allowable damage charts for structures such as fairings, webs, honeycomb panels, splice plates, landing gear, body skins, and frames.

### Crack repair and treatment

Do not neglect or dismiss any cracks. What may appear to be a minor crack could jeopardize the structural integrity of the aircraft and the safety of the crew. If a crack is suspected, clean up the area and contact the NDI shop to perform the appropriate inspection to determine the ends of the crack.

After verifying the crack, the next step is to determine a proper repair sequence. The TO may call for a simple stop-drill repair to prevent crack propagation, depending on where the crack is located.

To perform a basic stop-drill repair you would drill or counter bore a 0.25-inch diameter crack stop hole through the structure at each end of the crack so that the center of the hole is 0.10 inch beyond the visible end of the crack. For minor cracks and material that is 0.040 inch (or less) thick, the drill may be reduced to a diameter of 0.125 inch. In blind areas, make sure to use a drill stop to prevent damage to underside equipment.

After stop-drilling, have NDI perform another inspection to ensure the end of the crack was contained in the stop hole. If the crack extends beyond the stop hole, enlarge the hole by 1/16-inch diametrical increments until the crack indication is removed. Remove all burrs, nicks, and sharp edges from the cracked part and blend damaged areas smooth. Stop-drilled holes may be filled with rivets or aerodynamic filler to keep out moisture and corrosive elements. If necessary, perform split-sleeve cold expansion according to a weapon system-specific structural repair manual.

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## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 212. Damage removal procedures

1. How do you prevent the creation of highly stressed areas when making skin cutouts?

2. Besides determining how much damage you must remove, what other factors must you consider when making a cutout near or over a substructural member?

3. When is it necessary to extend the size of a cutout across a substructural member to the opposite side?

4. What three factors must you consider when selecting the removal method to use when making a cutout?

5. How do you protect a substructural member from damage when you're chain drilling a cutout over the member?

6. What should be foremost in your mind when removing a damaged substructural member?

7. Why should the sides of a substructural cutout be perpendicular to the skin cutout?

8. What must you do to protect the skin from damage when you're working in areas where the stringer cutout is larger than the skin cutout?

9. Why should you retain all damaged parts until the repair is completed?

### 213. Stopping drill cracks

1. How can you determine the severity of a crack?

2. What is the basic process for stop drilling a crack?

3. How would you keep out moisture from a stop drilled crack?

## 2–3. Fabrication and Installation of Repair Parts

In this section, we will cover the steps involved in completing a repair; that is, the fastener layout, fabrication and installation of the repair parts. As you will notice, repair requirements vary from repair to repair and because of this you must modify your repair procedures to meet the needs of each repair situation.

### 214. Fastener layout techniques

When you have the cutout completed, the next phase in the repair process is developing the fastener layouts (patterns). In general, you should try to make the spacing of the fasteners on a repair conform to the pattern used by the manufacturer in the area surrounding the repair. Aside from this fundamental rule, there's no specific set of rules that govern the spacing of fasteners in all cases. For specific rules, consult the applicable structural repair TO for the aircraft being repaired. Since most of the fasteners you'll use are rivets, our discussion centers on them. As you'd expect, there are certain minimum requirements you must observe to ensure the repaired area is returned to its original load-carrying capabilities.

## How to lay out rivet patterns

When we were discussing cutout procedures, we stressed the need for proper edge distance in making any cutout. You'll find the term edge distance, along with the terms rivet spacing and row spacing, is used throughout any repair manual dealing with structural repair. It's essential you know the meaning of these terms because you'll be continually using them. They are the three factors that are used to lay out rivet spacing patterns: edge distance, rivet spacing, and row spacing. The terms are explained in the table below.

**NOTE:** It's important to remember that edge distance, rivet spacing, and row spacing formulas are calculated using known rivet diameters.

**Rivet Pattern Terms**

| Term | Explanation |
|---|---|
| Edge distance | The edge distance, or distance from the center of the first rivet to the edge of the sheet, should not be less than 2 rivet diameters or more than 4 rivet diameters. The recommended edge distance is 2½ rivet diameters. If you space rivets too close to the edge of the sheet, the sheet is likely to crack or pull away from the rivets. If you space them too far from the edge, the sheet is apt to turn up at the edges. Figure 2–19 shows how edge distance is applied. |

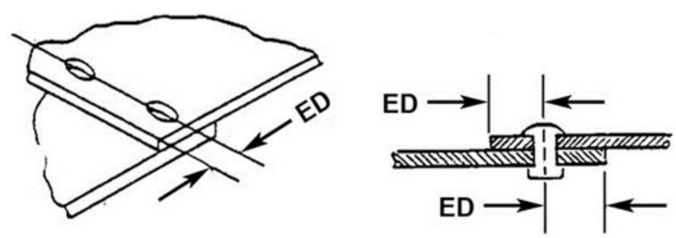



**Figure 2–19. Edge distance.**

| Term | Explanation |
|---|---|
| Rivet spacing | Rivet spacing, also known as rivet pitch, is the distance from the center of a rivet to the center of a neighboring rivet in the same row. The smallest allowable rivet spacing is 4 times the rivet diameter; the maximum allowable rivet spacing is 10 times the rivet diameter. The average rivet spacing usually ranges from 6 to 8 rivet diameters. |
| Row spacing | Row spacing is the perpendicular distance between the rivet rows. It's normally equal to 75 to 100 percent of rivet spacing. The distance must not be less than 2½ times the rivet diameter or more than the largest rivet spacing within either row. Figure 2–20 shows an example of rivet spacing and row spacing. |

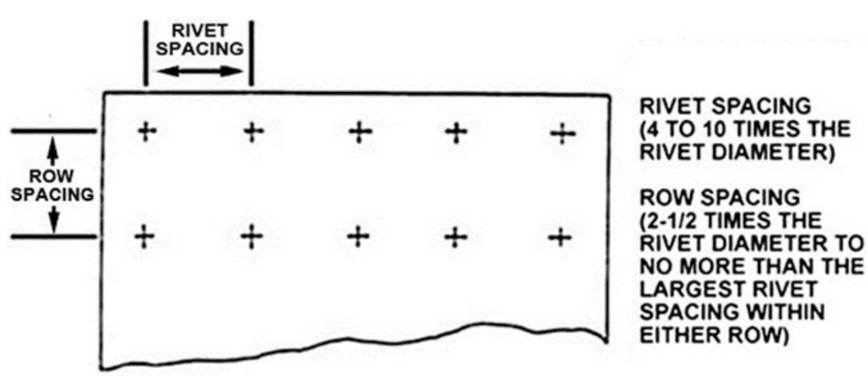



**Figure 2–20. Rivet spacing and row spacing.**

### How to develop rivet layouts for flush skin repairs

The shape and location of a skin cutout dictates the rivet layout used. There's no specific layout pattern that applies in all cases. Instead, refer to the applicable structural repair series TO for the guidelines to follow in individual cases. Where specific guidelines aren't given, there are two procedures for various cutouts that should meet requirements: circular layout and square layout.

#### *Circular layout*

A circular layout (fig. 2–21) normally has two rows of rivets around the cutout and one row of rivets for the filler plate. In making a circular layout, the rows outside the cutout are laid out first; then, after the repair parts have been fabricated, the inner row is laid out.

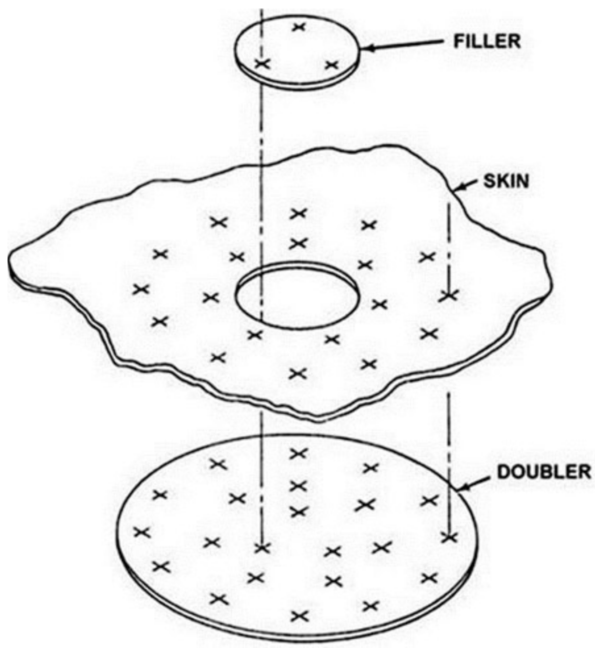



**Figure 2–21. Circular patch layout.**

##### *Outside layout procedures*

Before you do any layout procedures, you must establish the center point of the cutout. This is important because the locations of the outer rows of rivets are developed from the center point of the cutout area. You can locate the center point of the cutout by constructing perpendicular centerlines. To do this, take a scrap piece of metal and tape it over the back side of the cutout area, then draw the center point on the scrap piece of metal. Once you've done this, you're ready to locate the outer rivet rows.

Using a compass with an aircraft marking pencil, place the metal point of the compass at the center point of the cutout area and draw a circle around the cutout area. This circle should be equal to the radius of the cutout area, plus the required edge distance. Notice the point of the circle you've just drawn intersects the top centerline—this is the starting point for laying out the rivet locations. Next, use dividers to lay out the rivet locations, ensuring the proper rivet spacing is used. Using the dividers ensures consistent spacing between rivets.

The second row's location is equal to the radius of the cutout, plus edge distance, plus 75 percent of the rivet spacing used to locate the rivets on the first row. Besides assisting in locating the center point of the cutout area for circular cutouts, your centerlines also locate the starting points for laying out the rivet location on the rows. Your rivet locations—four each—come where the outer circle intersects the perpendicular centerlines. Use the proper rivet spacing to locate additional fasteners between these rivets.

Once you've marked the locations of all of the rivets, ensure they're center punched and pilot drilled. Only drill the rivet holes to the required size just before the countersinking and rivet installation. This procedure reduces the possibility of elongating the rivet holes—a result that could cause misalignment of repair parts and oversized fastener holes.

#### *Filler plate layout procedures*

In this procedure you develop the rivet layout *after* making the filler plate (plug) and fitting it to the cutout. Then, the rivet row must be edge distance from the edge. The number of rivets needed depends on the size of the cutout and the guidelines stated in the applicable structural repair TO. Whatever the number, use the recommended rivet spacing and equally space the rivets. A quick way to locate the first rivet location is to extend the top centerline downward until it intersects the rivet row line on the filler plate.

### *Square layout*

The layout procedures for a square cutout differ from the circular layout because of the shape of the skin cutout. Figure 2–22 shows the rivet layout generally used for a square cutout. The layout sequence for the rivet locations is the same as that used for the circular layout—outside first, then the filler plate layout. Make all layout lines with an aircraft marking pencil, *not* a scriber.

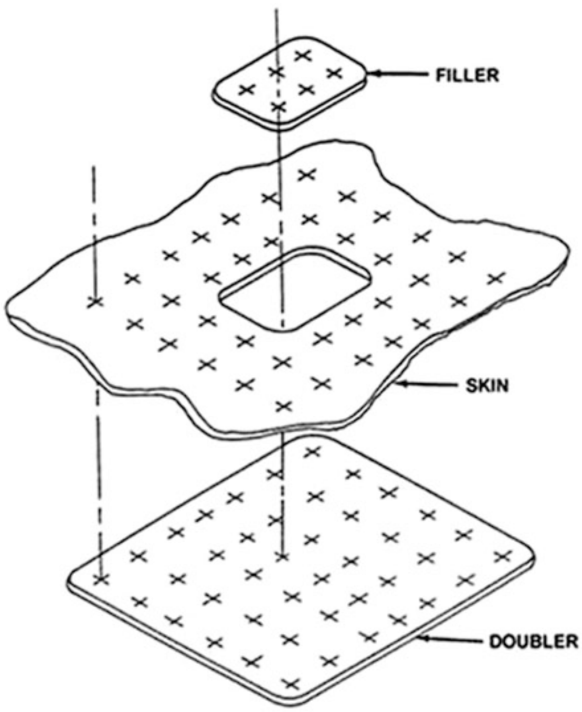



**Figure 2–22. Square patch layout.**

#### *Outside layout procedures*

Outside layout procedures call for locating the first row the proper edge distance from the cutout. Draw the sides so they intersect at each corner. The line intersections indicate the locations for the four corner rivets of the inner row. You can then locate other rivet locations between each corner rivet. Place the second row 100 percent of the rivet spacing used for locating the rivets on the inner row. The corner rivets are found where the outer layout lines for the second row intersect. Lay out additional rivets between the corner rivets. Since the row spacing and rivet spacing used on the inner row are identical, it's obvious the locations of the rivets on the second row are in line with the rivets on the inner row. You can use a straightedge to locate the rivet locations on the outer row. After you've completed the layout, center punch and pilot drill all locations.

#### *Filler plate layout procedures*

The number of layout rows needed in the filler depends on the size of the cutout and the guidelines stated in the applicable structural repair TO. In any case, remember the first row must be at the proper distance in from the edge of the filler plate. If more than one row is required, the rules for row spacing apply.

## 215. Fabricating repair parts

By this point in the repair process, you should have an idea of the number of parts necessary to restore a damaged area to its original strength and configuration. How you go about making the required parts depends on many factors. Recognizing this, the techniques discussed here are designed to save you time and ensure that you produce properly fabricated repair parts.

### How to fabricate parts for a flush skin repair

The basic parts required for a flush skin repair are a doubler and filler. As you'd expect, each part serves a specific function. The doubler restores the skin area's load-carrying abilities, while the filler returns the skin area to its original contour. In the following paragraphs, you'll study techniques for fabricating the doubler and filler for two flush skin repairs—an open area and a blind area.

#### ***Doubler***

The preferred sequence of fabricating flush skin repair parts is to make the doubler first. By doing this, the doubler can be placed into position when the filler is fitted to the cutout area.

| Doubler Fabrication for Flush Skin Repair | |
|---|---|
| **Area** | **Description** |
| Open area fabrication techniques | An open area exists where access to the back side of the cutout area is open. In open areas, fabrication of the doubler is relatively simple. These seven steps outline the techniques you use in this situation:<br>1. Draw a centerline on the skin area to indicate the center of the cutout area.<br>2. Select the material for the doubler. The material must be one-gage thicker than the skin and have the same temper condition. Cut the doubler material large enough so that it extends beyond the outside fasteners, plus edge distance.<br>3. Draw centerlines on the doubler material.<br>4. Position the doubler material behind the cutout, aligning the centerline on the doubler with those on the skin surface. The centerlines act as alignment lines and ensure the needed material has been positioned on both sides of the cutout area.<br>5. With the doubler material in place behind the cutout, use the fastener pattern on the undamaged skin as a template and pilot-drill through the fastener layout on the skin. Use an ample number of Cleco fasteners during the pilot drilling process to prevent doubler misalignment.<br>6. After pilot drilling all the fastener holes, remove the doubler material from the back side. Before removing, place alignment marks on the doubler that will serve as an aid in its realignment (for later repair procedures). Do this by placing a pencil mark on the edge of the skin cutout and placing a corresponding mark on the doubler.<br>7. With the doubler material removed, add the required edge distance out from the last row of fasteners. If the doubler is not a circular shape, radius the corners equal to the edge distance used in the fastener layout. |

| Doubler Fabrication for Flush Skin Repair | |
|---|---|
| **Area** | **Description** |
| Blind area fabrication techniques | You follow blind area fabrication techniques in cases where access to the back side of the skin cutout is impossible. The size and shape of the cutout area have a bearing on how you fabricate the doubler (how many doublers are required).<br>• When the size of the skin cutout is large enough, use a single doubler (fig. 2–23).<br>• If the size of the skin cutout is too small for a one-piece doubler, split the doubler into two parts<br>• For a circular skin cutout, use a single doubler after a hole has been punched in the center and a cut has been made from the outer edge to the hole. This procedure permits the doubler to be “turned” into the cutout area.<br>When you must split a doubler, make the cut on the doubler between the fastener locations, ensuring the proper edge distance is maintained. This practice also holds true when you’re cutting a doubler for insertion behind a circular cutout.<br>No matter which method you use, once you can position the doubler material behind the fastener layout, follow the open area procedures for making a doubler. Use special precautions to ensure proper alignment of the repair parts when working in a blind area. Also, use proper techniques to eliminate the possibility of repair parts falling into the blind area. |

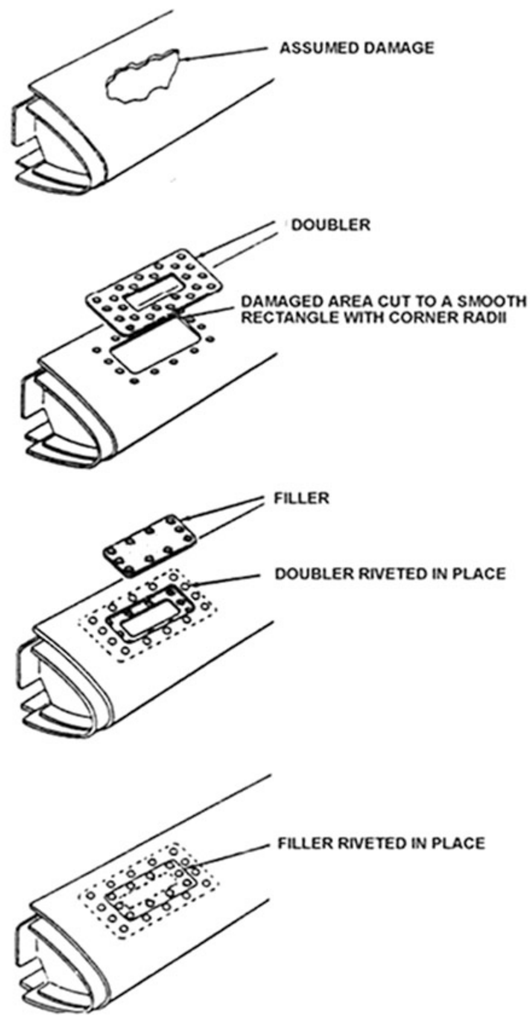



**Figure 2–23. Flush repair–single doubler.**

### *Filler plate*

Once the doubler is complete, fabricating the filler is next. To do this, you use a five-step sequence:

1. Select a filler material equal to the skin area in thickness and temper condition.
2. With a filler piece larger than needed, position it behind the cutout area using the cutout area as a template. While holding it in place, scribe around the cutout area, ensuring the scribe marks are visible. This develops the outline. Before removing it, place alignment marks on the filler layout.
3. Remove the metal and, cutting along the scribe line, remove the excess material. Be careful and keep your gap tolerance within $^{1}/_{32}$ inch.
4. Ensure the alignment marks are lined up and then Cleco the doubler in place.
5. Position the filler in the cutout, aligning the alignment marks and checking the amount of clearance between the filler and skin cutout. Remove the filler if additional filing is necessary. Repeat this procedure until you can maintain a clearance of $^{1}/_{32}$ inch between the filler and skin cutout.

In blind areas, you may find it easier to fabricate the filler before making the skin cutout. In this case, ensure that all of the damage falls within the overall dimensions of the filler. The corner radii of the filler are the same as those needed for the skin cutout. Once the filler is fabricated, it can be used as a template to trace the outline for the filler over the damaged area. When using this technique, take special care when making the skin cutout. Any deviations from the outline require fabricating a new filler plate.

At this point, the parts for a flush patch are completed. In areas where a substructural member is within the cutout area, you must modify these procedures somewhat. However, if you have followed the basic techniques we've discussed, you should be able to make the needed modifications with few, if any, problems.

## How to fabricate parts for a nonflush skin repair

A nonflush repair is used as a reinforcement plate for a damaged area. Nonflush repairs can be placed over prepared cutouts, small dents, cracks, and other areas where aerodynamic smoothness isn't critical and when the installation of a flush patch is impractical because of the structure of the area. A flush patch on certain areas of chem- and machine-milled skins is impossible or extremely difficult to install properly. Always consult the TO or applicable structural repair manual before installing a nonflush patch.

You can lay out the fastener locations for a nonflush skin repair on the damaged part or on the patch plate. The method you select dictates the technique you must follow in fabricating the patch plate. In the following paragraphs, we'll discuss the details for each of these techniques.

### *Layout on the damaged part*

In an open area, make the layout on the part. Here, the layout procedures are the same as those for developing a flush patch rivet pattern. Also, the techniques used to make the patch plate are the same as those used to make a doubler for a flush skin repair in an open area. However, after being trimmed to the proper dimensions, the material is placed on the outside of the skin area, not on the inside.

When you install a nonflush repair in a blind area that has existing fastener locations, laying out the fastener locations on the part creates two problems: (1) locating the holes in the patch plate; and (2) centering the patch plate over the cutout area for proper material allowances on both sides of the damaged area. You can overcome the problem of locating holes in the patch plate by using a hole finder. A hole finder is the fastest most accurate method for locating blind fastener holes. Figure 2–24 is an example of one size hole finder.

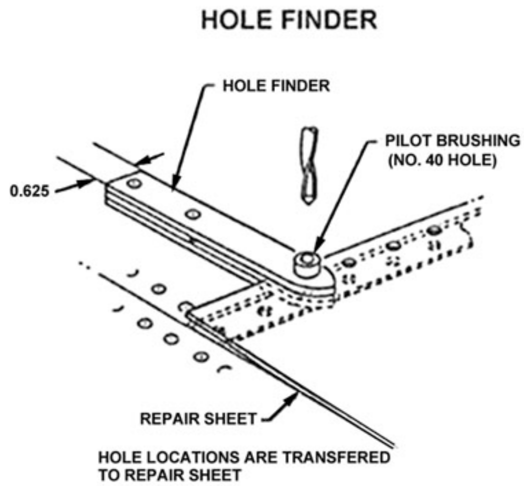



**Figure 2–24. Methods of locating blind holes.**

### *Layout on the patch plate*

When you're making a repair in an open area, you seldom develop a fastener layout on the patch plate. The pattern on the skin is used as a template because it's easier to use the rivet pattern on the part to drill the holes into the patch plate. After drilling through the patch plate, it's a simple matter of trimming the patch plate to the correct edge distance.

In blind areas containing no existing fasteners, you develop the required fastener pattern on the patch plate. Then, you can use the plate as a drilling template to locate the fastener holes on the damaged part. When using this method, mark alignment lines on the damaged part and the patch plate. Do this because the location of the cutout (or the area of the damage) must be shown on the patch plate when the fastener layout is developed. After all holes have been drilled, deburr them and trim the patch plate to the required size. If the holes aren't deburred, the joint won't be tight, and rivets might expand or flash between the parts being riveted. Now, the patch plate is ready to install.

### *Stringer filler*

The stringer filler must match the original stringer in material composition, thickness, and dimension. The fabrication procedures you use to make the repair part are directly related to the process used (formed or extruded) to make the original stringer. Extruded repair materials are fabricated by pouring molten metal into molds and curing it under pressure. In contrast, a formed part is created by using an available material (aluminum in most of our situations) and forming a finished product.

Take the overall dimensions for the stringer filler from the damaged sections you removed when making the cutout. The width of flanges and bend radii are the key measurements needed. If the original stringer has only two flanges, calculations for setback and bend allowance are not necessary. However, in cases where the stringer has a third flange—usually a small return flange—calculations are required. Setback and bend allowance calculations are necessary because you must match the two bend radii. The stringer in figure 3–24 has only two flanges, so we'll only cover the techniques that do not require calculation. Follow these general guidelines:

- Using a scrap piece of metal, adjust the cornice brake so the bend radius matches the original bend radius of the stringer. Too large a bend radius leads to problems later when rivets are installed in the flanges.
- Once the proper bend radius is obtained, bend a piece of metal $^{1}/_{32}$ inch shorter in length than the cutout and with flanges wider than needed.

- Position the filler inside the cutout, allowing $^{1}/_{64}$ inch clearance between each end of the stringer filler and stub ends of the stringer. This procedure eliminates any possibility of stress developing from contact between the parts.
- Find the required width of the flanges by scribing a cut line on the flanges. Position the stringer filler into the cutout, ensuring the bend radii are aligned, and scribe a cut line between both ends of the original stringer. Use this technique for both flanges.
- Remove the stringer filler and cut the flanges to the correct width indicated by the scribed cut lines. At this time, the stringer filler is completed.

### *Stringer splice angle*

The stringer splice angle is normally positioned inside the original stringer. The bend radius of the stringer splice angle must be smaller than that used for the stringer filler, so the cornice brake must be readjusted. To determine the overall length of the stringer splice angle, refer to your aircraft specific TO. However, typically three things will determine the length of your replacement stringer, they are: existing fastener locations, edge distance requirements, and size of the cutout area.

**NOTE:** Generally, keeping four original rivets plus edge distance on both sides of the cutout area is a good rule of thumb.

The stringer splice angle must be one-gage heavier than the original stringer. The procedures for fabricating the splices are as follows:

- After developing the correct bend radius, bend a piece of metal longer than required and having wider flanges than necessary.
- Place the stringer splice angle over the cutout area, ensuring enough overlap is allowed on each side of the cutout area. Drill through the existing fastener holes covered by the stringer splice angle. Install Cleco fasteners.
- With the stringer splice angle fastened in place, scribe cut lines for the proper width required on each of the flanges.
- Remove the stringer splice angle from the original stringer. Trim the flanges to their required width. Also, from the last (outermost) fastener hole drilled, measure out the required edge distance. This step develops the overall length of the stringer splice angle.
- Cut the stringer splice angle to the required length and radius for the ends of both flanges. In most cases, the size of the radius used is equal to the edge distance used for the fastener layout. Should this practice remove too much material from the flanges, a smaller corner radius measurement may be used.

## How to fabricate parts for a combination repair

Up to this point, you've learned the techniques to use in making a flush skin repair and a substructural member repair as separate repairs. In contrast, a combination repair requires repairing the outer skin and a substructural member at the same time. We won't repeat the individual part fabrication techniques here; instead we'll highlight the key points you need to remember when the repairs are combined together.

| Fabricating Parts for Combination Repair | |
|---|---|
| **Procedure** | **Description** |
| Cutout procedures | The combination repair cutouts on the skin and substructural member can be of the same or different size. The amount of damage and the location of existing fasteners determine the size of cutouts. In work situations where the cutouts are of different sizes, always provide protection to other members—whether it's the skin or the substructural member—when you're making the cutouts. |

| Fabricating Parts for Combination Repair | |
|---|---|
| **Procedure** | **Description** |
| Fastener layout procedures | Figure 2–25 shows the complete fastener layout required for a combination repair involving a stringer and skin. Four key points to remember when making this fastener layout are as follows:<br>• Locate the first fastener on either side of the substructural member. It must be edge distance from the edge of the substructural member, *not* from the center of existing fasteners.<br>• Employ the rivet spacing for existing fasteners in the substructural member to obtain row spacing in the fastener layout for the doubler.<br>• Pilot drill all fastener holes; then, just before installing the required fasteners, drill the holes to the proper size.<br>• Use Cleco fasteners to prevent the repair parts from shifting during the drilling operation. |
| Fabrication procedures | There are seven key points to remember when fabricating the repair parts:<br>1. Match the skin filler to the original skin in thickness, temper, material composition, and contour.<br>2. Manufacture skin doublers one-gage thicker than the skin thickness and of the same material composition, temper, and contour as that of the skin area, positioning the doublers alignment (fig. 2–26).<br>3. If the original stringer being repaired is a formed stringer, match the stringer filler to the original stringer. It should be the same thickness, shape, material composition, and temper as the original stringer.<br>4. Follow the procedures outlined for extruded stringers in the applicable structural repair TO to fabricate a required filler replacement.<br>5. Make the stringer splice one-gage thicker than the original stringer; position it inside the original stringer, fitting as closely as possible.<br>6. Use existing fastener locations and spacing to determine the length of the stringer splice. You must pick up a minimum of three existing fasteners on either side of the cutout (fig. 2–27).<br>7. Keep the width of the flanges on the stringer splice equal to the flanges of the original stringer. |

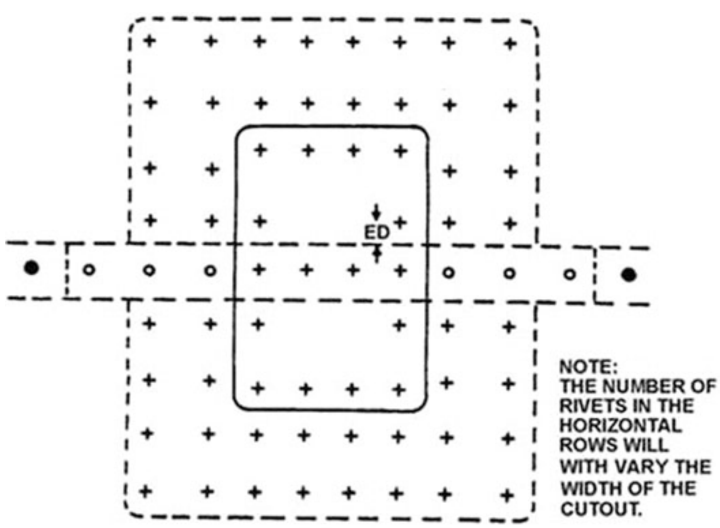



**Figure 2–25. Typical fastener layout— combination repair.**

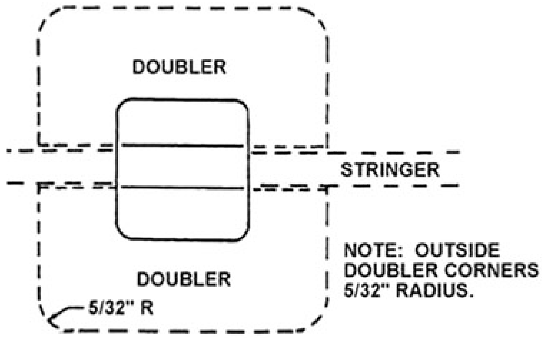



Figure 2–26. Doubler locations—stringer repair.

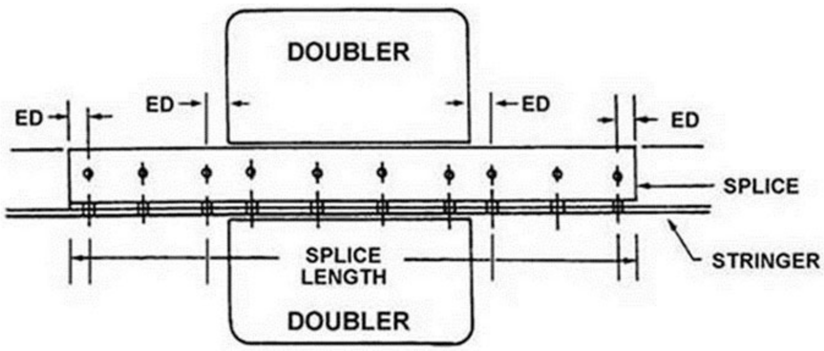



Figure 2–27. Determining the length of a stringer splice angle.

## Split sleeve cold working

Split sleeve cold working is used to increase the fatigue life of structural members and prevent premature fatigue failure. This process is applied to new, predrilled, and stop-drilled holes and countersunk holes.

Cold working is accomplished by pulling an oversized mandrel through a pre-sized split metal sleeve inserted into the hole being expanded. When the oversize mandrel is pulled thru the sleeve it creates a radial force on the hole thus cold working the metal around the hole. This cold working process affects the properties of the metal in an area twice the diameter of the hole (or larger) and greatly decreases the chances of fatigue cracking and stress cracking, without adding weight to the aircraft.

Split sleeve cold working is a tooling critical process. The use of nonconforming or worn tooling reduces fatigue life improvement or can result in extensive rework. Figure 2–28 shows how to check the mandrel to make sure it is not worn. Even though this is a very simple check, it must be accomplished. NEVER assume tooling works correctly. Personnel performing cold working procedures shall be trained and fully qualified.

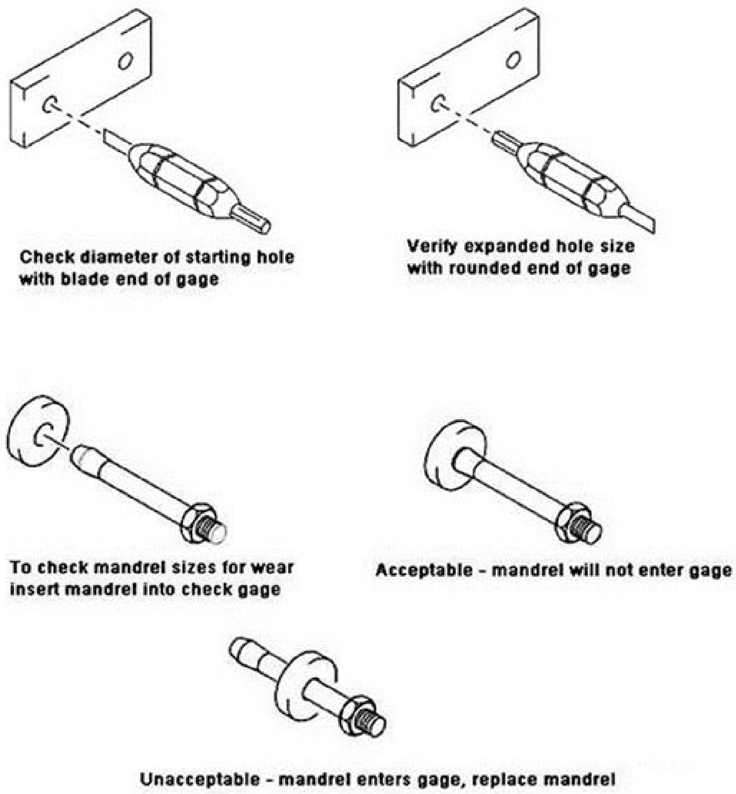



**Figure 2–28. Checking mandrel for proper cold expansion procedure.**

Listed are some general guidelines for split sleeve cold working:

- Holes to be worked shall be free of paint, primer, sealant, lubricant, metal particles, or any other foreign material.
- Strict attention needs to be paid to the initial starting hole diameters, mandrel diameter, and split sleeve gap and wall thickness.
- Split sleeve shall be discarded after one use.
- Cold working must be accomplished before counter boring, spotfacing, or chamfering operations.
- Split sleeve cold working shall be accomplished after final heat treatment, straightening operations, and plating operations.
- Hot forging operations such as dimpling shall not be performed on cold worked holes. These operations are permitted adjacent to cold worked holes provided the temperature in the area within one inch of the hole and does not exceed 130 degrees Fahrenheit (° F).
- Coining operations shall not be performed in or around cold worked holes.
- Minimum thickness of sheet or stack-up shall be greater than 20 percent of the diameter of the hole being cold worked.
- When a stack-up of material is specified to be cold worked, the entire stack-up shall be cold worked at the same time. Repair details shall not be cold worked separately and then combined into a stack-up.

Cold expansion is a simple process but it has to be accomplished step-by-step to be effective. The split sleeve cold working sequence is shown in figure 2–29.

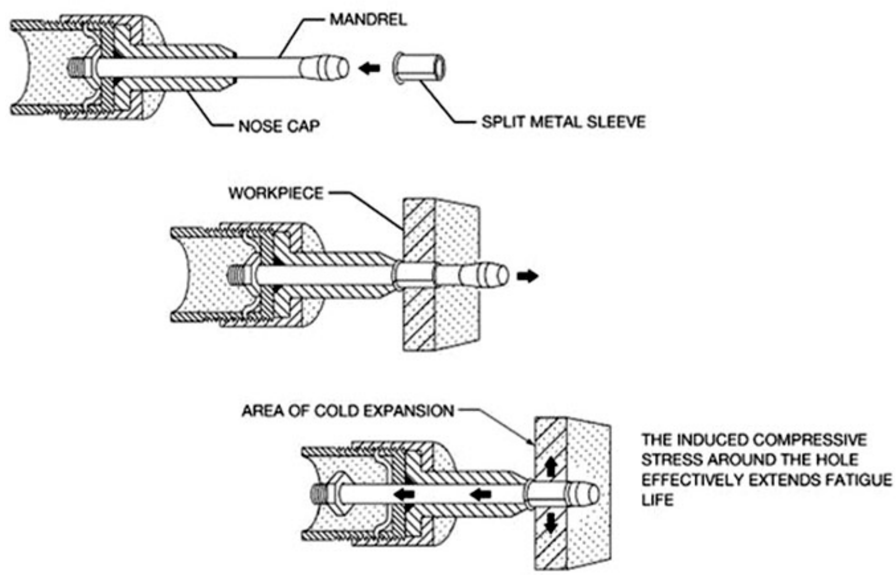



**Figure 2–29. Cold expansion procedure.**

Typical steps are as follows:

- Ensure that the calibration of the kit and components are current.
- Collect the starting hole drill bit, reamers, and check gages.
- Drill starting hole.
- Ream starting hole.
- Check starting hole with the blade end of check gage.
- Select specified mandrel, nose cap, expansion sleeve and final size reamer.
- Do not use countersink mandrels or nose caps on straight holes.
- Install mandrel and nose cap onto puller unit.
- Slide sleeve onto mandrel and insert into starting hole.
- Sleeve must extend a minimum of $^{1}/_{32}$ inch beyond the material.
- Nose cap must be held firmly against work piece.
- Actuate trigger of the puller unit to withdraw mandrel.
- Discard distorted sleeve.
- Verify the expanded hole size by using the rounded end of check gage.

## 216. Repair parts installation

The final step in the repair process is installing the repair parts. All previous steps have been leading up to this final step. The extra time you took in planning and fabricating the repair parts will pay off now. The quality of your workmanship will be reflected by the skills you demonstrate during the installation of repair parts. Therefore, it’s important that you closely observe the procedures discussed here.

### How to install fabricated repair parts

The final operation in completing a repair consists of drilling (and countersinking, if required) the fastener holes to the proper diameter, applying corrosion preventatives, and riveting the repair parts into place.

### *Final drilling procedures*

Before now, you should have pilot drilled all fastener holes. Prior to fastener installation the holes need to be drilled to their final size. When you've drilled the fastener holes to the correct diameter, Cleco the repair part in place on the repair site. This process reduces the possibility of misaligned holes on both the repair parts and the parts being repaired. Also, when countersinking is required—as in the case of a flush patch—have the doubler in place to provide a guide for the pilot on the countersink.

Where a repair part (non-flush repair) is to be installed over countersunk or dimpled holes, you must dimple the fastener holes in the repair part. When you can't dimple the repair part, use tapered washers to fill the countersinks. This action ensures there are no voids between the repair patch and the original part.

When the repair part must be dimpled and the part being repaired has non-countersunk or dimpled holes, you must do *subcountersinking*. Subcountersinking consists of countersinking the fastener holes in the part being repaired so that the dimples fit inside the countersunk areas of the fastener holes. Before subcountersinking, ensure the material being countersunk is thick enough so that it isn't weakened by countersinking. After all holes have been drilled, disassemble the repair parts to file and sand all the edges, and deburr the holes.

### *Application of corrosion preventatives*

Before installing the repair parts, apply a corrosion inhibiting primer to all faying surfaces including the part being repaired. However, before you can apply the primer, you must clean the surfaces. Use a clean, soft rag and an approved solvent to clean the surfaces. Be sure to remove all dirt, grease, and oil from the surface. Remember, there's oil in the pores of your skin so, once you've cleaned the surface, keep your hands off it. Because the solvent may leave a film residue on the surface you need to take another clean, soft rag and remove it. At this point, the area is ready to be primed. Mix the primer before application. When the primer is thoroughly mixed, apply a thin film with a spray gun or brush.

### *Structural sealing*

After final drilling and priming, your next step in the installation process of repair parts is sealing. Most technical orders will require you to perform what is called a sealed structural repair which entails applying a coating of sealant to your repair parts prior to putting them together. As you will learn in a later section sealing is an important component of the repair process. Each repair scenario is going to require some modification but the basic process for performing a sealed structural repair is as follows:

- Clean the parts for the faying surface seal.
- Mix your sealant in accordance with the appropriate technical order or manufacturer's instructions.
- Apply the sealant to the faying surface of the doubler.
- Assemble the repair using Clecos.
- Rivet the repair.
- Continuously clean the excess sealant from the repair.
- Check the repair for faulty rivets or other defects.
- Remove and replace faulty rivets.

## Aerodynamic smoothing compound

After the repair parts have been installed, you may need to apply aerodynamic smoothing compound to the seams, gaps, and manufactured heads of the fasteners. This is required to restore the aerodynamic smoothness requirements to the repair area. It also helps reduce the possibility of corrosion by eliminating areas where dirt and moisture could collect.

Specific types of smoothing compounds or fillers that are used in critical aerodynamic smoothness areas are available for each aircraft. Such compounds are manufactured as pastes, putties, and sealants. Basically, there are two types:

1. One-part compounds: An evaporative type whose chemical action controls the speed of curing.
2. Two-part compounds: Made of a filler and accelerator that controls the setup or curing time.

**NOTE:** Before you select any smoothing compound or filler, consult the applicable technical order for requirements.

| **Aerodynamic Smoothing Compound Procedures** | |
|---|---|
| **Procedure** | **Description** |
| Preparation of area | When you're preparing the area:<br>• Remove all primers or organic paint finishes to a distance along each side of the area (recommended by the applicable TO) to which the filler or smoothing compound is to be applied.<br>• Clean and wipe the area to be filled with approved solvent or a specified cleaner. Apply these cleaners with a clean cheesecloth or brush.<br>• After applying the cleaner, rinse the area clean with water and wipe or allow its surface to dry thoroughly.<br>Repeat the whole cleaning process until the surface is completely free of residual film or any foreign matter. |
| Mixing procedures | Thoroughly mix smoothing compounds or fillers according to the manufacturer's instructions.<br>• Closely follow the directions for mixing found on the label of all containers.<br>• Measure and mix the compounds you use by weight or volume in proportions recommended by the manufacturer.<br>• Always mix these compounds at room temperatures and ensure they're used within a specified time. Improperly mixed compounds lack the ideal consistency, and lead to improper curing and lowered hardness values. Improper mixing also creates air bubbles, which causes pits or holes in the finished surface.<br>Remember that toxic fumes are given off during the blending process. Ventilate the area to minimize these fumes. Never inhale the vapors! |
| Application of compounds | After properly cleaning the surface and thoroughly drying it:<br>• Apply the smoothing compound or filler with a putty knife or spatula.<br>• Work the compound over the area evenly and force it into slots, crevices, or heads of recessed fasteners, allowing a slight (overfill) excess for shrinkage during curing time. |
| Curing and finishing | Allow the smoothing compound or filler to dry (cure) thoroughly according to a specific time given for prevailing conditions.<br>• Consult the applicable TO for the proper curing time at normal room temperatures and for other time intervals acceptable for the specific compound being cured.<br>• After the area has been completely cured (dried), remove the excess compound by filing or sanding, depending on the hardness of the compound surface.<br>• While removing the excess compound, take care to avoid marring the surfaces, preventing unnecessary repairs to the area.<br>Clean the area with recommended cleaners and allow it to dry thoroughly.<br>Prime the area with a suitable primer. |

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 214. Fastener layout techniques

1. How do you measure the following rivet patterns?

   a. Edge distance.

   b. Rivet spacing.

   c. Row spacing.

2. How do you determine the rivet layout to use for a flush skin repair?

3. What's the sequence for developing a circular layout pattern?

4. After you have marked rivet locations on a circular patch, what steps should you accomplish to prevent elongating the rivet holes?

5. How do you determine the number of rivets required in a filler plate?

6. When working on a square layout, what is the first step of the outside layout procedure?

### 215. Fabricating repair parts

1. What procedure do you use to locate fastener holes on the doubler when a flush repair is made in an open area?

2. How do you split a circular doubler so that it may be "turned" into a cutout area?

3. What procedure do you use to develop the outline of a filler plate for a flush patch in an open area?

4. What step must be accomplished before you install a nonflush repair on an aircraft?

5. What is the most accurate method of locating blind fastener holes?

6. What must be marked on the patch plate for a nonflush repair when the fastener layout is developed on the patch plate?

7. What two key measurements are needed to fabricate a stringer filler?

8. How do you locate the proper width of the flange when you’re fabricating a stringer filler?

9. What two factors determine the size of cutouts when you’re making a combination repair?

10. When fabricating repair parts, when do you drill the fastener holes to the proper size?

11. What is the next step after drilling the starting hole during the split sleeve cold working procedure?

12. How far past the material must the split sleeve extend?

13. What is the last step in the split sleeve cold working process?

### 216. Repair parts installation

1. When should the fastener holes in repair parts be drilled to the correct diameter?

2. What should you do first when preparing a repair area for sealant?

3. How do you apply aerodynamic smoothing compound over a repair area?

4. What factor determines how to remove excessive aerodynamic smoothing compound after it has been cured?

## 2–4. Structural Sealing

Certain areas of aircraft structures are sealed compartments where fuels or air must be confined. Some of these areas contain fuel tanks; others consist of pressurized compartments (e.g., the cockpit). Since it's impossible to seal these areas completely airtight or watertight with a riveted joint alone, a sealing compound or sealant is used. You'll find there's a lot to know when you're accomplishing structural sealing. We've designed this section to provide the essential information you need to know to do sealing jobs properly.

### 217. Preparing sealing compounds

When properly applied, sealants prevent the intrusion of moisture from condensation, rain, and salt water as well as dust, dirt, and aircraft fluids into joint areas where they can cause extensive corrosion. Sealants are one of the most important tools for corrosion prevention and control. To be effective, it is critical that the correct sealant be chosen for a specific area/situation and that it be applied correctly. Only qualified personnel thoroughly familiar with sealants and their application shall be permitted to handle and apply them.

#### Sealing compounds

There are many different types of sealing compounds available to you. The type that you use will be dependent on the job at hand and the directives of the specific technical order.

Sealants are used for the following reasons:

- Fuel sealing (fuel tanks and delivery components).
- Pressure area sealing (aircraft cabin areas).
- Weather and fluid sealing (aircraft, missile, and equipment exterior and interior skin and structural joints and surfaces).
- Firewall sealing (engine and ordnance areas).
- Electrical sealing (bulkhead wiring, electrical connectors, and components).
- Acid-resistant sealing (aircraft, missile, and equipment battery compartments, and aircraft relief tubes and waste collection tanks).
- Window sealing (aircraft and equipment windows).

- High temperature sealing (engine areas, anti-icing ducts, and some electronics).
- Aerodynamic sealing/smoothing (aircraft and missile exterior skin surfaces).

### *Sealing terms*

As a low observable aircraft structural maintenance journeyman, you must be familiar with those sealing terms commonly used to describe materials and procedures for maintaining general aircraft sealing. For that reason, the following table of sealing terms is given.

**Sealing Terms**

| Term | Definition |
|---|---|
| Accelerator | An accelerator is an internal curing agent for sealants. |
| Base compound | A base compound is the major component of sealant material used with the accelerator to produce a fuel-, acid-, or water-resistant sealant. |
| Faying surface seal | This is a seal affected by the sandwiching of sealant between mating surfaces of assemblies. |
| Fillet seal | A fillet seal is a bead of sealant applied along structural junctions or seams. |
| Sealant | A sealant is a mixture of a base compound and accelerator. This compound can be a fuel-, acid-, or water-resistant material. |
| Semkit | A plastic cartridge assembly that stores both the sealant accelerator and the base component in separate chambers. |
| Tack-free time | Tack-free time is the length of time it takes for the sealant to become tack-free. A common way to check to see if the sealant is tacky is to lightly touch a dry knuckle to the sealant or topcoat. If your knuckle doesn't stick to the sealant, you don't have a tacky sealant. |

**NOTE:** TO 1–1–691, *Cleaning and Corrosion Prevention and Control, Aerospace and Non-Aerospace Equipment*, contains sealant terms and expressions.

### *Types of sealants*

Different sealant applications require sealant compounds with varying properties, refer to your aircraft specific TO for the sealant required for your application. In addition, you will need varying quantities of materials based on the job so sealants are generally packaged and available as different types of packaging or units of issue (U/I) for your convenience.

1. Two-Part Kit (KT): The package consists of two separate containers, usually metal cans. One contains the catalyst (Part A) and the other contains the base compound (Part B), each in premeasured amounts for mixing together.
2. Cartridge (CA): Cartridges come in two different types; one for single component sealants and one for two component sealants.
   - Single component sealants: Single component sealants are contained in a plastic cartridge or tube in a ready-to-use condition requiring no mixing. If some of a single component sealant remains after a job, it can be stored and used at a future time as long as the cartridge/tube is tightly capped at the nozzle opening to prevent contact with air.
   - Two component sealants: Two component sealants are packaged in Semkits. Mixing of sealant materials is accomplished within the assembly, which is then used for application.

## Preparing sealant compounds

The handling and preparing of sealing compound is critical; so store, mix, and use sealant according to specific directions (e.g., applicable TO instructions and the manufacturer's directions). Deviations from accepted procedures aren't permitted since poor sealing can cause the loss of the aircraft and its people. Your close surveillance of material work-life and cure-time is an absolute requirement.

### *Sealant storage*

You'll find storing instructions for sealants given by manufacturers and contained in the applicable technical orders. Since age limits are established, check all outdated sealants before using them.

All sealants have a specified shelf life. The date of manufacture and the shelf life are listed on each container. The shelf life is dependent on storing the sealant in its original, unopened container in an area where the temperature does not exceed 80° F. To increase a sealants usability, most sealants should not be stored in areas where the temperature exceeds 80° F.

Prior to use, sealant containers must be inspected to determine if the material has exceeded its shelf life. If a sealant has exceeded its original shelf life, then it must not be used until support personnel have verified the batch number has passed update testing.

### *Sealant mixing*

The proper weighing and mixing of components is essential to assure proper curing and adhesion of sealants. Use an appropriate weight scale to accurately measure the materials before blending. Accomplish all mixing in one designated central area in each organization.

#### *Hand mixing*

Sealants consist of two separately packaged components, a base compound (usually Part B) and an accelerator/catalyst (usually Part A) in ½ pint (6 oz.), pint (12 oz.), and quart (24 oz.) kits. The base to accelerator/catalyst ratio varies with different manufacturers of the same type of sealant. It is important, therefore, to mix the material according to the manufacturer's instructions on the kit you are using. Add accelerator/catalyst into the base in the correct ratio and mix until a uniform color is obtained.

Difficulties with curing and/or adhesion of sealants are frequently caused by incomplete mixing. Two component sealants are chemically cured and do not depend on solvent evaporation for curing. Slow hand mixing is recommended for two-component can type kits. A high speed mechanical mixer should not be used as internal heat will be generated thus reducing application life and introducing air into the mixture.

#### *Semkits*

Semkits (fig. 2–30) are compact, two-part mixing application units designed for convenient storage, easy mixing, and proper application of the sealant in small quantities. These kits are a convenient method of sealant mixing because they eliminate the need to measure and handle the materials for mixing and generate less waste.

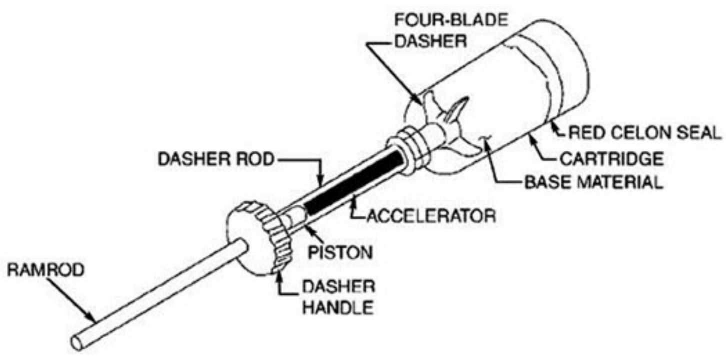



**Figure 2–30. Injection style Semkit.**

The base component of the sealant is packed in standard 2 ½ OZ and 6 OZ cartridges which are placed in a filleting gun or injection gun for application after mixing with the accelerator/catalyst. There are two styles:

1. Barrier style—holds proportioned amounts of the two components separated by an aluminum barrier disc.
2. Injection style—stores the accelerator/catalyst material within the injection rod to separate it from the base compound prior to use. Refer to manufacturer's instructions for the proper mixing sequence.

When using Semkits, note that the handle or the injection/dasher rod contains a pre-measured amount of accelerator/catalyst and should be retained until the ramrod has been operated to break the seal at the bottom of the injection/dasher rod releasing the accelerator/catalyst into the base component and mixing is completed.

## 218. Using sealing compounds

Various types of seals are used to produce a sealed area. Each type has a definite place where it's to be used. Always consult the applicable section of the structural repair TO before you use any sealant. The TO gives you the correct type of sealant to use, and the thickness and type of seal required for various sections of the aircraft.

### How to clean surfaces before sealant application

Obviously, a surface to be sealed must be cleaned immediately before you apply the sealing compound because sealant won't adhere to a surface that hasn't been cleaned completely. Many types of impurities form a film on the surface. The film may not be visible, but it prevents adhesion of the sealant.

To remove foreign materials from the areas to be sealed thoroughly clean these areas and all metal in adjacent areas using an approved solvent/cleaner. Begin at the top of each area to be sealed and work downwards, using a clean, lint-free cheesecloth pad saturated with the cleaning solvent. The solvent floats foreign materials (e.g., oil, grease, dirt, etc.) to the surface, making it easy for you to wipe away the materials from the surface with a dry, lint-free cheesecloth. However, don't allow all of the solvent to evaporate from the surface before wiping it because some or all of the foreign materials gets re-deposited on the surfaces and can't be removed with a dry cloth. Also, never dip the pad into a fresh supply of solvent. Instead, pour the solution onto the cheesecloth to avoid contaminating the solvent with the oil or dirt that may have collected on the cloth. Use a stiff bristle brush to clean more effectively around bolts, rivets, and other hardware. Of course, use a clean piece of cheesecloth to clean each new area.

During the whole cleaning operation, always ensure there's adequate ventilation. This is required because cleaning solvents are toxic and flammable. Never use an excess amount of any cleaner. Don't touch the area with your fingers. If you do, oil from your skin leaves a film on the metal to which sealant cannot adhere. Continue the cleaning process until there's no discoloration on the clean drying cloth.

### Applying seals

Since materials, type, and application procedures vary with different models of aircraft, use the appropriate method of application to properly seal different areas of the structures. Even though there are many different types of seals, it is very important that during any type of application you don't allow the recently sealed areas to become contaminated with foreign material. Also, don't allow the fresh, uncured sealant to be dislodged by jarring or vibration. If it's necessary for you to work near or on the repaired part before the sealant is cured, use a cloth-backed tape to cover the sealant. Covering the sealant prevents damage and keeps foreign materials off the sealed area.

In the following paragraphs, we'll describe the types—faying-surface sealing, fillet sealing, injection seals, and fastener seals—and explain their uses.

### *Faying-surface sealing*

This type of seal (fig. 2–31) is applied between the contacting surfaces of two or more parts. There are two types of faying-surface seals: removable and permanent.

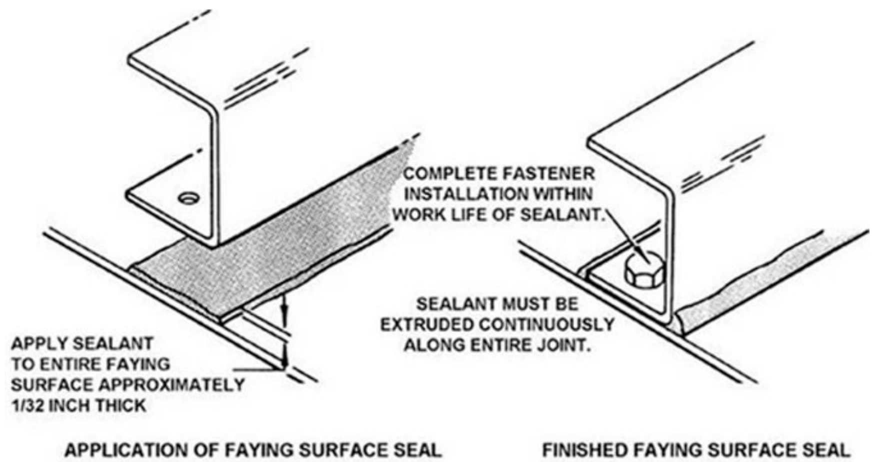



**Figure 2–31. Faying-surface sealing.**

The removable type is used around access doors, removable panels, inspection plates, windows, and so forth. In contrast, the permanent type is used between parts of a structure fastened together permanently. In some instances, the permanent type is used to produce a block-off seal to effect a seal between parts where a fillet seal means extensive sealing and where the assembly sequence restricts the use of fillet seals.

As we mentioned earlier, faying-surface sealing is the application of sealant between mating surfaces of attached parts. To apply the sealant, coat one surface with sealant before assembling the parts. Be sure to apply enough sealant to form a bead of excess sealant along the joint after assembly. Assemble the parts while the sealant is freshly mixed.

### *Fillet sealing*

The fillet, or seam, seal (fig. 2–32) is a primary seal and the most common type found on an aircraft. Note that fillet seals are used to cover structural joints along stiffeners, skin butts, walls, spars, and longerons, and to seal around fittings and fasteners. Also, this type is the most easily repaired and the most efficient seal that can be produced.

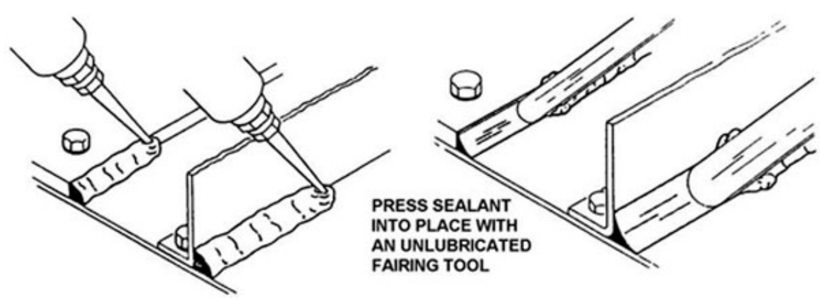



**Figure 2–32. Fillet seal.**

To attain the structural dimensions, make a single application of sealant using a sealing gun (fig. 2–33). When applying sealant using the gun, the nozzle tip must be pointed into the seam and held at a 45 angle to the line of travel. This forces the bead of sealant to precede the gun tip, which minimizes air entrapment. Work fillets into seams with fairing tools. Such tools enable you to work the sealant into seams, and to level and smooth the sealant after the application is completed. Remember; avoid air bubbles as much as possible during this operation. Allow the sealant to cure at least to the tack-free stage before moving the assembly.

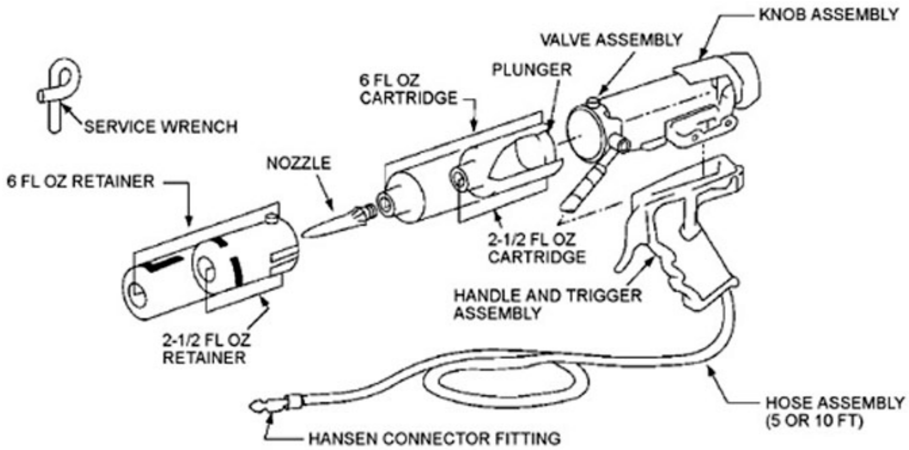



**Figure 2–33. Filleting gun.**

### *Fastener seals*

Fasteners can be sealed during or after assembly. Refer to the aircraft specific TO for procedures on how and when to seal fasteners.

### Adhesion promoters

Solvent based adhesion promoters are hygroscopic (absorb moisture) and must be kept away from moisture. Discard material if it becomes cloudy or a precipitate is formed. Some sealing compounds may require the application of a special primer or adhesion promoter prior to sealant application in order to develop a good adhesive bond with the surface. Use only those primers or adhesion promoters recommended by the manufacturer for their product.

### Work life and curing factors

The time required to cure sealant depends on three factors:

1. Application of the sealant.
2. Ambient temperature.
3. Relative humidity.

For example, high temperature and high humidity shorten the cure; low temperature and low humidity lengthen the cure time. Therefore, a long work-life sealant requires a longer curing period than a short work-life material.

Cure can be accelerated by using heat; however, the sealant temperature shouldn’t exceed 120° F. Accelerated heat may be supplied by hot-air blowers, heat lamps, or by pre-warming the structure.

The addition of water vapor to raise the relative humidity to about 60 percent (the ideal relative humidity for sealant curing) shortens the cure life of a two-part sealant.

### Sealant defects and repair or replace conditions

Being able to create a seal is very important. Of equal importance is being able to inspect seals and, when necessary, remove defective sealant seals.

Repair or replace sealants is necessary when any of the following seven conditions are present:

- The sealant is peeled away from the structure.
- Seams are exposed through a fillet seal.
- The fillet or hole-filling sealant is exposed through the coating.
- The sealant is damaged because of removal and installation of fasteners, access doors, or other sealed parts.
- Cracks or abrasions exist in the sealant.
- Air bubbles appear in the sealant (air bubbles expand at high altitude, resulting in damage to the seal).
- Leakage occurs between sealed faying surfaces.

Only plastic shall be used to manufacture sealant removal and application tools. Properly and completely removing sealant is imperative to the repair process

## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

### 217. Preparing sealing compounds

1. Match the term in column B with its definition in column A. Items in column B are used only once.

| *Column A* | *Column B* |
|---|---|
| _____ (1) Internal curing agent for sealants. | a. Sealant. |
| _____ (2) A bead of sealant applied along structural junctions or seams. | b. Accelerator. |
| _____ (3) A seal affected by the sandwiching of sealant between mating surfaces. | c. Faying-surface seal. |
| _____ (4) Mixture of a base compound and accelerator used to cure a water-resistant material. | d. Fillet seal. |
| _____ (5) The major component of sealant material. | e. Base compound. |

2. How can you increase the usability of most sealants?

3. Why shouldn’t a high speed mechanical mixer be used to mix two-part sealants?

4. When using a Semkit, how do you get the accelerator into the base component?

### 218. Using sealing compounds

1. How do you clean a surface before applying sealant?

2. What must you do to keep from contaminating the cleaning solvent while you're engaged in the cleaning process?

3. What main safety precaution must you follow when you're using cleaning solvents?

4. When is the cleaning process completed?

5. When you're doing a job where you must work near or on the repair part before the sealant is cured, what must you do to protect the sealant?

6. To properly apply a fillet seal, how do you position the nozzle tip?

7. After applying sealant, how long should you wait before moving the assembly containing the sealant?

8. What three methods can you use to apply heat to a sealant to accelerate the curing time?

9. What step is required if a sealant contains trapped air bubbles?

## Answers to Self-Test Questions

**209**

1. Fuselage, wings, engines, landing gear, and empennage.
2. Fuselage.
3. Wings.
4. They provide the power for the forward thrust of the aircraft.
5. Provides a means for the aircraft to take off and land, support and directional control of the aircraft while on the ground and provides a cushioning effect that absorbs shock during landing and taxiing.
6. (1) e.
   (2) c.
   (3) a.
   (4) f.
   (5) b.
   (6) d.
7. (1) c.

(2) e.
(3) a.
(4) f.
(5) d.
(6) b.

8. (1) c.
   (2) d.
   (3) b.
   (4) a.

**210**

1. Inspect the skin and all supporting structures for cracks and deformation.
2. When performing a visual inspection.
3. Compare the results to a tap test of other like parts that are known to be good.
4. Visually check for scratches, nicks (chipping), cracks, bubbles, delaminations, fractures, crazing and optical distortion.

**211**

1. Negligible, Repairable by Patching, Repairable by Insertion, and Necessitating Replacement.
2. Necessitating Replacement, if the damage is excessive and the material required for repair exceeds the cost of a new component then it would be financially responsible to replace the part.
3. Class II.
4. The damage would be classified as repairable if there are broken filaments: if no broken filaments exist than the classification would be negligible.
5. It should be smooth, with only slight visual distortions, the delamination will be near the edge of the plastic and spreads inward or along the edge, the appearance maybe milky and difficult to detect except at an angle.

**212**

1. By using the proper corner radii.
2. Edge distance from the cutout to the nearest fastener and allowance for the fastener spacing required in the filler and doublers.
3. Where needed space is required for proper spacing of fasteners in the repair parts.
4. (1) The material that's damaged.
   (2) Location of the damage.
   (3) Equipment located behind the damaged area.
5. By inserting a scrap piece of metal between the substructural member and the skin.
6. Do no damage to surrounding structural members or equipment.
7. So the replacement part fits properly.
8. Insert a scrap piece of metal between the substructural member and the skin.
9. It may be necessary to refer to them for repair information in later repair steps.

**213**

1. By assessing the length and geometry of the crack, the area in which the crack occurs, the rate of propagation, and the depth.
2. Drill or counter bore a 0.25-inch diameter crack stop hole through the structure at each end of the crack so that the center of the hole is 0.10 inch beyond the visible end of the crack.
3. Fill the stop drilled hole with a rivet or aerodynamic filler.

**214**

1. (a) Measure the distance from the center of the first rivet to the edge of the sheet.

(b) Measure the distance from the center of a rivet to the center of a neighboring rivet in the same row.

(c) Measure the perpendicular distance between the rivet rows.

2. By the shape and location of the skin cutout.
3. The rows outside the cutout are laid out first; then, after the repair parts have been fabricated, the inner row is laid out.
4. Center punch and pilot drill all rivet locations only to the required size.
5. Identify the size of the cutout area and guidelines stated in the applicable structural repair TO.
6. Locate the first rivet row the proper edge distance from the cutout.

**215**

1. Use the fastener pattern on the undamaged skin as a template and pilot drill through the fastener layout on the skin.
2. Cut the doubler between the fastener locations, ensuring the proper edge distance is maintained.
3. Position the material behind the cutout; then, scribe the outline of the cutout on the material.
4. Consult the TO or applicable structural repair manual.
5. Hole finder.
6. Location of the cutout or damaged area.
7. (1) Bend radius. (2) Width of flanges.
8. By positioning the filler into the cutout and scribing a cut line between the two ends of the original stringer.
9. (1) The amount of damage to each member. (2) Location of existing fasteners.
10. Just before installing the required fasteners
11. Ream the starting hole.
12. Sleeve must extend a minimum of 1/32” beyond the material.
13. Verify the expanded hole size by using the rounded end of check gage.

**216**

1. Just before fastener installation
2. Remove all primers or organic paint finishes to a distance along each side of the area (recommended by the applicable TO) to which the filler or smoothing compound is to be applied.
3. Apply evenly and force it into slots, crevices, or heads of recessed fasteners, allowing a slight (overfill) excess for shrinkage during cure.
4. Compound surface hardness.

**217**

1. (1) b.
   (2) d.
   (3) c.
   (4) a.
   (5) e.
2. Do not store the sealants in areas where the temperature exceeds 80°F.
3. Internal heat will be generated thus reducing application life and introducing air into the mixture.
4. Use the ramrod to break the seal at the bottom of the injection/dasher rod releasing the accelerator/catalyst into the base component.

**218**

1. Begin at the top of each area to be sealed and work downwards, using a clean, lint-free cheesecloth pad saturated with the cleaning solvent.
2. Never dip the pad into a fresh supply of solvent; pour the solution onto the cheesecloth.
3. Ensure there’s adequate ventilation.

4. When there's no discoloration on a clean drying cloth.
5. Use a cloth-backed tape to cover the sealant.
6. Maintained at a 45° angle to the line of travel.
7. Until the sealant reaches the tack-free stage.
8. (1) Hot-air blowers.
   (2) Heat lamps.
   (3) Pre-warming the structure being sealed.
9. Repair or replace the sealant.

**Do the unit review exercises before going to the next unit.**

## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

**Do not return your answer sheet to AFCDA.**

18. (209) What stabilizes an aircraft along the *longitudinal* axis?
    a. Wings.
    b. Nacelles.
    c. Fuselage.
    d. Empennage.

19. (209) What reduces sway or yaw about the *vertical* axis of an aircraft?
    a. Wings.
    b. Fuselage.
    c. Vertical stabilizer.
    d. Horizontal stabilizer.

20. (209) When the cockpit control is moved to the *right*, the right
    a. and left ailerons move up.
    b. and left ailerons move down.
    c. aileron moves up and the left aileron moves down.
    d. aileron moves down and the left aileron moves up.

21. (209) Which of these is an *auxiliary* flight control?
    a. Flap.
    b. Rudder.
    c. Elevator.
    d. Stabilizer.

22. (210) When performing a visual inspection on nicked plastic assemblies, what are you looking for?
    a. Nicked area is near the edge of the plastic and spreading inward.
    b. White powdered glass is often seen in a chipped area.
    c. Visibility through the nicked area is slight.
    d. Chipped area has a smooth appearance.

23. (210) When inspecting for distortions besides excellent lighting what else do you use?
    a. A grid made up of horizontal and vertical lines.
    b. Viewing lines through panel at a distance of at least 40ft away.
    c. A dark background placed outside of the panel while viewing from inside.
    d. A dark grid made up of parallel curved lines of varying lengths and thicknesses.

24. (211) When classifying damage to a composite structure, a puncture of a fiberglass panel that extends through one facing is which classification?
    a. Repairable.
    b. Class III.
    c. Class II.
    d. Class I.

25. (212) When preparing a cutout for an “open area,” you should remove all damage and
    a. stop-drill all cracks.
    b. relieve stress concentrations.
    c. ensure the cutout is centered over a substructural member.
    d. anneal the cutout areas so the area is not work-hardened during the cutout operation.

26. (212) One way to prevent substructure damage when making a skin cutout is to
    a. use a dubbed drill bit.
    b. remove the substructure.
    c. use a rotary file with a flat bottom.
    d. use a scrap piece of metal between the skin and substructural member.

27. (212) You must consider the location of any existing fasteners near a damaged area when determining the
    a. overall size of the cutout.
    b. material thickness of the repair parts.
    c. number of fasteners required for the repair.
    d. classification of the repair to be accomplished.

28. (213) What size drill bit would you use to stop drill a crack in a .032 inch skin?
    a. 0.025.
    b. 0.125.
    c. 0.225.
    d. 0.325.

29. (213) An angle drill is used to remove damage when
    a. the damage is in a limited space.
    b. the skin and substructural damage cutout are the same.
    c. the skin and substructural damage cutout are *not* the same.
    d. only the skin is damaged and the substructural member is intact.

30. (214) Rivet spacing refers to the
    a. perpendicular distance between the rivet rows.
    b. distance between the rows in a two-row layout.
    c. distance from the center of the first rivet to the edge of the sheet.
    d. distance between the centers of neighboring rivets in the same row.

31. (214) Before you develop a rivet layout for a circular flush repair, you *must first* establish the
    a. center point of the cutout area.
    b. head style of the rivets to be used.
    c. rivet spacing required on the filler plate.
    d. direction of the stress concentrations within the part being repaired.

32. (215) When fabricating a filler plate for a flush skin repair in an open area, you determine the overall dimensions of the filler by
    a. using the cutout area as a template.
    b. using the dimensions of a previously installed flush repair.
    c. measuring the damaged area before making the skin cutout.
    d. multiplying the length of the damage by the width of the damage, and adding the edge distance requirements.

33. (215) In which situation is a fastener layout *more than likely* done on the patch instead of the repair part?
    a. Open area with existing fasteners.
    b. Blind area with existing fasteners.
    c. Open area with no existing fasteners.
    d. Blind area with no existing fasteners.

34. (215) The *key* measurements for fabricating a filler angle for a stringer splice repair are the
    a. length and width of the cutout.
    b. width of flanges and bend radii.
    c. width of flanges and length of cutout.
    d. size of cutout and thickness of the material composition.

35. (215) The fastener holes for the repair parts used in a combination repair are drilled to the required diameters
    a. before you make the installation.
    b. during the fabrication procedures.
    c. before you begin the fabrication procedures.
    d. after you've completed the countersinking or dimpling.

36. (215) What percentage of the diameter of the hole being cold worked shall the *minimum* thickness of sheet or stack-up be
    a. 10%.
    b. 15%.
    c. 20%.
    d. 25%.

37. (216) As it applies to the installation of repair parts, what is a *primer* and when is it applied?
    a. Cleaning solvent; applied before painting.
    b. Precleaning agent; applied before using an approved solvent.
    c. Corrosion preventative; applied before the installation of repair parts.
    d. Bonding agent; applied on repair parts to provide a base for a corrosion preventative.

38. (216) Before applying an aerodynamic smoothing compound to repair seams,
    a. smooth the edges with sandpaper.
    b. clean the area with distilled water.
    c. smooth the edges with a rotary file.
    d. clean the area with an approved solvent.

39. (216) The method you use to remove excess aerodynamic smoothing compound from seams depends on the
    a. hardness of the material sealed.
    b. hardness of the compound surface.
    c. amount of heat used to cure the compound.
    d. temperature and relative humidity at the time the compound was applied.

40. (217) What type of seal is produced by sandwiching sealant between mating surfaces?
    a. Fillet.
    b. Faying.
    c. Contact.
    d. Injection.

41. (217) When preparing to mix a two-part sealant, you mix the sealant in accordance with the
    a. job guide.
    b. technical order.
    c. shop operating instructions.
    d. manufacturer's instructions.

42. (218) To clean dirt and grease from a surface to be sealed, you use
    a. soapy water.
    b. alkaline cleaner.
    c. an approved solvent/cleaner.
    d. a high pressure water blaster.

43. (218) When the technical order (TO) calls for a *permanent type of seal between two parts*, you install a
    a. fillet seal.
    b. injection seal.
    c. faying surface seal.
    d. close tolerance seal.

44. (218) Sealants that have a long work-life *normally* have a
    a. long curing period.
    b. short curing period.
    c. curing temperature above 120° F.
    d. 3-percent addition of deionized water.

45. (218) What do you use to fabricate a sealant removal tool?
    a. Brass.
    b. Plastic.
    c. Aluminum.
    d. Stainless steel.

**Please read the unit menu for unit 3 and continue ➔**

# Unit 3. Corrosion



WITH THE ARRIVAL OF THE IRON AGE, iron became our basic construction metal. This metal was soft, had little strength, and corroded very rapidly in certain environments. It was discovered that, when milk was poured over the metal surface, particles of butterfat would form a passive film; thus isolating the metal from the corrosive environment. As we progressed from the Iron Age into what may be called the Alloy Age, iron was replaced as the basic construction metal. We found that we could combine metallic elements into metals that were stronger than iron. Then the problems of corrosion control became even more acute because the metals were exposed to new and more varied environments. Simply placing butterfat on the surfaces no longer sufficed, so more corrosion-resistant surface protections had to be developed. Modern-day research has provided many corrosion-resistant materials (e.g., organic coatings, chemical films, and corrosion-preventive compounds).

## 3–1. Process

Controlling corrosion is of major importance in all of aircraft maintenance. Our national security depends on the reliability of our weapons system. Corrosion can weaken structural components enough to destroy system reliability. This weakening will eventually require major repairs or replacement of the entire system. Such repairs or replacements are costly and time-consuming. It is impossible to compute the exact cost of corrosion to aerospace industry, but experts have estimated it at billions of dollars annually. Much of this waste is a result of a lack of knowledge on the subject of corrosion control. To control corrosion effectively, you must thoroughly understand corrosion reaction and types of corrosion that occur.

### 219. Corrosion cell

Corrosion is the electrochemical deterioration of a metal because of its chemical reaction with the surrounding environment. This reaction occurs due to the tendency of metals to return to their naturally occurring states. For example, iron in the presence of moisture and air will return to its natural state, iron oxide or rust. Aluminum and magnesium form corrosion products that are white oxides or hydroxides. The most common type of corrosion (and the one that can be treated most effectively by maintenance personnel) is electrochemical corrosion. To understand the mechanics of the corrosion process, you must first have a good science foundation. Let’s discuss some of the basic chemical terms that you need to know.

| Term | Definition |
|---|---|
| Physical Properties | Describes a specimen's color, odor, taste, density, and freezing point. |
| Chemical Properties | Refers to the way matter reacts when it is placed in contact with other kinds of matter. For example, hydrogen combines with oxygen to produce water. |
| Atom | An atom is the smallest unit of an element. The atom is composed of three principal parts:<br>1. Protons, which have a positive charge;<br>2. Electrons, which have a negative charge; and<br>3. Neutrons, which have no charge but contribute to the weight of the atom.<br>An atom has an equal number of protons and electrons and is electrically neutral (stable). |
| Electron | A negatively charged particle. An electric current occurs when electrons are forced to move through metal conductors. |
| Ion | An ion is an atom that has gained or lost electrons and has acquired an electrical charge. If one electron is lost, the ion has a positive charge. If one electron is gained, the ion has a negative charge. |

## Components

As you study the electrochemical process of corrosion, you will find that corrosion is a flow of electricity between certain areas on a single metal surface or between two different kinds of metals. For the electrochemical-corrosion process to occur there must be four components: (1) anode, (2) cathode, (3) metal path (conductor), and (4) electrolyte (fig. 3–1). If you remove any one of the four components, the corrosion will stop.

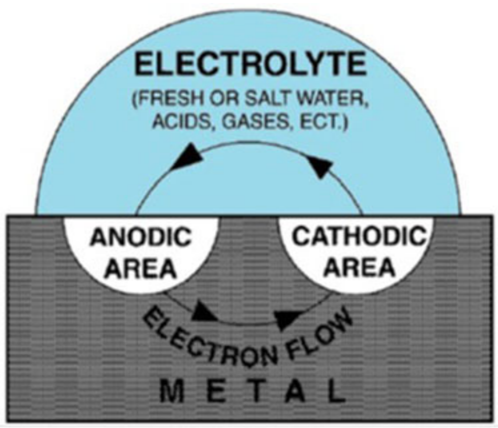



**Figure 3–1. Simplified corrosion cell.**

| Term | Definition |
|---|---|
| Anode | The metal that corrodes; it is the most active. In the electrochemical cell, the anode is the only component that deteriorates. |
| Cathode | Causes the anode metal to corrode. The cathode metal is more passive, stronger, and draws electrons from the anode. |
| Metal path | Also, known as the conductor. This is where the anode metal and cathode metal connect (touch) and where the transfer of electrons occurs. The electrons flow from the anode to cathode. |
| Electrolyte | The electrolyte is any liquid path that can hold an ion. The electrolyte is the most important factor; it is the only condition that can be controlled. The example in figure 3-2 shows the paint acting as a barrier and keeping the electrolyte from coming into contact with the other three components. |

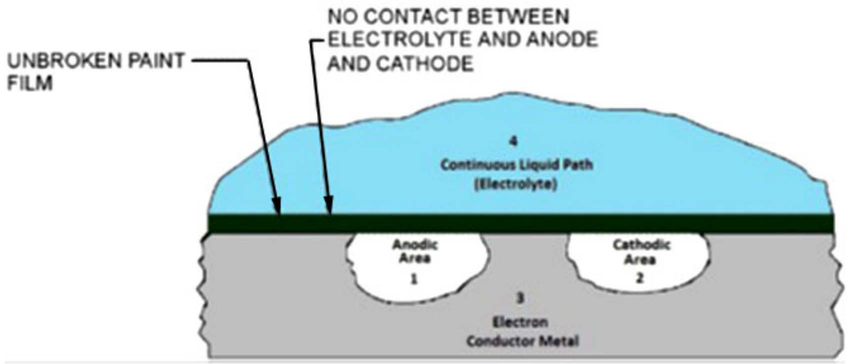



**Figure 3–2. Metal protected from electrolyte.**

### Development

All corrosion begins on the surface, because that is where the electrolyte first makes contact with the metal. If the corrosion is allowed to stay on the metal surface, the surface will become rough and frosted leaving a powdery deposit. The corrosion will eventually begin to penetrate below the surface of the metal attacking the grain structure. In some cases, corrosion will produce an oxidized film that will slow down or stop the corrosion attack. However, that is dependent how tightly the oxidized film adheres to the metal. If the film is loose, the electrolyte will go straight through the film and the corrosion will continue to attack the metal. If the film is tight (passive film) like on noble metals (e.g., titanium, stainless steel, platinum) the oxidized film will stop the corrosion attack.

## 220. Factors

In any corrosion process, one or more factors may influence the corrosion rate. We do not try to list the factors in any order of importance because, in a specific environment, a different factor may influence the corrosion rate. Instead, we discuss the influence of metals, electrolytes, other elements such as biological organisms.

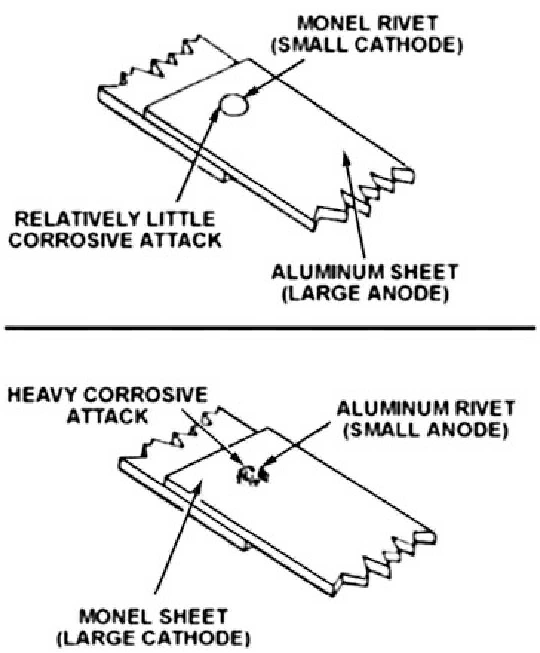



**Figure 3–3. Effects of area relationships.**

## Influence of metals

The characteristics of a metal that determine its tendency to corrode include the anode-to-cathode surface area, type of metal, electrode potential, surface texture, and the metal's ability to passivate itself.

### *Anode-to-cathode surface area*

The rate of corrosion depends on the size of the parts in contact. If the corroding metal (the anode) is smaller than the surface of the passive metal (the cathode), the corrosion will be rapid and severe. When the corroding metal (anode) is larger, the rate of corrosion will be slow and superficial, as shown in figure 3–3.

Ideally, the large anode to small cathode relationship is better in components used in aerospace structures. The ideal situation would be to have the same materials in contact but this is not always possible due to factors such as strength requirements, stress applications, component configurations and so forth.

### *Type*

Corrosion can occur on surfaces of metal that are less resistant and result in the formation of pits and intergranular corrosion. The most commonly used metals in aerospace construction are aluminum, magnesium, steel, stainless steel (also known as corrosion resistant steel, or CRES), and titanium.

These metals have a wide range of corrosion resistance and require varied degrees of protection from a corrosive environment. The most active metals, such as magnesium and aluminum, corrode easily. The metals susceptible to corrosive attack are referred to as *anodic* and are listed at the top of the table.

Passive metals, such as stainless steel and titanium, however, corrode slowly. These metals are listed at the bottom of the table and are referred to as *cathodic*. One of the biggest factors affecting the rate of this corrosive attack is the galvanic difference between the metals. The closer the metals are to each other on the chart (fig. 3–4), the less severe the corrosion. The farther apart they are on the chart the more severe the corrosion.

### *Passivation*

Some metals and alloys have the inherent ability to become electrochemically inactive or passive under certain conditions because of the formation of oxide films that make a metal nobler. For instance, in figure 3–4 you find that stainless steel is not far below ordinary steel in its active state, but in its passive state it is one of the more noble metals.

Chromate coatings can protect commonly used metals that do not form natural highly resistant oxide films. If the metal is exposed to electrolytes, it can be protected by the addition of an inhibitor to its liquid environment.

Passivity reduces the corrosion rate by doing the following:

1. Reducing the potential difference between the anode and the cathode.
2. Polarizing the anode.
3. Polarizing the cathode.

Passivation can result from any of the above actions, acting separately or together.

**ANODIC (High Corrosion Potential)**

Lithium
Magnesium Alloys
Zinc (plate)
Beryllium
Cadmium (plate)
Uranium (depleted)
Aluminum Alloys
Indium
Tin (plate)
Stainless Steel 430 (active)
Lead
1010 Steel
Cast Iron
Stainless Steel 410 (active)
Copper (plate)
Nickel (plate)
AM 350 (active)
Chromium (plate)
Stainless Steels 350, 310, 301, 304 (active)
Stainless Steels 430, 410 (passive)
Stainless Steel 13-8, 17-7PH (active)
Brass, yellow, Naval
Stainless Steel 316L (active)
Bronze 220
Copper 110
Stainless Steel 347 (active)
Copper-Nickel 715
Stainless Steel 202 (active)
Monel 400
Stainless Steel 201 (active)
Stainless Steels 321, 316 (active)
Stainless Steels 309 13-8 17-7 PH (passive)
Stainless Steels 304, 301, 321 (passive)
Stainless Steels 201, 31, 6L (passive)
Stainless Steel 286 (active)
AM355 (active)
Stainless Steel 202 (passive)
Carpenter 20 (passive)
AM355 (passive)
Titanium Alloys
AM350 (passive)
Silver
Palladium
Gold
Rhodium
Platinum
Carbon/Graphite

**CATHODIC (Low corrosion potential)**

**Figure 3–4. Galvanic series of metals and alloys.**

## Electrolytes and electrolyte concentration

An electrolyte is like a wire that carries electricity from point A to point B. It carries the charges between the anode and the cathode, which in turn cause corrosion. Electrically conducting solutions are easily formed on metallic surfaces when condensation, salt spray, rain, or rinse water accumulate. Dirt, salt, acidic stack gases, and engine exhaust gases can dissolve on wet surfaces, increasing the electrical conductivity of the electrolyte, thereby increasing the rate of corrosion. Corrosion will also occur if the concentration of the electrolyte on the surface varies from one location to another. This corrosive situation is known as a *concentration cell*.

Another factor to consider is the strength of the electrolyte. The strength of an electrolyte is measured according to the potential of hydrogen (pH) scale. This scale represents how acidic a substance is, or how basic (alkaline) it is. It runs from 0-14, with 7 being neutral. The further the pH is from 7 (either higher or lower) the stronger the electrolyte. Figure 3–5 illustrates the pH scale and the pH values of common substances.

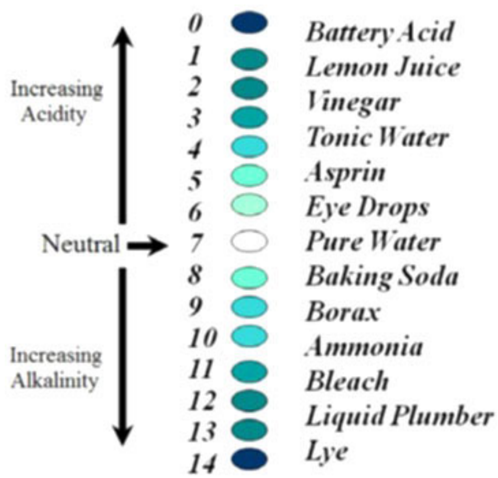



**Figure 3–5 Potential of hydrogen (pH) scale.**

## Other factors to consider

Some other factors that affect corrosion are oxygen, temperature, time, biological organisms, and mechanical stresses.

### *Oxygen*

When some of the electrolyte on a metal surface is partially confined (such as between faying surfaces or in a deep crevice) metal in this confined area corrodes more rapidly than other metal surfaces of the same part outside this area. Corrosion occurs more rapidly than would be expected because the reduced oxygen content of the confined electrolyte causes the adjacent metal to become anodic to other metal surface areas on the same part immersed in electrolyte exposed to the air.

### *Temperature*

Higher temperature environments tend to produce more rapid corrosion due to accelerated chemical reactions and, in humid environments, higher concentration of water vapor in the air. In addition, nightly drops in temperature can cause greater amounts of condensation, leading to increased corrosion rates.

### *Time*

Along with the other factors just discussed, probably one of the most overlooked items affecting the rate of corrosion is the period of time in which the electrolyte is allowed to be in contact with the surface. It is important to keep the exposure time of the electrolyte on the surface to a minimum. To slow the progression of corrosion, the metal should be kept as clean and dry as possible.

### *Biological organisms*

Certain living organisms in contact with metal surfaces tend to destroy the metal. In some cases, microbiological bacteria reduce the rate of corrosion, but in most cases, they assist in the formation of electrochemical corrosion cells. Slimes, molds, fungi, and other living organisms (some microscopic) can grow on damp surfaces. Once they are well established, the area tends to remain damp, increasing the possibility of corrosion. Their presence can cause the areas they occupy to have different oxygen and electrolyte concentrations. In addition, corrosive wastes are secreted, which cause corrosion.

### *Mechanical stress*

Almost all alloys used in aircraft construction are sensitive to a form of corrosion known as stress corrosion cracking. Manufacturing processes such as machining, forming, welding, or heat treatment can leave stresses in aircraft parts. This residual stress and/or stress applied to a part causes corrosion to proceed more rapidly in structurally important regions of the part until failure occurs.

## 221. Types

In this lesson we cover some of the common types of corrosion you are likely to encounter on the job. This is not a complete listing of all types of corrosion; you can consult TO 1–1–691, *Cleaning and Corrosion Prevention and Control. Aerospace and Non-Aerospace Equipment*, for a more comprehensive listing.

### Uniform surface corrosion

Uniform surface corrosion results from a direct chemical attack on a metal surface. These chemicals can be salts deposited from coastal operations, urine spray, battery acid spillage, or gases absorbed from the environment. Three factors can produce cyclical corrosion of this type: chemicals, water, and oxygen. On a polished surface, uniform surface corrosion is first seen as a general dulling of the surface as shown in figure 3–6. If it continues, the surface becomes rough and sometimes frosted. Uniform surface corrosion is not usually very severe, and it can be removed with chemical and mechanical methods. The more common name for this type of corrosion is *uniform etch*.

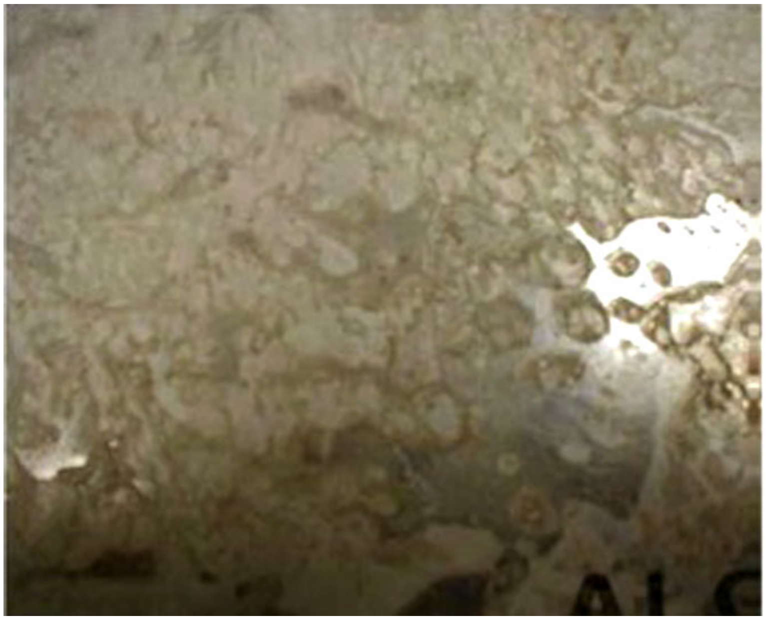


**Figure 3–6. Uniform surface corrosion.**

### Galvanic corrosion

Galvanic corrosion occurs when dissimilar metals are in contact with each other in the presence of an electrolyte, such as salt water. It is usually recognizable by the buildup of corrosion at the joint between the metals. In figure 3–7, the steel fastener installed in the magnesium sheet metal is corroding in the presence of the electrolyte. A common source of galvanic corrosion on aircraft is piano hinges; the hinge is made of aluminum (anode) but the pin is made of steel (cathode). Over time, the aluminum will start to corrode around the pin area. The severity of the corrosion will depend on the size of the cathode verses the anode, strength of the electrolyte, and the dissimilarity of metals.

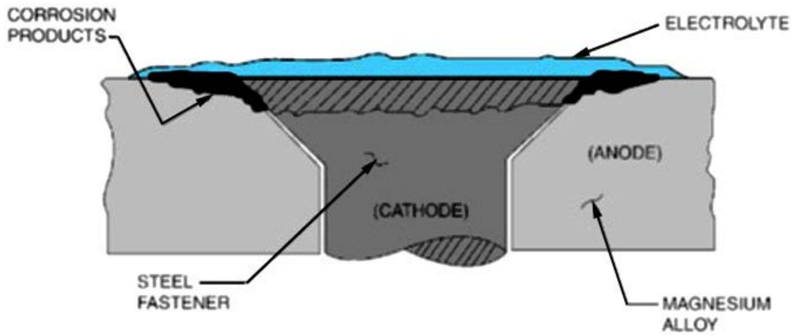



**Figure 3–7. Galvanic corrosion.**

## Pitting corrosion

Pitting corrosion is a localized attack that is caused by small, anodic and cathodic areas in the metal. The combination of small active anodes to large passive cathodes causes severe pitting, as shown in figure 3–8. Pitting corrosion of aluminum or magnesium is first noticed as white or gray powdery deposits that blotch the surface. When you clean away these deposits, you find tiny pits or holes.

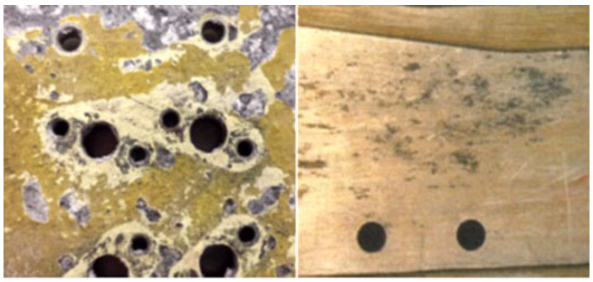


**Figure 3–8. Pitting corrosion.**

## Intergranular corrosion

Intergranular corrosion is a selective attack along a metal's grain boundaries. A highly magnified cross-section of an alloyed metal (fig. 3–9) shows the metal's granular structure consisting of a large number of individual grains, each grain with a definite grain boundary. Frequently, the grain boundaries are anodic (tend to corrode more easily) to the metal within the grain. As shown in figure 3–10, when in contact with an electrolyte, rapid corrosion occurs at the grain boundaries. Intergranular corrosion can be detected with some types of nondestructive techniques. Unfortunately, by the time it is discovered, the corrosion is usually so severe that the component must be replaced.

**Figure 3–9. Cross section of 7075-T6 aluminum alloy.**

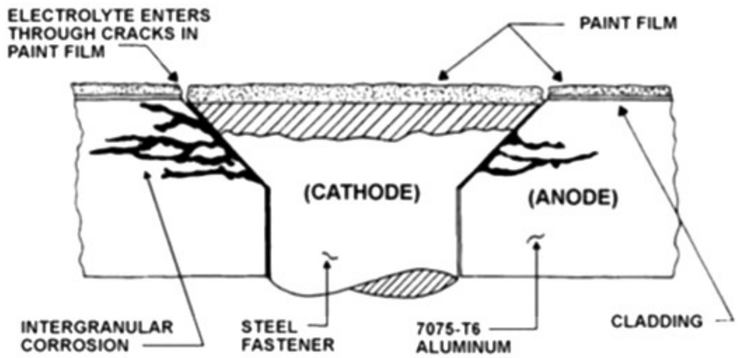



**Figure 3–10. Intergranular corrosion.**

## Exfoliation

Exfoliation corrosion is the advanced form of intergranular corrosion. The expanding corrosion products that form at the grain boundaries forces the grains of the metal to lift up as shown in figure 3–11. Exfoliation corrosion is found on extruded, rolled, wrought or forged aluminum and magnesium parts. Just as with intergranular corrosion, exfoliation corrosion usually constitutes replacement of the material.

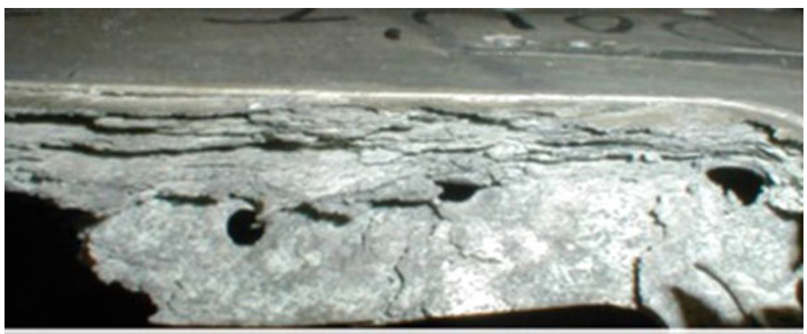


**Figure 3–11. Exfoliation corrosion.**

## Crevice/concentration cell corrosion

Just as two dissimilar metals that are joined cause corrosion, so do dissimilar conditions within the electrolyte. Crevice corrosion occurs when the electrolyte has a different concentration from one area to another. Electrolyte inside the crevice contains less oxygen and more metal ions than electrolyte just outside the crevice. As a result, the metal surfaces, even though they may be part of the same metal, have different activities and corrosion occurs inside the crevice. Another term for this type of corrosion is concentration cell. We will discuss the three general types of crevice/concentration cell: metal ion cell, oxygen concentration cell, and active-passive cell.

### *Metal ion cell*

Stagnant electrolytes under faying surfaces will normally have a high concentration of metal ions, while a low concentration of metal ions will exist adjacent to the crevice created by the faying surface. The area of the metal in contact with the higher concentration of metal ions will be cathodic and not show signs of corrosion, but the area in contact with the lower metal ion concentration will be anodic and suffer corrosion. A typical metal ion cell may be found around a riveted lap joint, as shown in figure 3–12. This reaction is caused by the relatively high ion concentration in the stagnant area just under the edge of a lap joint; the lower ion concentrations are at the outer surface of the lap joint.

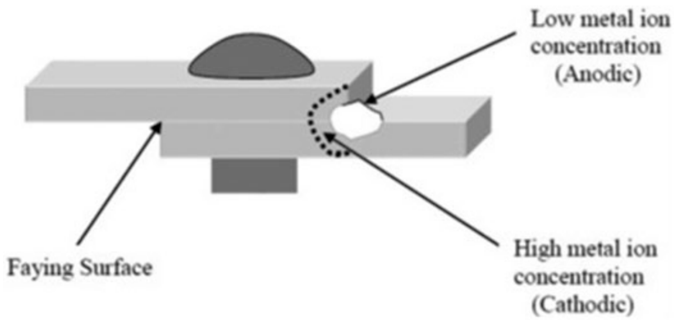



**Figure 3–12. Metal ion cell corrosion.**

### *Oxygen concentration cell*

Oxygen concentration cells occur when an electrolyte contains varying amounts of dissolved oxygen. A crevice, sharp corner, or lap joint can keep the oxygen from dissolving uniformly throughout the electrolyte. This non-uniform electrolyte will create an electrochemical corrosion cell.

Typical locations of oxygen concentration cells are under either metallic or nonmetallic deposits (dirt) on the metal surface and under faying surfaces such as riveted lap joints. Oxygen cells can also develop under gaskets, wood, rubber, plastic tape, and other materials in contact with the metal surface. Corrosion will occur in the area of low oxygen concentration (anode) as illustrated in figure 3–13.

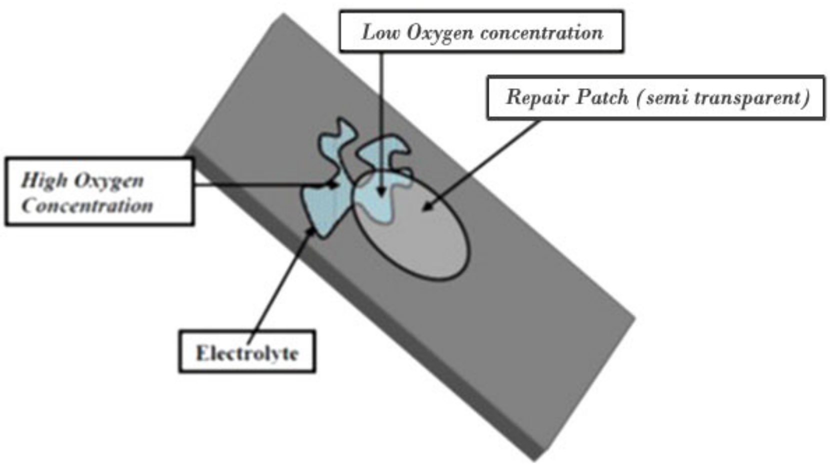



**Figure 3–13. Oxygen concentration cell corrosion.**

### *Active-passive cell*

Metals that rely on a tightly adherent oxide film for corrosion prevention are prone to active-passive concentration cell corrosion. These metals (e.g., pure aluminum, titanium, and corrosion-resistant steels) form their own corrosion-resistant films; if the film is broken, it immediately repairs itself as long as the metal is in contact with the oxygen. If the surface becomes contaminated with foreign materials (e.g., with carbon, salt, or dirt deposits) and the oxygen cannot reach the surface, the oxide film beneath the deposit will be broken. The passive film around the break will be cathodic to the active metal, producing an active-passive concentration cell. The small anodic area will corrode rapidly due to the much larger area of the surrounding cathode (passive film). The result is rapid pitting of the surface, as illustrated in figure 3–14.

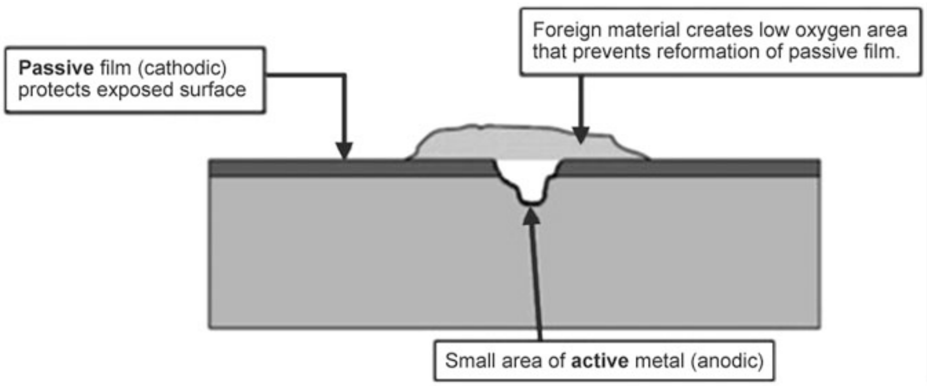



Figure 3–14. Active-passive cell corrosion.

### Filiform corrosion

Occasionally, metals with organic coatings undergo a type of corrosion that results in numerous threadlike filaments (wormlike) of corrosion products under the coating (fig. 3–15). This type of corrosion is caused by the diffusion of oxygen and water through the coating and is considered a special type of oxygen concentration cell. Filiform corrosion can attack steel, magnesium, and aluminum surfaces. This may lead to more serious corrosions in some locations. You can control or curtail filiform corrosion by storing aircraft and equipment in a low humidity environment, maintaining coatings in good condition, and by washing equipment and aircraft to remove acidic contaminants from the surface.

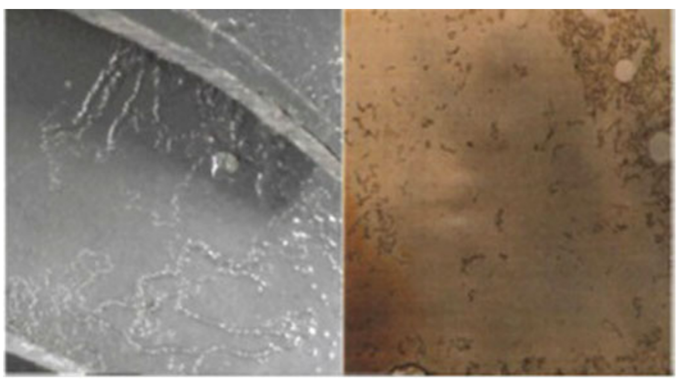


Figure 3–15. Filiform corrosion.

### Stress-cracking corrosion

The simultaneous effects of tensile stress and a corrosive environment produce stress-cracking corrosion (fig. 3–16). If a part in a stressed condition is in contact with an electrolyte, severe corrosion can occur. The primary cause of stress-cracking corrosion is that the material is under constant stress or load in a corrosive environment. The corrosive environment combined with the stress causes a fracture of the material at the stressed area.

Often internal stresses are produced by non-uniform deformation during cold working, such as bending a piece of metal, driving rivets, bolting, and press fitting. Any metal that has been cold-worked should be stress-relieved (annealed) before it is subjected to a corrosive environment. When a crack appears, it usually runs parallel to the granular structure of the metal.

**Figure 3–16. Stress cracking corrosion.**

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 219. Corrosion cell

1. Match each term in column B with its definition in column A. Column B items may be used only once.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Smallest unit of an element. | a. Physical properties. |
| ____ (2) Color, odor, taste, and density. | b. Chemical properties. |
| ____ (3) The way matter reacts with other matter. | c. Electron. |
| ____ (4) A negatively charged particle. | d. Atom. |
| ____ (5) An atom that has lost or gained electrons. | e. Ion |

2. What are the parts of a corrosion cell?

3. If any one of the four components is eliminated what happens to the corrosion cell?

4. What component deteriorates in a corrosion cell?

5. What component of a corrosion cell is a liquid?

6. Where does corrosion development begin? Why?

7. Generally, what do corrosion products look like on metal?

### 220. Factors

1. What are the characteristics of a metal that determine its tendency to corrode?

2. How does the anode to cathode relationship affect the rate of corrosion?

3. How do the galvanic differences of the metals on the Galvanic series of metals and alloys chart affect corrosion?

4. How does passivation reduce the corrosion rate?

5. What scale is used to measure the strength of an electrolyte? How is it used to determine strength?

6. How does temperature affect the rate of corrosion?

7. What is the most overlooked item affecting the rate of corrosion?

8. How do biological organisms, such as slimes, molds, and fungi, affect the surface of metal?

### 221. Types

1. Match the type of corrosion in column B to the definition in column A. Items in column B may be used once, more than once, or not at all.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Expanding corrosion products just below medal surface cause a blister to form. | a. Uniform surface. |
| ____ (2) Selective attack along a metal's grain boundaries. | b. Pitting. |
| ____ (3) Threadlike filaments of corrosion products. | c. Intergranular. |
| ____ (4) Metal cracks parallel to granular structure of the metal. | d. Exfoliation. |
| ____ (5) Recognized by the presence of corrosion products where dissimilar metals are joined together. | e. Galvanic. |
| ____ (6) Direct chemical attack. | f. Concentration cell. |
| ____ (7) Localized attack. | g. Stress cracking. |
| ____ (8) A crevice, sharp corner, or lap joint can keep the oxygen from dissolving uniformly throughout the electrolyte. | h. Filiform. |

## 3–2. Inspection and Removal Procedures

Corrosion is a major problem affecting the operational capabilities of present-day equipment. In the previous section you learned about the different types of corrosion, now you need to learn how to spot it on aircraft and support equipment. Once you find the corrosion, it will need to be removed before it causes further damage. This section focuses on procedures for finding and removing corrosion from Air Force (AF) equipment.

### 222. Types of inspection equipment

You need to know what equipment you will need before you can start inspecting for corrosion. The inspection equipment you use will vary from inspection to inspection due to differences in specific aircraft and equipment. You need to be familiar with the function and use of each item. This lesson discusses the tools most commonly used for inspection.

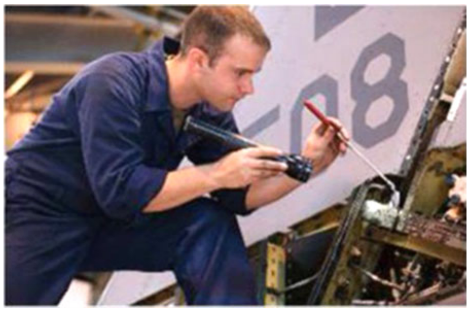


**Figure 3–17. Inspection mirror usage.**

#### Flashlight

A flashlight is your light source for corrosion inspection of interior or dark surfaces. If you are working around open fuel cells or areas where fuel leaks are expected, you must use an explosion proof flashlight.

#### Inspection mirror

An inspection mirror aids in inspecting hard to see areas. As you can see in figure 3–17, the mirror is being used to inspect the interior portion of the structure that would otherwise be difficult to see.

### Plastic scraper

If blisters, bubbles, or other coating irregularities are present, attempt to dislodge the paint by scraping with a sharp plastic scraper. If paint does not dislodge easily, the irregularity is probably a sag or run that is confined to the paint film itself and no further action is necessary.

### Magnifying glass

You will usually use a 10X power magnifying glass to get a closer look at the area you are inspecting. This gives you a zoomed in view of the surface and the suspected damage.

### Straight edge

A straight edge, such as a scale, can be used to check for areas that have already been reworked to remove corrosion. This is accomplished by placing the straight edge across the area being examined at various angles and checking for irregularities, low spots, or depressions as shown in figure 3–18.

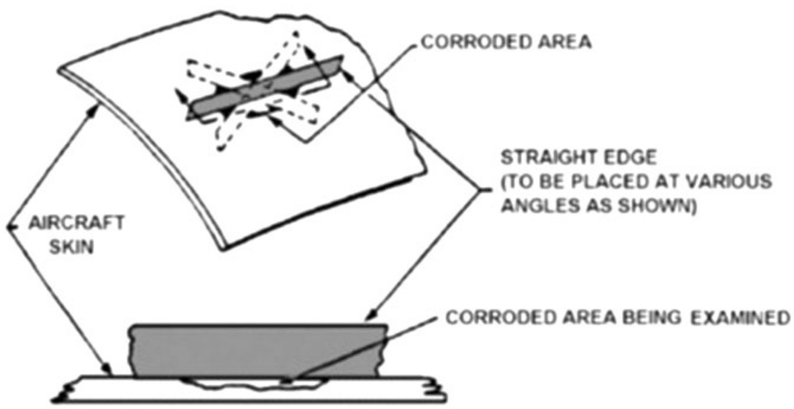



**Figure 3–18. Straightedge inspection.**

### Depth gauges

Depth gauges are tools used to measure the depth of corrosion pits and areas reworked for pitting, exfoliation and other types of corrosion to determine the extent of corrosion damage and the amount of metal removed during rework. It is not suitable for determining the depth of a stress corrosion or corrosion fatigue crack due to the relatively large size of the indicator pin.

Before you measure any pits you *must* zero the gage. Take several depth readings in the affected area and select the deepest reading as the corrosion damage depth. You can find the maximum pit depth by subtracting the C reading (pit depth) from the average of the A and B readings (wing surface). To get the average of A and B, add the readings and divide by 2. The pit depth is determined by the formula:

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

### Optical micrometer

The optical micrometer (fig. 3–19) is used to measure the depth of scratches, cracks, pits, reworked areas, and the height of spurs and other protrusions. To use this equipment, place it over the area you are trying to measure and turn the thimble either clockwise or counter-clockwise until the surface comes into sharp focus; obtain the reading from the vernier scale located on the micrometer. The vernier scale is not easy to read so an experienced technician with the proper training is required to read the scale accurately. To find the depth of a corrosion pit the micrometer is first focused on the highest surface in the area of interest and a reading is taken. Next, a second reading is taken on the lowest. The difference between the readings is the distance between the two surfaces.

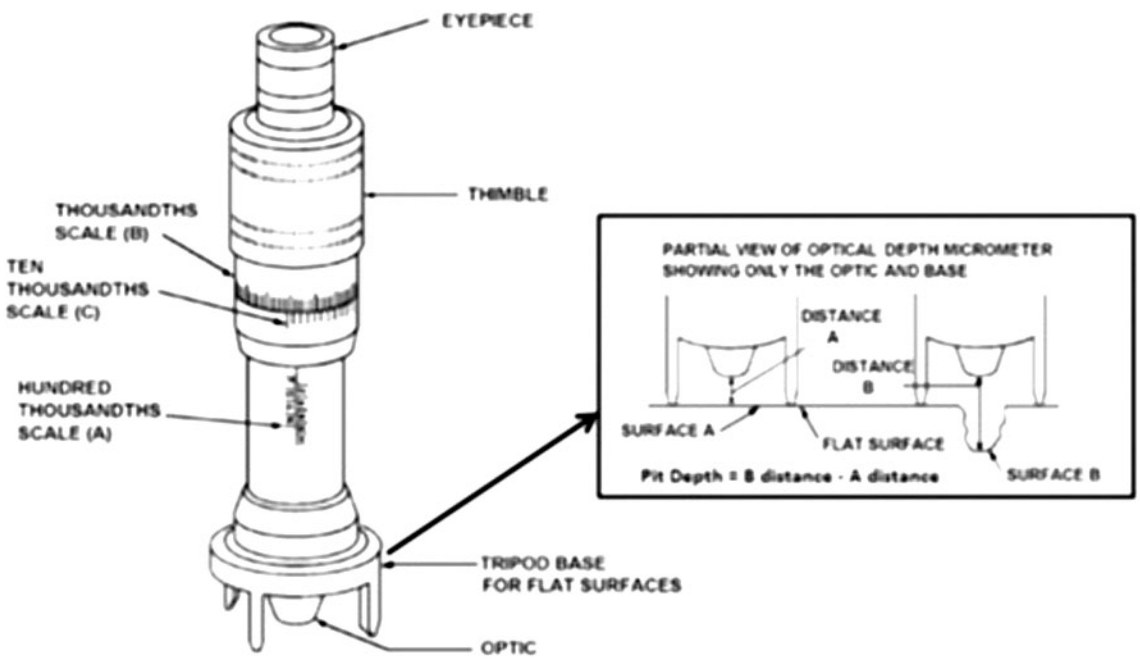



**Figure 3–19. Optical micrometer.**

### Borescope

The borescope (fig. 3–20) is used to aid in the inspection of interior surfaces that are not accessible by any other method. Insert the head assembly into any cavity having a large enough opening. With the cavity illuminated, visually inspect its interior for defects, such as corrosion.

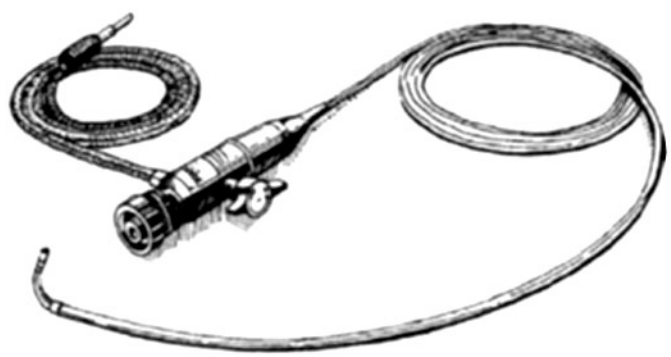


**Figure 3–20. Borescope assembly.**

## 223. Inspection procedures

As mentioned before, if corrosion is left untreated it can cause parts to fail. In order to remove the corrosion and prevent it from spreading, we must first know what areas to inspect and how often the inspections should be accomplished. In this lesson, you'll learn about the different surfaces susceptible to corrosion, as well as the different types of inspection.

### Surfaces susceptible to corrosion

As stated previously, all surfaces are susceptible to corrosion. Although most of the surfaces discussed below are only applicable to aircraft, some of same principles can be used when inspecting support equipment. Obviously, support equipment does not have landing gear, but you will find areas such as fasteners, piano hinges, and possibly battery compartments. Keep in mind the areas discussed below are not all-inclusive; always refer to the applicable equipment or aircraft TO for proper corrosion inspection guidance.

### *External surfaces*

The many external surfaces respond to the corrosive effects of the environment in various ways. The following areas are known problem areas.

#### *Fasteners*

There are hundreds to thousands of fasteners on aircraft, missile and equipment exterior surfaces, and areas around these fasteners are trouble spots. These areas are subject to high operational loads and strains that can cause paint to crack around the fasteners. Once the paint cracks, it provides a path for corrosive materials to enter the joint between fastener heads and skin panels. These high operational strains and moisture intrusion makes the skin material vulnerable to corrosion at fastener locations.

#### *Exhaust paths*

Jet and reciprocating engine exhaust deposits are very corrosive; particularly troublesome are seams, fairings, and fasteners in their paths (fig. 3–21). Exhaust deposits can be trapped in these areas and not be reached by normal cleaning methods; therefore, exhaust paths must be cleaned thoroughly and inspected frequently. Crevice types of corrosion are common in engine exhaust areas.

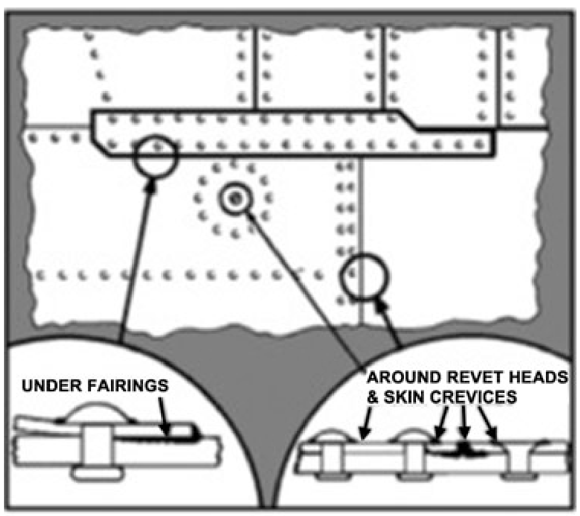



**Figure 3–21. Exhaust path corrosion.**

#### *Rocket and gun blast areas*

Surfaces in the path of rocket and gun blasts are particularly subject to corrosive attack and deterioration. These surfaces include gun compartment venting systems, spent ammunition collection chutes, and jet assist rocket and missile exhaust paths (fig. 2–22). In addition to the corrosive effect of the gases and exhaust deposits, the protective finish is often blistered by heat, blasted away by the high-velocity gases, or abraded by spent shell casings and solid particles from gun and rocket exhausts. Watch these areas for corrosion and clean them carefully after firing.

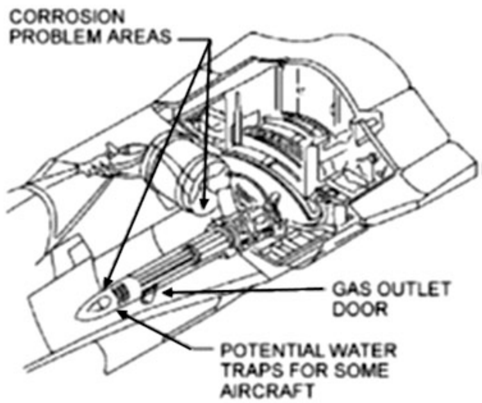



**Figure 3–22. Gun blast area corrosion points.**

### *Engine frontal areas and air inlet ducts*

The engine frontal areas and air inlet ducts are constantly abraded by airborne dirt and dust; bits of gravel from runways; and eroded by rain, all of which can remove the protective finish. The constant flow of moist air over these surfaces makes them prime targets of corrosion. Special attention should be given to the following areas:

- Engine frontal areas should be inspected for general surface corrosion, pitting, and intergranular corrosion.
- Leading edges of air inlet ducts, including hardware inside ducts, should be inspected for damaged/deteriorated protective coating, galvanic corrosion at fastener locations, general surface corrosion, and exfoliation corrosion.
- Air cooler cores, reciprocating engine cylinder fins and engine accessory mounting bases are usually not painted and are vulnerable to corrosion when moist, salty air flows over the surface. These areas should be inspected for general surface corrosion and pitting.

### *Spot welds*

The chief cause of corrosion of spot welded metals is the entrance and entrapment of corrosive agents between the layers of metal. Corrosion in these areas is usually caused by moisture working its way in through open gaps and seams (fig. 3–23). If left untreated the corrosion can cause skin buckling or spot weld bulging, and eventual spot-weld fracture. You can detect skin bulge in its early stages by sighting along a spot weld seam or by using a straight edge. The only technique that prevents this condition is to keep potential moisture entry points (e.g., gaps and seams) filled with a sealant or a suitable preservative compound.

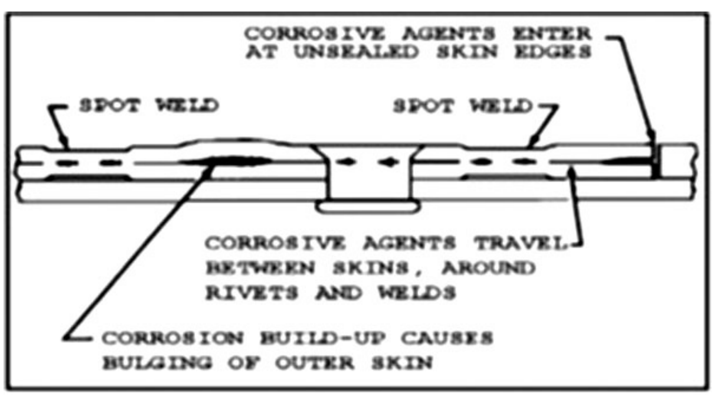



**Figure 3–23. Corroded spot weld.**

*Piano hinges*

Corrosion on piano hinges is still a problem on aircraft. Not only are they prime spots for galvanic corrosion because of the dissimilar metal contact between the steel pin and the aluminum hinge tangs, but they are also natural traps for dirt, salt, and moisture. Figure 3–24 shows areas where hidden corrosion occurs.

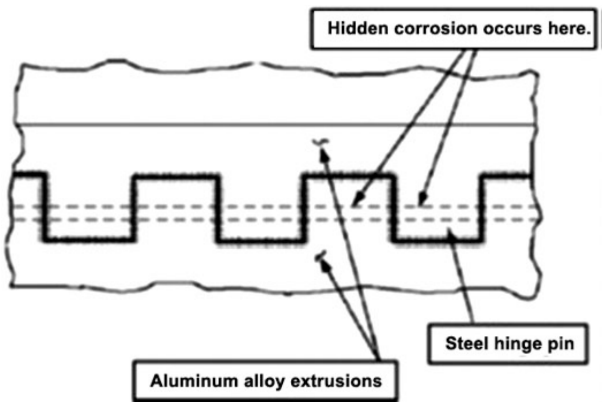



**Figure 3–24. Hinge corrosion points.**

*Composites*

Composites are used increasingly in modern aircraft. These advanced surfaces have improved corrosion resistance, but they require attention on corrosion inspections for evidence of erosion to the skin and corrosion to the attaching hardware (e.g., steel pins and plates). Pay particular attention to graphite fiber composites. Galvanic corrosion can occur any time graphite is in contact with other metal surfaces. Inspect the surrounding areas visually for evidence of corrosion.

*Painted surfaces*

Just because the section you are inspecting has paint on it, do not overlook it. Areas with coatings are often subject to corrosion. Look for signs of bubbling of the paint, blistering of the coating, cracks in the paint, scratches that have penetrated the primer coating, or any other damage that may expose even the slightest area to corrosive attack.

*Miscellaneous trouble areas*

Areas likely to collect moisture from condensation are around antennas, radomes, and external lights. Inspect all bolts, rivets, and other fasteners for improper installation and signs of corrosion. Another area to check is the seams. Check them for cracks in the sealant and improper rivet fit. For aircraft, give special attention to fixtures on the lower fuselage.

***Internal surfaces***

Now that we've covered external surfaces susceptible to corrosion, let's turn our attention to internal surfaces that are subject to corrosion.

*Electronic compartments*

Electronic and electrical package compartments, cooled by ram air or compressor bleed air, are subjected to the same conditions as engine and accessory cooling vents and engine frontal areas. The degree of their exposure is less because a smaller volume of air passes through them, and special design features keep 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, and should be inspected for these conditions during routine checks as thoroughly as their design permits. If design features hinder examination while the items are installed, corrosion control specialists should take advantage of the component's removal for other reasons to inspect the items carefully. As a precaution, corrosion in an electrical or electronic component should be treated only by, or under the direction of, personnel familiar with the function of the component; conventional corrosion treatment can damage some units.

*Battery compartments*

In spite of protective paint systems and extensive sealing and venting provisions, battery compartments continue to be corrosion problem areas. The fumes from overheated battery electrolyte are hard to contain and they can spread to adjacent internal cavities, causing rapid corrosion on unprotected surfaces. If the openings are on the skin surfaces, include these areas as part of your battery compartment inspection and maintenance. Frequent cleaning and neutralization of battery electrolytes minimizes corrosion from this cause.

*Galleys, lavatories, and relief tube outlets*

Areas where spilled food and waste products can collect (particularly the deck area behind lavatories, sinks, and ranges) are potential trouble spots if they are not kept clean. Even if some contaminants are not corrosive, they can still attract and hold moisture, which, in turn, causes corrosion. Pay attention to bilge areas under galleys and lavatories, and to relief tube outlets. Human waste products are very corrosive to common aircraft metals. The relief tubes are usually made of plastic and do not present a corrosion problem, but the surrounding metallic aircraft fuselage structure can be severely corroded by urine products. Clean these areas frequently and touch up the paint whenever necessary

*Water entrapment areas*

Design specifications require that aircraft have drains installed in all areas where water may collect, but in many cases, these drains are ineffective: either because of improper location or sealants, fasteners, dirt, grease, and/or other debris have plugged them. The plugging of a single drain hole or the altering of the attitude of the aircraft can cause serious structural defect if salt water or other corrosives remain for any significant amount of time in one of these entrapment areas.

Daily inspection and cleaning, if necessary, of low point drains is a standard requirement. These areas may accumulate water following washing or rinsing of aircraft. Where this is a recurring problem, field units shall request the aircraft system program director (SPD) to develop procedures to prevent water accumulation. Field units shall not drill drain holes unless specifically authorized by the aircraft SPD.

*Bilge areas*

Aircraft bilge areas are natural collection points (i.e., low points/areas in an aircraft fuselage) for water, salt water, dirt, loose fasteners, drill shavings, and other debris. Check to make sure the bilge areas are free of debris and fluids and the protective finish system is in good condition.

*Flap and slat recesses*

Flap and slat recesses/wells, and equipment installed in them normally are hidden from view since flaps and slats are usually maintained in the retracted/closed position when an aircraft is on the ground. These areas may experience corrosion that goes unnoticed unless special inspections are performed.

*Faying surfaces and crevices*

These surfaces are very susceptible to corrosion because moisture and corrosion products collect there. Similar to corrosion around fasteners, corrosion in faying surfaces, seams, and joints is caused by the intrusion of corrosive fluids or agents. The effect of the corrosion in joint areas is usually detectable as bulging of the skin surface.

*Wheel wells and landing gear*

The wheel-well area probably gets more punishment than any other area of the aircraft. The wheel wells are exposed to water spray, mud, salt and other runway deicing agents, gravel, and other flying debris from runways during taxis, takeoffs, and landings. Because of the complicated shapes, assemblies, and fittings in the area (fig. 3–25) it is difficult to maintain a protective paint film. In inspecting this area, pay particular attention to these trouble spots:

- Magnesium wheels, especially around bolt heads, lugs, locking rings, and wheel-web areas, particularly for the presence of entrapped water or its effects.
- Exposed position indicator switches and other electrical equipment.
- Crevices between stiffeners, ribs, and lower skin surfaces, which are typical water and debris traps.

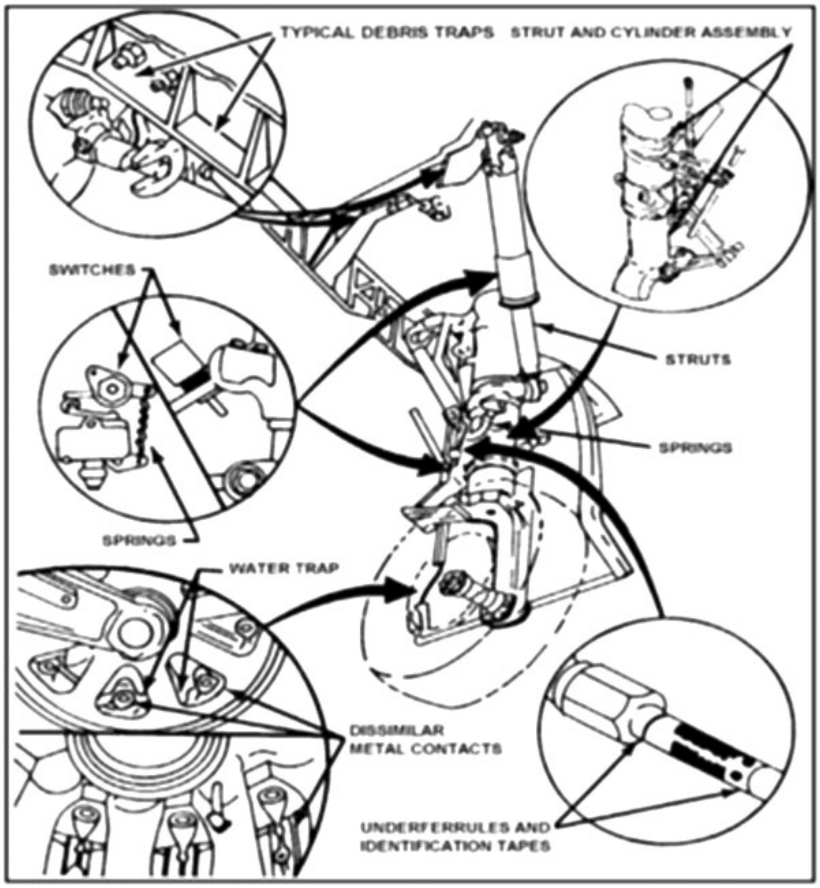



**Figure 3–25. Landing gear corrosion points.**

## Inspection guidelines

The frequency of corrosion inspection depends on humidity, temperature, and geographic location. An aircraft and equipment must be inspected carefully for corrosion in accordance with its corrosion inspection workcards. Inspections assure detection, removal, and inhibition of corrosion, and should constitute a major part of the overall corrosion control program.

### *Frequency*

The aircraft SPD and/or the missile or equipment system program manager (SPM) establish the frequency and extent of inspections. However, during scheduled or unscheduled maintenance actions, aircraft, missiles, or equipment and their components should be inspected visually for corrosion.

Additional inspections of areas particularly prone to corrode, such as magnesium gearboxes, wheel and control surface wells, and bilge areas, repaired areas may also be necessary.

### *General inspections*

Adequate corrosion inspection is not an isolated technique, but must be done in a series of cleanups and inspections. The procedures listed below are general guidelines; always follow your aircraft or equipment specific TO when performing a corrosion inspection.

1. Ensure the area or areas being inspected have been thoroughly cleaned in accordance with the applicable TO.
2. If corrosion is suspected, examine the area with a 10X magnifying glass and flashlight. Pay particular attention to edges of skin panels, rivet heads, and other corrosion prone areas. If blisters, bubbles, or other coating irregularities are present, attempt to dislodge the paint by scraping with a sharp plastic tool. If paint does not dislodge easily, the irregularity is probably a sag or run which is confined to the paint film itself and no further action is necessary
3. Where paint is removed, inspect and determine the extent/degree of corrosion.
4. Remove corrosion, clean and treat the surface, and touch-up paint in accordance with the applicable TO.

**NOTE:** Some aircraft specific TOs require you to mark areas that have been *corrosion reworked to the maximum limits allowed.* All airframes are different so ensure you are using the aircraft specific TO.

### *Detailed inspections*

A detailed inspection of aircraft, missiles, and equipment is required if the corrosion damage found during a general inspection is suspected to be extensive or severe as specified in appropriate system specific aircraft, missile, or equipment TO. This requires the NDI workcenter to perform a more detailed look with methods such as ultrasonic, eddy current, fluorescent penetrant, or radiography inspections.

### *Documentation*

The areas that meet the maximum rework limits must be documented in the appropriate section of the aircraft or equipment forms. Pay particular attention to these areas during the regular inspection intervals.

## Degrees of corrosion

After the initial inspection and cleaning, corrosion must be evaluated to determine the nature and extent of needed repair or rework. Since it is hard to draw a distinct dividing line between degrees of corrosion, the first requirement for a reliable evaluation is sound maintenance judgment. Use the categories in the following table for reporting degrees of corrosion:

**Degrees of Corrosion**

| Category | Description |
|---|---|
| Light corrosion | At this level, the condition is characterized by discoloration of surface corrosion and pitting to about 0.001″ maximum. This type of damage is normally removed by light hand sanding or a minimum of chemical treatment. |
| Moderate corrosion | This looks like light corrosion, except there may be some blisters or evidence of scaling and flaking, and the pitting depths may be as deep as 0.010″. It's normally removed by extensive hand sanding or light mechanical sanding. |
| Severe corrosion | Its general appearance may be similar to moderate corrosion with severe blistering, exfoliation, and scaling or flaking, but the pitting is deeper than 0.010″. It must be removed by extensive mechanical sanding or grinding. |

### Allowable limits

The next step in the inspection process is to determine if the corrosion is within limits. Once you have determined the severity of the corrosion you must then check the aircraft or equipment specific TO to find out the allowable damage removal limits. If allowable damage limits will not be exceeded, the corrosion can be removed. Prior corrosion removal and corrosion removal on the opposite side of part must be considered when determining allowable removal limits. If allowable damage removal limits will be exceeded, repair or replace parts per instructions in system specific TO.

## 224. Corrosion removal

When removing corrosion it is important that you chose the right method and tooling to get the job done. To do this you need to know what factors to consider when choosing a method (nonpowered versus powered) as well as the correct tools and equipment. We will discuss the different methods and some general procedures for corrosion removal.

### Factors to consider

There are several different methods for mechanically removing corrosion from metal. Certain factors (e.g., type of metal, the location and accessibility of the corroded area, the degree of damage, and the type of corrosion involved) are considered to determine the best method of removal. These factors will also help you determine what type of tooling and equipment is most appropriate for the removal process. Another important factor to consider is that the corrosion products must be removed completely without causing additional damage to the structure. Failure to remove all corrosion allows the corrosion to continue even after affected surfaces are refinished.

### Mechanical and material compatibility

It is important that the removal method, tooling, and equipment selected be compatible with the metal surface. Compatibility involves two considerations:

1. The mechanical effect of the equipment and tooling on the surface and the compatibility of metallic particles worn off the removal equipment.
2. Tooling which might become embedded in the metal surface.

#### *Mechanical compatibility*

Mechanical compatibility refers to the selection of the right tools and equipment to prevent additional damage caused by the removal process. Often it is necessary to select a series of removal techniques involving the use of different grades or classes of equipment and material to remove effectively the corrosion products. The initial use of a rapid and coarse removal method followed by a slower and finer removal method produces a smooth metal surface finish. An example would be using a low grit abrasive paper first followed by using a fine abrasive cloth to finish the job.

#### *Material compatibility*

Material compatibility refers to using a medium for brushing, abrading, blasting, and so forth that will not cause additional corrosion. To ensure material compatibility always use a tool consisting of like metals during corrosion removal operations. For example, regular carbon steel wool should never be used to remove corrosion from aluminum alloys as it will embed in the aluminum alloy surface and cause galvanic corrosion.

### Non-powered mechanical corrosion removal

There are several tools and abrasives used for nonpowered corrosion removal. We will discuss the most commonly used tools and abrasives, as well as general procedures for the nonpowered method.

#### *Abrasives*

Normally, abrading is used to remove surface corrosion and other forms of mild to moderate corrosion by scraping or wearing away the corrosion products along with a minor amount of base metal. Commonly used types include abrasive mats, abrasive cloth, and abrasive paper.

### *Wire brushes*

Wire brushes are available with carbon steel, stainless (CRES) steel, aluminum, and brass bristles and are used to remove heavy corrosion deposits and flaking paint that are not tightly bonded to the metal surface. Densely set, short, stiff bristles are most effective for rapid corrosion removal. The metallic bristles must be compatible with the metal surface being treated to prevent galvanic corrosion with stainless (CRES) steel being considered neutral and usable on all metals. Do not use brushes with a bristle wire gauge or diameter above 0.010 inch, as severe gouging of the surface leading to stress risers and fatigue cracking may occur. Remove the corrosion with a linear motion to ensure you do not unnecessarily damage the surrounding surface area. After wire brushing, the surface areas must be polished with fine abrasive paper to remove and/or smooth out gouges and scratches.

## Powered mechanical corrosion removal

Normally, this method is used to remove heavy corrosion by wearing away the corrosion products. You must be careful when using power tools to remove corrosion. Part of the base metal is abraded away with the corrosion products using this procedure so applying excessive pressure can damage the metal.

### *Pneumatic drills*

Powered corrosion removal is generally done using pneumatic drills wire brush wheels, rotary files, flap brushes, sanding pads, abrasive wheels, or buffing wheels. When using the pneumatic tool as a sander, be sure to keep the sanding disc tilted to approximately a 10º angle so that only one side of the disc is in contact with the metal surface. If the entire disc surface is in contact with the surface, a “bucking” effect will occur. 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 extended length of time without stopping and allowing the metal to cool.

### *Pneumatic sanders*

Pneumatic sanders can be used with various grits of abrasive paper, depending on the amount of corrosion to be removed. To prevent the sander from digging into the metal, start the sander before it touches the metal. When the sanding stroke is finished, lift the sander from the metal before pressing the stop switch. Do not lay the unit down with the motor running. For best results, apply moderate pressure while holding the sander against the work. Move the sander over the surface with parallel and slightly overlapping strokes. Move it as slowly as possible without causing overheating of the metal. Generally, the coverage rate should be about two square feet per minute.

## General removal procedures

When removing corrosion you want to ensure all corrosion products are removed completely without causing additional damage to the structure. This can be accomplished by first removing all corrosion visible through a 10X magnifying glass, then remove an additional two mils (.0020 inch) to ensure that all deposits have been eliminated. The basic steps listed below are for non-powered and powered corrosion removal. Remember, you should always consult your aircraft or equipment specific TO before performing any maintenance.

1. Determine whether all the corrosion can be removed without exceeding the allowable damage limits before starting the removal operation. If damage limits will be exceeded, repair or replace the part per directions in the applicable system peculiar TO.
2. Protect adjacent components and/or areas from scale, chips, corrosion products, and chemical agents.
3. Clean the affected area to remove grease, oil, and soils.
4. Using materials listed in TO 1–1–691; remove all corrosion using the mildest effective method. Determine whether corrosion has been completely removed by inspecting with a 10X magnifier. If necessary, a more sensitive evaluation can be made by using fluorescent

penetrant in conjunction with the magnifier. (Contact Nondestructive Inspection section for more guidance.)

5. When complete removal has been attained, blend out the edges of the damaged areas using fine abrasive paper or cloth.
6. After all corrosion has been removed, recheck to ensure that allowable damage limits have not been exceeded.
7. Treat the surface in accordance with TO 1–1–691 and apply protective coatings in accordance with TO 1–1–8 and the applicable system specific TO.

### Abrasive blasting corrosion removal

In abrasive blasting, abrasive media is propelled toward the work piece with air pressure to remove paint and corrosion products. Small blast cabinets known as glove boxes are built to accommodate small parts and have a recycle system that removes dust and light particle contaminants such as paint chips or corrosion products. Blasting rooms, designed for large components, use a recycling and ventilating system. The operator works within the room, using a blast gun.

A wide variety of materials in various sizes (measured by mesh or grit size) are available for blasting applications. Media types vary depending on the type of material you are blasting. Consult TO 1–1–691 and the aircraft or equipment specific TO for proper media selection.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 222. Types of inspection equipment

1. Match the piece of inspection equipment in column B with its description or function in column A.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Used to inspect interior edges of structures. | a. Flashlight. |
| ____ (2) Used to determine the depth of corrosion pits. | b. Inspection mirror. |
| ____ (3) Provides light for corrosion inspection. | c. Plastic scraper. |
| ____ (4) Allows you to get a closer view of are you are inspecting. | d. Magnifying glass. |
| ____ (5) Used on blisters, bubbles, or other coating irregularities. | e. Depth gage. |
| ____ (6) Used to check if areas have been reworked. | f. Optical micrometer. |
| ____ (7) Measure depth of scratches and height of spurs and other protrusions. | g. Borescope. |
| ____ (8) Aids in inspection of interior surfaces that are not easily accessible. | h. Straight edge. |

2. How is the depth gauge different from an optical micrometer?

### 223. Inspection procedures

1. What type of corrosion should you inspect for in engine exhaust areas?

2. How can you help prevent the spread of corrosion in rocket and gun blast areas?

3. What areas require special attention when inspecting engine frontal areas and air inlet ducts?

4. How can you detect skin bulge caused by corrosion in or around a spot weld area?

5 What signs of corrosion should you look for when inspecting painted surfaces?

6. When inspecting electrical components, what areas are extremely sensitive to corrosion attack?

7. What precaution should be taken when dealing with corrosion on electrical or electronic components? Why?

8. What steps can be taken to minimize corrosion in a battery compartment?

9. What areas in the wheel wells and landing gear should you ensure you inspect?

10. List the steps of a general corrosion inspection.

11. What is required if you find corrosion that you suspect is extensive or severe during a general corrosion inspection?

12. What is the classification of each of the following conditions according to the type of corrosion damage—light, moderate, or severe?

    a. Scaly, flaky corrosion with pits deeper than 0.010″.

    b. Corrosion characterized by discoloration.

    c. A corroded area with pits no deeper than 0.010″.

    d. Removed by light hand sanding.

    e. Removed by extensive mechanical sanding or grinding.

13. Prior to corrosion removal, what must be determined?

### 224. Corrosion removal

1. What will happen if all corrosion is not removed?

2. What are the two compatibilities involved with mechanical corrosion removal?

3. How can you ensure material compatibility when removing corrosion? Why is it important?

4. What step should you take after removing corrosion with a wire brush?

5. How do you remove corrosion using a pneumatic drill?

6. How do you prevent a pneumatic sander from digging into the metal when removing corrosion?

7. What steps can you take to ensure all corrosion has been removed?

8. What should you do if the corrosion exceeds the allowable damage limits?

9. What is the last step in the corrosion removal process?

## 3–3. Prevention Procedures

Once corrosion has been removed, you must protect the metal to prevent it from reoccurring.

### 225. Surface treatment

Surface treatment of the metal with a prescribed chemical conversion coating to form a protective film is an important step in corrosion prevention. Properly applied chemical conversion coatings considerably increase corrosion resistance of the metal and greatly improve the adhesion of applied paints.

#### Preparing the surface

Proper surface preparation is important to ensure adhesion of the protective film to the metal. The steps for surface prep are as follows:

1. After corrosion has been removed, feather the edges of the paint around areas that have been stripped for removal and treatment of corrosion. This will ensure a smooth, overlapping transition between the old and new paint surfaces. Feathering shall be accomplished using approved materials listed in TO 1–1–691.
2. Clean the surface of the parts and/or areas being treated in accordance with procedures in TO 1–1–691, to remove all grease, oil, and dirt, and then rinse with fresh water. For water sensitive areas, use an approved cleaning solvent listed in TO 1–1–691.
3. Abrade the area from which corrosion was removed with a very fine aluminum oxide abrasive mat to remove the oxide layer/coating. This is the most effective means for cleaning the surface so that it will accept a prepaint treatment/chemical conversion coating. For aluminum alloy surfaces, the oxide layer may be removed from the area being treated with corrosion removing compound per procedures in TO 1–1–8 and/or TO 1–1–691. Follow by rinsing with fresh water.

4. After abrading and/or deoxidizing the area, rinse the surface thoroughly by flushing with fresh water, paying particular attention to fasteners and other areas where residues may become entrapped. At this stage of the cleaning process, the surface should be water break-free (fig 3-26). A surface showing water breaks (water beading or incomplete wetting) means there is contamination, which will later interfere with conversion coating, sealing, and painting.

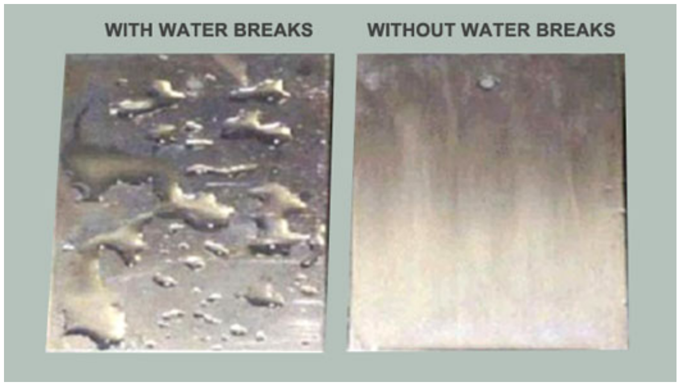



**Figure 3–26. Water break example.**

5. If the surface is not free of water breaks, repeat steps 2 thru 4.

## Application of surface treatments

Observe the following precautions when applying chemical prepaint treatments on aluminum, titanium, or magnesium:

- Chemical prepaint treatments are toxic to the skin, eyes, and respiratory tract. Use chemical resistant rubber gloves and aprons, and chemical, splash proof goggles and/or face shield during mixing or application. If the material (which is an acid) accidentally contacts the skin or eyes, flush immediately with plenty of fresh water, and report to the closest medical facility if eyes are affected or the skin is burned. The Material Safety Data Sheet (MSDS) should be consulted for more guidance.
- Mix and apply only in an adequately ventilated area. Avoid prolonged breathing of vapors.
- Chemical conversion coating/prepaint treatment materials are strong oxidizers and are a fire hazard in contact with flammable, combustible, and readily oxidizable materials. They must be stored separately from these materials and never mixed in containers previously containing the above listed materials. Rags contaminated with chemical conversion coating materials should be disposed of as soon as it is practicable.
- Do *not* use chemical prepaint treatments on high-strength steel parts. Catastrophic failure may occur due to hydrogen embrittlement. Hydrogen embrittlement involves the ingress of hydrogen into a component/metal, an event that can seriously reduce the ductility and load-bearing capacity.
- Do *not* use steel, lead, copper, or glass containers for storing chemical prepaint treatments. Use only plastic, rubber, or stainless steel. Brushes with tin-plated steel handles or ferrules may be used, but contact with the treatment solution should be minimized.

Refer to TO 1–1–691 for recommended materials and procedures for specific alloys. Immediately after cleaning a water break-free surface and rinsing thoroughly, apply chemical conversion coating material by brush, sponge stick moistener, immersion, or non-atomizing spray. The type of application method used depends on the type of conversion material being applied, the area to be covered, and whether application is on a removed part or on an assembly or on equipment area. The sponge stick moisteners and the Touch-N-Prep™ (TNP) pens are particularly useful for small areas. The sponge stick moisteners may be used to apply all types of conversion coatings for aluminum, magnesium, and titanium alloys.

### Surface treatment failures

Failure to obtain a good conversion coating may be attributed to the following:

- Allowing too long a period of contact prior to rinsing can result in a powdery coated surface. Chemical conversion coating/prepaint treatments for aluminum alloys shall be rinsed immediately when the surface has an iridescent yellow to gold appearance. This usually occurs in one to five minutes. A brownish color indicates too long a dwell time and produces a powdery coating. This will not provide a good surface to which the paint/coating system can adhere. If a powdery coating is formed, remove it with an appropriate abrasive mat and reapply the material. The normal dwell time for magnesium conversion coating/paint pretreatments takes one to three minutes to form a brown-green film, but longer contact times for magnesium pretreatments do not usually cause problems. Titanium alloys require a dwell time of 45 minutes using a solution. Consult TO 1–1–8 and the material manufacturer’s instructions for additional information for mixing and application of conversion coating solutions.
- Allowing pretreatment solutions to contact lead, steel, copper, glass, or other incompatible materials can reduce the effectiveness of the solutions and may prevent adequate pretreatment.
- Insufficiently cleaned metal surfaces will prevent the conversion coating from forming on the metal surface. Cleaning must provide a water break-free surface.
- Insufficient dwell time does not allow the conversion coating to form on the metal surface. As the solution approaches its shelf life, or at temperatures below 50° F (10° Celsius [C]), more time may be required to form good films.

### Post treatment

Allow the chemical conversion coated surface to dry for a minimum of two hours before painting or the paint may not adhere to the metal. More time may be required at low temperatures or high humidity. The coating is soft until completely dried. Do *not* wipe the area with a cloth or brush when coating is still wet, since this will remove the coating.

To avoid contamination of the treated surface and to provide a surface that is receptive to organic coatings, prime the treated area per procedures in TO 1–1–8 with the primer specified in the aircraft or equipment specific TO. This must be done within 48 hours after application of the conversion coating/prepaint treatment. If this is not possible, perform temporary preservation procedures as soon as possible. If the surface is allowed to become dirty, scratched, or more than 48 hours have elapsed since its application, it must be cleaned with a wet abrasive mat and retreated before any organic coatings/paint systems or sealants are applied.

### Temporary preservation

Under adverse conditions or when the pressure of operations will not permit the application and curing of an organic coating/paint system, apply an appropriate corrosion preventive compound (CPC) in accordance with procedures covered in TO 1–1–691.

## 226. Compounds

CPCs are used to protect metal aircraft parts and components. They prevent corrosive materials from contacting and corroding bare metal surfaces. Many CPC’s are able to displace water, seawater, and other contaminants from the surfaces to be protected. Others provide lubrication, as well as some corrosion protection. Generally, CPCs are mixtures of special additives in petroleum derivatives and range in appearance and consistency from the thick black to the light oils. Thicker CPCs provide the best corrosion protection, are longer lasting, and are more difficult to remove. While the thinner ones provide some lubrication and do not crack, chip, or peel, they must be frequently removed and replaced to provide continuing protection. Remember, there are several authorized compounds and each one may be further divided into various types. A complete list of CPCs, including the various types, specifications, intended uses, and application and removal instructions, can be found in TO 1–1–691.

### Operational preservation

The day-to-day application of CPCs to prevent corrosion to operational aircraft is known as operational preservation. Areas which are prone to corrosion or where paint has been damaged, should be protected by CPCs until permanent protection can be applied, such as paint touchup or sealing.

### Non-operational preservation

Preservation of aircraft or components during prolonged periods of inactivity, storage, or shipment is known as non-operational preservation.

### Types of CPCs

CPCs can be separated into two categories: water displacing and nonwater displacing compounds.

#### *Water displacing compounds*

Water displacing CPCs can be used to remove water, including seawater, or other electrolytes from metal surfaces. An advantage of this type of CPC is the ability to penetrate into cracks, crevices, voids in faying edges, around fastener heads, and into hinges. They usually provide very thin coatings, 1 mil (0.001 inch) or less in thickness (a dollar bill is 5 mils thick), and are usually clear or translucent. Most water displacing compounds are soft oily compounds and do not provide long-term protection outdoors or in areas which are frequently handled.

#### *Nonwater displacing compounds*

Nonwater displacing compounds are normally used on dried surfaces or on surfaces that have been prior treated with a water displacing CPC. They are heavier bodied oils or greases that provide long-term corrosion protection. These CPCs are much thicker than water displacing compounds and are light to very dark brown in color and present a waxy or greasy appearance. They provide good corrosion protection in areas where large amounts of water collect on or run off structures.

### Application

CPCs can be applied by brushing, dipping, or spraying. The area of application, viscosity (thickness) of the material, and conditions under which they need to be applied are factors that determine the method of application to use. Low viscosity (thinner) materials are best applied by spraying, whereas high viscosity (thicker) materials are better suited for dipping or brushing. Dipping may be used for all CPCs, but you may end up with too thin a film with the low viscosity materials. Remember to remove any old CPC material before applying a new coating.

| Applying Corrosion Preventive Compounds | |
|---|---|
| **Method** | **Explanation** |
| Brushing | You can effectively brush on a CPC using an ordinary paint brush. This method is appropriate for applying thick materials, for use in small areas, or where it is necessary to prevent material from getting on surrounding areas or nearby equipment. |
| Dipping | Dipping is easily completed using any suitable container for the CPC. This method is appropriate for smaller disassembled parts. It cannot be used for assemblies that contain other parts that may be adversely affected by CPCs. |

| Applying Corrosion Preventive Compounds | |
|---|---|
| **Method** | **Explanation** |
| Spraying | May be accomplished using paint spraying equipment, various types of sprayers, or aerosol containers. This method is very effective when you need to apply a CPC to a large area. The viscosity of the CPC will determine which type of spraying apparatus you use. After each use of an aerosol can, invert the can and spray until the spray tip (nozzle) is clear of entrapped material. If an aerosol can does not spray, invert and depress the spray tip several times to clear the delivery tube and spray head. If the can still does not spray, remove and clean the plastic spray head and then spray again to clear the delivery tube. |

### Precautions

When you use CPCs, do *not* apply them in the interior of fuel tanks or cells, engines, or engine fuel systems as fouling of fuel system may occur. It is important to note they are not compatible with liquid oxygen, so do not use them with oxygen equipment, lines, fittings, or storage bottles. Fire may result. Furthermore, CPCs are not recommended for use where temperatures may exceed 800° F (427° C). The use of some CPCs in certain areas of specific equipment may be detrimental. Consult the appropriate technical data before applying a CPC in a new area to determine which, if any, CPCs may be used.

## 227. Aircraft wash management

Aircraft cleaning is the first step in preventing aircraft corrosion. Cleaning is a broad term, covering several methods and materials to remove soil from aircraft and equipment surfaces. Proper cleaning is a proven method of minimizing environmental corrosion and frequent cleaning as a method of controlling corrosion cannot be overstressed.

### Aircraft wash rack supervision

Although washing and general cleaning are the responsibilities of the aircraft mechanic, an important part of your job is to supervise wash rack operations. To perform the duties of wash supervisor, you must hold at least a 5-level and be trained on proper wash procedures. This training must be signed off in your training records. It will be your responsibility as wash supervisor to ensure the following:

- Aircraft wash crew personnel are task trained and qualified.
- Personnel using these facilities are familiar with instructions contained in TO 1–1–691, concerning safety and precautionary measures, treatment, and disposal of wash rack waste.
- Appropriate number and size of serviceable fire extinguishers are readily available.
- Water hoses, pumps, motors, explosion- and vapor-proof electrical fixtures, and high-pressure equipment are properly monitored, maintained, and serviceable.
- All wash crew personnel are trained on proper use of safety and personal protective equipment and wash rack procedures before starting any washes and that all approved safety and health procedures are followed.
- The wash rack is kept clean and properly maintained and foreign-object walks are performed at the beginning and end of each scheduled work shift.
- Maintenance stands are routinely inspected, documented for serviceability, and properly used.
- Waste treatment and drainage systems are inspected daily and serviced at proper intervals to preclude overflow of polluting agents.
- Sufficient covered, nonflammable waste receptacles are available and properly marked.

It is imperative that you know how to ensure proper cleaning because if the system is not kept clean, corrosion is bound to occur.

## Reasons for cleaning

There are several reasons for periodically cleaning aircraft. Proper cleaning of aircraft and equipment is necessary for the following reasons:

- Prevents corrosion by removing salt deposits, other corrosive soils, and electrolytes.
- Reduces fire hazards by the removal of accumulations of leaking fluids.
- Allows a thorough inspection for corrosion damage.
- Maintains visibility through canopies and windows.
- Ensures aerodynamic efficiency of the aircraft.
- Maintains paint scheme characteristics.
- Improves overall appearance.

## Cleaning frequency

The frequency of inspection, cleaning, and related corrosion treatment depends on the type of systems assigned as well as the existing local environmental and other conditions. TO 1–1–691 specifies the required aircraft/weapon system wash interval by base or location as dictated by existing, recorded environmental and pollution data at each base and/or location unless a different interval is specified in a system specific technical order. The following table provides you with a sample of wash frequencies as specified in TO 1–1–691.

| Air Base Name and Location | Wash Interval by Severity | | |
|---|---|---|---|
| | Severe (30 Days) | Moderate (90 Days) | Mild (180 Days) |
| Al Dhafra UAE | | | X |
| Anderson AFB, GU | X | | |
| Anchorage IAP, AK | | | X |
| Bagram AB, Afghanistan | | | X |
| Balad | | | X |
| Dhahran, SA | | | X |
| Diego Garcia | X | | |
| Eglin AFB; Valparaiso, FL | | | X |
| Elmendorf AFB; Anchorage, AK | | | X |
| Luke AFB, Glendale AZ | | | X |
| Hickam AFB; Honolulu, HI | X | | |
| Hill AFB; Ogden, UT | | | X |
| Langley AFB; Hampton, VA | X | | |
| Luke AFB, Glendale AZ | | | X |
| Tyndall AFB; Panama City, FL | X | | |
| Whiteman AFB; Knob Noster, MO | | | X |

Under certain local conditions, depending on aircraft type and usage, the established wash cycle may be insufficient. Also, the unit commander may at his/her discretion direct a wash cycle that is more frequent (not less frequent) than the established aircraft wash cycle to promote the professional appearance of assigned aircraft, missiles, and equipment. In addition to the established wash cycles, some types of aircraft and related equipment may require more frequent cleaning of affected areas.

### *Immediate cleaning*

The following affected areas and soils must be cleaned immediately:

- Spilled electrolyte and corrosive deposits found around battery terminals and battery area shall be cleaned, neutralized, and treated. Close attention and regular cleaning is required for battery areas of aircraft, missiles, and equipment.
- Areas of aircraft, missiles, and equipment exposed to corrosive fire extinguishing materials shall be cleaned within four hours after application, if at all possible. If an aircraft, missile, or piece of equipment is impounded by an Accident Investigation Board, the board shall consider the corrosive effect of firefighting materials and direct their removal as soon as possible consistent with the accident investigation. Prompt removal of these materials saves considerable labor hours and materials when salvaging and restoring equipment to a serviceable status.
- Salt deposits, relief tube waste, or other contaminants.
- Aircraft, missiles, or equipment exposed to significant amounts of salt water. If shipped or transported via ship over salt water, they shall be cleaned and given any necessary treatment after receipt, particularly if the preservation and/or packaging are damaged.
- Fungus growth.
- Chemical, biological, or radiological (CBR) contaminants. Spills of corrosive chemicals.

### *Clear water rinse*

Aircraft exposed to a salt-water environment require clear water rinse (CWR). All aircraft stationed at bases located within 1.25 miles of salt water require a CWR at least once every 15 days unless washed first. Aircraft flown at low level (under 3,000 feet) or making two or more take-offs and/or landings, including touch-and-go landings, over salt water require a CWR after the last flight of the day. Keep in mind, a CWR does not satisfy aircraft-washing requirements as a CWR only removes readily water-soluble matter from aircraft exterior surfaces.

All aircraft deployed to stations within 1.25 miles of salt water for 10 days or more must follow the CWR requirements of the deployment location. Deployment locations where mission requirements and/or facilities limitations prevent accomplishment of CWR, the aircraft forms will be documented to require a CWR be performed within three days of return to home station. Aircraft deployed for 30 days or more to a location where a CWR cannot be accomplished shall require a complete aircraft wash within five days of returning to home station.

### *Deployed aircraft wash*

All aircraft deployed to a location for more than 20 days shall follow the wash intervals of the deployed base location. Aircraft deploying from a location with a shorter wash interval than the deployed location must be washed immediately prior to deploying, then will fall into the wash intervals of the deployed location. If an aircraft cannot be washed prior to deploying, the aircraft would remain on its home station wash cycle until after the first wash. After the first wash at the deployed location, the aircraft would follow the wash interval of the deployed location.

## Cleaning compounds

Cleaning compounds work by dissolving soluble soils, emulsifying oily soils, and suspending solid soils. There are several types of cleaning compounds, each of which cleans a surface using one or more of these mechanisms. Refer to TO 1–1–161 for direction on cleaning specific areas and components. There are three main factors to consider in selecting a cleaner:

1. Type and amount of soil to be removed.
2. Material size and surface condition of the part.
3. Degree of cleanliness required.

There are many types of cleaners available, and you should examine each type carefully to determine which one to use in a given situation. Mix cleaning materials exactly as specified by product data, and only in the quantity required. Improper mixing will cause the product to be ineffective and can lead to potential airframe damage. Do not exceed the recommended cleaner dilution ratios. More concentrated solutions than those recommended do not clean any better and are wasteful; more is not always better. In fact, if too much cleaner is used, the solution merely becomes slippery film, preventing the washing pad from loosening the soil and making rinsing more difficult.

### *Alkaline cleaners*

There are a variety of alkaline cleaners available and many are not authorized for cleaning of AF aircraft, missiles, and related equipment because they are incompatible with the polyimide insulation on the electrical wiring used. Cleaning compounds that conform to military specifications that are listed on the qualified product list/qualified product database (QPL/ QPD) for each specification have been tested and proven compatible with polyimide insulation.

Certain types of approved alkaline cleaners contain detergents and foaming agents and work the same way as any detergent solution. Some types also contain solvents and are more effective for removal of heavy oils and greases such as wire rope lubricant, but they cannot be used in poorly ventilated areas due to their solvent content. There are also types of alkaline cleaners that are good general cleaners for removal of dirt, grime, light oils, and hydraulic fluid, and are usable in confined areas such as cockpits, cabins, bilges, and equipment bays as they contain no solvents.

You must be extremely careful when using alkaline cleaners around high strength steel and aluminum components. When high strength steels, some high strength aluminum, and some stainless steels are exposed to acid paint removers, plating solutions, other acidic materials (i.e., cleaners, etc.) and even some alkaline materials, a cathodic reaction on the metal surface produces hydrogen. The hydrogen diffuses into the bulk metal, accumulating at grain boundaries and weakens the structure. If the part is under load or contains residual manufacturing stresses, sudden catastrophic failure known as hydrogen embrittlement occurs when the part can no longer sustain the internal and/or applied stresses. Hydrogen embrittlement has been known to occur in parts stressed to only 15 percent of the nominal tensile strength of the metal.

### *Solvent cleaners*

Cleaning solvents dissolve oily and greasy soils so that they can be easily wiped away or absorbed on a cloth. However, solvents differ significantly in their cleaning ability, toxicity, evaporation rate, effect on paint, and flammability. Solvents such as alcohols, ketones, chlorinated solvents, and naphtha, are specialized materials restricted for use. Solvent cleaning operations are becoming more and more limited due to environmental regulations. Determine local requirements regarding limitations on type and volume used and disposal from your work center supervisor, safety officer, and/or bioenvironmental engineer.

### *Solvent emulsion cleaners*

Solvent emulsion cleaners are very effective for removal of oily and greasy soils from the exterior of painted (polyurethane only) and unpainted areas of aircraft, missiles, and other equipment. Do not use solvent emulsion on non-polyurethane paint systems and markings as their high solvent content can cause the paint and markings to fade and/or streak. These cleaners also leave a very thin oil and/or solvent film on the surface, so they are not suitable for use as a final cleaner prior to painting, sealing, or adhesive bonding. The aerosol type materials are excellent spot cleaners for removal of oily and greasy soils. Be aware that large-scale use of bulk solvent emulsion cleaners may cause problems for wastewater treatment facilities and local air pollution regulations may restrict the amount and application methods of solvent emulsion cleaners.

### *Steam cleaning*

Steam cleaning shall not be used on aircraft and missiles at any level of maintenance (organizational/unit, intermediate, or depot). In addition, do not use steam cleaning on any the following items:

- Honeycomb bonded structure.
- Sealant.
- Fiberglass composites.
- Acrylic windows and canopies.
- Electrical wiring.

Steam cleaning erodes paint, crazes plastics, disbonds adhesives, damages electrical insulation, and drives lubrication out of bearings.

## Cleaning equipment

When you are choosing a cleaning method, consider the size of the area being cleaned and the cleaning compound that you are using.

### *Aircraft washing kit*

The aircraft washing kit is a conformable plastic device/head with a surface for attaching non-abrasive cleaning pads and sponges. It attaches to a mop handle for cleaning aircraft surface areas.

### *Wash pads/brushes*

Nonmetallic cleaning and scouring pads are crimped polyester fiber pads for use with detergents and solvents for cleaning aircraft, missile, and equipment surfaces. These pads can also be attached to an aircraft washing kit. Non-metallic bristle brushes are used to agitate detergent cleaners on aircraft, missile, and equipment surfaces during cleaning operations.

### *Cleaning cloths*

Cleaning cloths are used for cleaning critical areas where an exceptionally clean cloth is required, such as solvent cleaning prior to painting, adhesive bonding, or sealing.

### *High pressure/hot water wash equipment*

If approved, high pressure/hot water wash equipment can be used for general purpose cleaning of aircraft, support equipment, and vehicles. These machines can deliver four gallons per minute of water and/or cleaning solution at a temperature of 210° F and a pressure of 3000 pounds per square inch (psi) at the attach points on the machine for each output hose. These machines shall be operated per the directions in the specific equipment-operating manual. When this equipment is in use, you must ensure the following requirements are met:

- Only fill the cleaner reservoir with approved cleaning compounds.
- Water cleaning compound mixture ratio is set to 50 parts water to one part cleaner.
- Only 40° flat fan spray nozzles are used.
- Nozzle standoff distance to the surface is always at least 12 inches and never less.

### *Masking*

Certain areas need protection from liquid cleaning agents, paint, or chemical corrosion removers, and they must be masked. These liquid agents can do great harm to the equipment. If there is a chance of fluid entrapment inside the aircraft or if these chemicals attack, unprotected material such as rubber, plastic, or metal, protection must be provided. Mask all openings to primary structures and any other openings that might let the cleaning agents get into the aircraft or equipment interiors. Extremely critical areas on most aircraft are landing gear, engines, elevons, elevators, rudders, wings and wing stubs (namely, longerons, spars, webs, support mounting brackets and braces), lap joints, hinges, faying surfaces, access doors, air scoops, lubricated parts, radomes, plastic and fiberglass components, and antennas. When masking seams, use waterproof barrier paper, water/greaseproof barrier material, tape and/or low adhesion sealant.

*Rinsing*

Rinsing is a very important step in the cleaning process. Various cleaners require different rinse procedures. Some cleaners may need only cold water, low-pressure rinse, while others might require rinse water to be a specific temperature, or pressure. Failure to completely rinse cleaning materials will lead to streaking, premature paint failure, and structural corrosion.

***Aircraft paint scoring***

At this time, LO aircraft are not scored like legacy aircraft. Scoring support equipment is commonly done by the AGE section. However, you may be called upon to score SE, depending on your local protocol which is governed by TO 35–1–3, *Corrosion Prevention and Control, Painting, and Marking of USAF Support Equipment (SE).*

### Wash facility waste treatment

Make every effort to prevent wash facility waste from contaminating lakes, streams, or other natural environments. Some chemicals used during washing procedures require special treatment prior to final disposal. Accumulate and turn in these materials in accordance with all applicable local, state, and federal environmental guidelines. Because of the environmental concerns, only accomplish wash operations at an approved wash facility. Temporary facilities established to support combat operations or special missions are obvious exceptions.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 225. Surface treatment

1. What do properly applied chemical surface treatments do for metal?

2. What is the first step when preparing a surface for a chemical conversion coating?

3. At what stage in the cleaning process should the metal be water break free?

4. Why must the surface be water break-free?

5. What precautions must be taken when mixing chemical prepaint treatments?

6. What does a brownish color and powdery coating on aluminum indicate?

7. After rinsing, why is it important *not* to wipe the coating while it is still wet?

### 226. Compounds

1. What are CPCs used for?

2. What CPCs provide the *best* corrosion protection?

3. What do you do with the thinner CPCs to ensure continuing protection?

4. Where can you find the complete list of CPCs?

5. What is the difference between operational and non-operational preservation?

6. What are the two categories of CPCs?

7. List the three methods of applying CPCs.

### 227. Aircraft wash management

1. What are the requirements to be a wash supervisor?

2. How does proper cleaning of aircraft help prevent corrosion?

3. How often do aircraft stationed at bases located within 1.25 miles of salt water require a clear water rinse?

4. If it is deploying to an area with a longer wash cycle, when must it be washed?

5. Name the main factors in selecting a cleaner.

6. Why are many alkaline cleaners *not* authorized for cleaning of Air Force aircraft, missiles, and related equipment?

7. What cleaner removes soils by dissolving?

8. What are some areas of an aircraft that need to be protected from cleaners?

## Answers to Self-Test Questions

**219**

1. (1) d.
   (2) a.
   (3) b.
   (4) c.
   (5) e.
2. Anode, cathode, electrolyte, and metal path (conductor).
3. It stops.
4. Anode.
5. Electrolyte.
6. On the surface of metal. That is where the electrolyte first makes contact with the metal.
7. Rough and frosted leaving a powdery deposit.

**220**

1. Anode to cathode surface area, type of metal, electrode potential, surface texture, metal's ability to passivate itself and become polarized.
2. If the anode is smaller than the surface of the cathode, the corrosion will be rapid and severe. When the anode is larger than the surface of the cathode, the rate of corrosion will be slow and superficial.
3. The closer the metals are to each other on the chart, the less severe the corrosion. The farther apart they are on the chart the more severe the corrosion.
4. By reducing the potential difference between anode and cathode, polarizing the anode, and polarizing the cathode.
5. The pH scale. The further the pH is from 7 (neutral), either higher or lower, the stronger the electrolyte.
6. Higher temperature environments tend to produce more rapid corrosion due to accelerated chemical reactions and, in humid environments, higher concentration of water vapor in the air. Nightly drops in temperature can cause greater amounts of condensation, leading to increased corrosion.

7. The period of time in which the electrolyte is allowed to be in contact with the surface of metal.
8. (1) Sometimes reduce the rate of corrosion.
   (2) Can cause the formation of electrochemical corrosion cell.
   (3) Areas they occupy tend to remain damp and have different oxygen and electrolyte concentrations.
   (4) They secrete wastes which cause corrosion.

**221**

1. (1) d.
   (2) c.
   (3) h.
   (4) g.
   (5) e.
   (6) a.
   (7) b.
   (8) f.

**222**

1. (1) b.
   (2) e.
   (3) a.
   (4) d.
   (5) c.
   (6) h.
   (7) f.
   (8) g.
2. The depth gauge can only measure corrosion pits and reworked areas. The optical micrometer can measure corrosion pits and reworked areas as well as the height of spurs and other protrusions.

**223**

1. Crevice types of corrosion.
2. Watching the areas for corrosion and cleaning them carefully after firing.
3. (1) Engine frontal areas should be inspected for general surface corrosion, pitting, and intergranular corrosion.
   (2) Leading edges of air inlet ducts, including hardware inside ducts, should be inspected for damaged/deteriorated protective coating, galvanic corrosion at fastener locations, general surface corrosion, and exfoliation corrosion.
   (3) Air cooler cores, reciprocating engine cylinder fins and engine accessory mounting bases are usually not painted and are vulnerable to corrosion when moist, salty air flows over the surface. These areas should be inspected for general surface corrosion and pitting.

4 By sighting along a spot weld seam or by using a straight edge.

5. Bubbling of the paint, blistering of the coating, cracks in the paint, scratches that have penetrated the primer coating, or any other damage that may expose even the area to corrosive attack.
6. Circuit breakers, contact points, and switches.
7. They should be treated only by, or under the direction of, personnel familiar with the function of the component. Conventional corrosion treatment can damage some units.
8. Frequent cleaning and neutralization of battery electrolytes.
9. (1) Magnesium wheels, especially around bolt heads, 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.

10. (1) Ensure the area or areas being inspected have been thoroughly cleaned in accordance with the applicable TO.

    (2) If corrosion is suspected, examine the area with a 10X magnifying glass and flashlight. If blisters, bubbles, or other coating irregularities are present, attempt to dislodge the paint by scraping with a sharp plastic tool.

    (3) Where paint is removed, inspect and determine the extent/degree of corrosion.

    (4) Remove corrosion, clean and treat the surface, and touch-up paint in accordance with the applicable TO.

11 A detailed inspection performed by NDI.

12. (a) Severe; (b) Light; (c) Moderate; (d) Light; (e) Severe.

13. The allowable damage removal limits provided in the system peculiar technical order or manual.

**224**

1. It will allow the corrosion to continue even after affected surfaces are refinished.
2. Mechanical and material.
3. Always use a tool consisting of like metals during corrosion removal operations. Incompatibility can cause additional corrosion.
4. Surface areas must be polished with fine abrasive paper to remove and/or smooth out gouges and scratches.
5. Move the tool over the surface with slightly overlapping strokes. Do not grind, sand, or file in one area for any extended length of time without stopping and allowing the metal to cool.
6. Start the sander before it touches the metal and when the sanding stroke is finished, lift the sander from the metal before pressing the stop switch.
7. By first removing all corrosion visible through a 10X magnifying glass, then remove an additional two mils (.0020 inch).
8. Repair or replace the part per directions in the applicable system peculiar TO.
9. Treat the surface in accordance with TO 1–1–691 and apply protective coatings in accordance with TO 1–1–8 and the applicable system specific TO.

**225**

1. They impart considerable corrosion resistance to the metal and greatly improve the adhesion of subsequently applied paints.
2. Feather the edges of the paint around areas that have been stripped for removal and treatment of corrosion.
3. After abrading and/or deoxidizing the area and rinsing the surface thoroughly with fresh water.
4. A surface showing water breaks indicates contamination that will interfere with conversion coatings, sealing and paining.
5. Mix and apply only in an adequately ventilated area. Avoid prolonged breathing of vapors.
6. Too long of a dwell time.
7. The coating will be removed.

**226**

1. They are used to protect metal aircraft parts and components by preventing corrosive materials from contacting and corroding bare metal surfaces.
2. The thicker ones.
3. Remove and replace them frequently.
4. TO 1–1–691.
5. Operational is for day-to-day application of operational aircraft and non-operational is used during prolonged periods of inactivity, storage, or shipment.
6. Water displacing and non-water displacing.
7. Brushing, dipping and spraying.

**227**

1. Hold at least a 5-skill level and be trained on proper wash procedures.
2. It removes salt deposits, corrosive soils and electrolytes.
3. At least once every 15 days.
4. Immediately prior to deploying.
5. Type and amount of soil to be removed; material size and surface condition; and degree of cleanliness required.
6. They are incompatible with the polyimide insulation on the electrical wiring used.
7. Solvent.
8. It erodes paint, crazes plastics, disbonds adhesives, damages electrical insulation, and drives lubrication out of bearings.

**Do the unit review exercises before going to the next unit.**

## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

**Do not return your answer sheet to AFCDA.**

46. (219) An atom that has gained or lost electrons and has acquired an electrical charge is called
    a. an ion.
    b. a proton.
    c. a neutron.
    d. an electron.

47. (219) Corrosion in an electrochemical cell always starts at the
    a. cathodic surface.
    b. surface of the metal.
    c. weakest point in the metal path.
    d. point where the electrolyte contacts the anode.

48. (220) What is the rate of corrosion when the anode is smaller, in relation to the cathode in the electrochemical corrosion cell?
    a. Slow and severe.
    b. Rapid and severe.
    c. Slow and superficial.
    d. Rapid and superficial.

49. (220) Metals such as stainless steel and titanium that corrode slowly are referred to as
    a. anodic.
    b. cathodic.
    c. resistant.
    d. inhibited.

50. (220) Some metals have the ability to become electrochemically inactive or passive under certain conditions because of the formation of
    a. oxide films.
    b. noble films.
    c. inhibiter films.
    d. chromate films.

51. (221) On a polished surface, uniform surface corrosion is first seen as
    a. a general dulling of the surface.
    b. a discoloration of the paint.
    c. white powdery deposits.
    d. small pits or holes.

52. (221) Pitting corrosion of aluminum or magnesium is first noticed as
    a. small pits or holes.
    b. white powdery deposits.
    c. a discoloration of the paint.
    d. a general dulling of the surface.

53. (222) When performing a corrosion inspection, which tool would you use to dislodge blisters or bubbles?
    a. Knife.
    b. Straight edge.
    c. Metal scraper.
    d. Plastic scraper.

54. (222) Which formula would you use to determine maximum corrosion pit depth when using a depth gauge?
    a. (A – B) ÷ 2 – C = Depth.
    b. (A – B) ÷ 3 – C = Depth.
    c. (A + B) ÷ 2 – C = Depth.
    d. (A + B) ÷ 3 – C = Depth.

55. (223) When inspecting exhaust paths for corrosion, what areas should be inspected because they cannot be reached with normal cleaning?
    a. Spotwelds.
    b. Bilge areas.
    c. Seams and fairings.
    d. Water entrapment areas.

56. (223) What is the *first step* in a general corrosion inspection?
    a. Dislodge paint irregularities by scraping.
    b. Determine the extent/degree of corrosion.
    c. Ensure the area has been thoroughly cleaned.
    d. Examine the area with a 10X magnifying glass.

57. (223) Corrosion that appears as blistering, exfoliation, and scaling or flaking is classified as
    a. light.
    b. severe.
    c. moderate.
    d. superficial.

58. (223) Prior to corrosion removal, what must be determined?
    a. Type of removal tooling.
    b. Type of removal method.
    c. Type of paint to be used to recoat surface.
    d. Allowable damage removal limits.

59. (224) Material compatibility refers to using a medium that will
    a. not cause additional corrosion.
    b. slow down the corrosion rate.
    c. speed up the corrosion rate.
    d. cause additional corrosion.

60. (224) Which motion should you use when removing corrosion with a hand held wire brush?
    a. Linear.
    b. Circular.
    c. Oscillating.
    d. Cross hatch.

61. (224) When removing corrosion with a pneumatic sander, how do you keep the sander from digging into the metal?
    a. Move the sander slowly.
    b. Only use light pressure.
    c. Start the sander before it touches the metal.
    d. Only allow a portion of the sanding disc to contact the surface.

62. (224) After all visible corrosion is removed, how many additional mils should be removed?
    a. 1 (.0010 inch).
    b. 2 (.0020 inch).
    c. 3 (.0030 inch).
    d. 4 (.0040 inch).

63. (224) What is the *last step* in the general corrosion removal process?
    a. Blend out edges of damaged area.
    b. Re-evaluate using fluorescent penetrant.
    c. Treat the surface and apply protective coatings.
    d. Ensure allowable damage limits have not been exceeded.

64. (225) The paint edges around the chemically stripped areas are feathered in order to
    a. ensure a smooth, overlapping transition between the old and new paint surfaces.
    b. allow for accurate measurements corrosion removal areas.
    c. ensure good surface contact for chemical strippers.
    d. allow for easier access to the bare metal areas.

65. (226) The two categories that corrosion preventive compounds (CPC) are separated into include
    a. light and heavy.
    b. clear and translucent.
    c. viscous and nonviscous.
    d. water displacing and non-water displacing.

66. (226) Low viscosity corrosion preventive compounds (CPC) are best suited for what type of application?
    a. Dipping.
    b. Spraying.
    c. Brushing.
    d. Immersion.

67. (227) Which is not a reason for immediate cleaning?
    a. Salt deposits.
    b. Fungus Growth.
    c. Spilled electrolytes.
    d. Poor Aerodynamic smoothness.

68. (227) When would an aircraft that took off four time over salt water require a clear water rinse?
    a. After every flight.
    b. After every second flight.
    c. After the last flight of day.
    d. At least one time every 15 days.

69. (227) What conditions do you consider when you are choosing a cleaning method?
    a. Size of the area and type of soil.
    b. Type of metal and surface condition.
    c. Type of metal and degree of cleanliness required.
    d. Size of the area and cleaning compound being used.

**Please read the unit menu for unit 4 and continue ➔**

# Unit 4. Hazardous Materials



THROUGHOUT HISTORY, mankind has always put forth great effort to create materials and chemicals that make our lives easier. However, mankind has also learned that many of these materials and chemicals are harmful to the environment and the people using them. In many cases, sickness and early death are the result. These substances are called hazardous materials or HAZMAT. Almost every chemical you use, or will use, is HAZMAT.

## 4–1. Materials and Shelf Life

As a low observable aircraft structural maintenance journeyman, you'll become familiar with HAZMAT. The Air Force has a program called Hazardous Communication (HAZCOM) that is based on Air Force Occupational Safety and Health (AFOSH) standards, which you'll become very familiar with during your career. HAZCOM training is mandatory for everyone in this career field and includes topics such as material safety data sheets (MSDS), hazardous material identification, labeling and storage, handling procedures, proper disposal, and respirator training.

### 228. Authorized materials

Once you have determined there is a valid need to wash or paint an aircraft or piece of support equipment, it is very important to know if the components you plan to use are approved for your particular application. Each job requires a different type of material. Authorized materials can be found by consulting the following:

- Applicable technical orders.
- Military specification (mil-spec)/standard (mil-std).
- Current qualified products lists or databases.

TOs, mil-specs, mil-stds, qualified products lists, and qualified products databases all work hand-in-hand.

#### Technical orders

Working on multi-million-dollar aircraft can seem like a daunting task. As a maintainer, it is up to you to ensure only authorized materials are used. Aircraft specific TOs are the primary document you will use to determine what materials are needed. If an aircraft specific TO does not call for a specific material you will need to refer to the general series TO. Remember; aircraft specific TOs always overrule general TOs. When you are performing research prior to performing a job, pay close attention to the materials the TO requires you to use. The TO will usually refer to a material by mil-spec or mil-std.

#### Military specifications/standards

In general, mil-specs describe the essential technical requirements for purchased materials that are military unique or substantially modified commercial items and a mil-std establishes uniform engineering and technical requirements for military-unique or substantially modified commercial processes, procedures, practices, and methods.

Before you can use a material, you must first determine if the material meets mil-spec/mil-std requirements. The material you are using should have the mil-spec on the label and you match the mil-spec on the material with the mil-spec called for in the TO. For example, TO 1–1–8, *Application & Removal of Organic Coatings*, *Aerospace and Non-Aerospace Equipment*, requires a standard exterior primer for AF aircraft. The mil-spec sets the standards for color, drying time, adhesion, flexibility, thinner compatibility and many other factors. It is up to you to ensure that the primer you are using meets the mil-spec.

### Qualified products lists or databases

The final piece of the puzzle is the QPL/QPD. The QPL is a list of manufacturers and their commercial products that have been tested and meet the various requirements of a mil-spec. A QPD is simply an electronic database that contains the same information as a QPL. Local units must know which manufacturer has a product that meets specific requirements of the applicable mil-spec. Local units must use a QPL/QPD when they purchase products directly from commercial sources. However, if a local unit orders their products directly from the General Services Administration (GSA) using the national stock number (NSN), they will only get products from manufactures currently listed on the QPL/QPD for that mil-spec.

## 229. Hazardous material and waste

The hazardous materials/fluids we use in low observable aircraft structural maintenance (LOASM) are numerous and just too many to list. The different materials that you will work with can be very dangerous. For example, Alodine 1201 is a mutagen (induces genetic changes) and a teratogen (causes physical defects in an embryo); polyurethane paint contains isocyanates (targets the nervous system, kidneys etc.) It is imperative that you know the hazards associated with each hazardous material/fluid you come across in your shop.

### Categories of hazardous materials

Essentially hazardous materials can be broadly divided into two categories:

#### *Health hazards*

Health hazards can be either long term (chronic) or short term (acute), or both. These effects include carcinogenic (cancer causing), mutagenic (causes changes in cellular make up), corrosive, irritating, and sensitizing (causes a person to be overly sensitive).

These exposures can occur through inhalation, ingestion, absorption through the skin, and skin surface contact. Health effects from these exposures vary from minor irritation and temporary illness, to permanent organ damage and the formation of cancer. Specific parts of the body affected include the liver and kidney. The body’s blood forming ability may also be negatively impacted. In addition, the reproductive system could sustain serious injury.

#### *Physical hazards*

Physical hazards include burns, fires, explosions, and suffocation. Other physical hazards associated with chemicals include splashes, spills, and incidents involving broken containers.

Each workplace using or handling HAZMAT must maintain a Hazard Communication Program (HCP). The purpose of a HCP is to reduce the occurrences of occupational illnesses and injuries by informing all personnel of the hazards associated with, and the proper preventive measures to be taken, when they’re using or handling HAZMAT. Your section’s HCP monitor will ensure the following elements are maintained:

- A comprehensive written program.
- Current hazard determinations.
- MSDS.
- Labeling requirements and procedures.

- Hazardous chemical inventories.
- Employee information and training.

We won't discuss all of these elements; however, we will discuss the more significant aspects of HAZMAT that will affect you as a LOASM journeyman. These items include the classifications of HAZMAT, handling, storing and labeling (to include MSDSs), and proper hazardous waste disposal.

## Types of hazardous materials and fluids

Knowing what form a chemical takes helps you determine how it might get into your body. Health hazards can cause illness or injury when you are exposed to hazardous chemicals by breathing, swallowing, skin contact, or eye contact. The general physical classifications of hazardous materials are gases and vapors; liquids; and solids. Let's learn about each classification.

### *Gases and vapors*

The definition of a gas is the state of matter differentiated from the liquid or solid states because of its ability to diffuse rapidly. A type of gas we are exposed to while performing aircraft maintenance is carbon monoxide. Carbon monoxide is a colorless, odorless, extremely poisonous gas  formed by incomplete combustion of carbon materials, such as gasoline. This gas is present around any type of combustion engine.

A vapor is the gaseous state of a substance that, under ordinary conditions, is a liquid or a solid. Gases and vapors are grouped together because their behavior is so similar. Both expand or contract with changes in temperature and pressure. Both spread out, or diffuse rapidly, to fill a room, enabling quick exposure to the chemical. Gaseous forms are also the easiest to get into the body and can cause rapid toxic reactions.

### *Liquids and liquid aerosols*

Some types of hazardous liquids you might come in contact with on a daily basis include solvents, paints, acids, and hydraulic fluids. Besides these liquid types of HAZMAT, this group also includes mists and fogs. Mists and fogs are considered liquid aerosols, the difference being mainly the size of the droplets. A mist broadly refers to very small droplets generated from a liquid state by spraying or splashing. You find mist in operations such as spray painting or parts cleaning, usually combined with the vapor form. A fog is sometimes developed by spraying hot liquids on cold metal. This can make some chemicals quite dangerous to the skin, as well as to the respiratory tract.

### *Solids and solid aerosols*

Many of the solid materials that you will encounter may be considered hazardous. Fumes and dust, which are solid aerosols, are distinguished from one another by their makeup and method of generation rather than by size differences. You will be exposed to hazardous fumes during a variety of operations ranging from composite repairs to painting operations. You will also generate dust during sanding and abrasive blasting operations.

## Material safety data sheets

MSDS identify the hazards of specific chemicals. Chemical manufacturers must prepare and provide to the user an MSDS for every hazardous chemical material they sell. Each MSDS highlights the hazards of the chemical and ways to control those hazards. Your work center must have an MSDS for every chemical used in the shop. MSDSs must be made available to every person using chemical compounds. Shop chiefs are required to ensure MSDSs are easily accessible on each shift, and you should never be hindered when you need one.

## Globally Harmonized System

The Globally Harmonized System (GHS) is a standardized international approach to HAZCOM. The GHS standardizes labeling requirements and safety data sheets (SDS). The SDS is the same as a MSDS in that it gives safety data for the material; the major difference is the SDS is standardized so that no matter what the material or manufacturer, the information will be organized the same. Another change with GHS is the definitions of hazards have been changed to provide specific criteria for classification of health and physical hazards, as well as classification of mixtures. These specific criteria will help to ensure that evaluations of hazardous effects are consistent across manufacturers, and that labels and safety data sheets are more accurate as a result.

## Hazardous waste

Nearly every chemical compound you use can be considered a hazardous material. Many chemicals are totally consumed in the process of using them. When you have byproducts or leftovers, they may become a hazardous waste (HW).

### *Determining whether something is hazardous waste*

What is a hazardous waste? As defined by the Environmental Protection Agency (EPA), a hazardous waste is a waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment. Unfortunately, in order to develop a regulatory framework capable of ensuring adequate protection, this simple narrative definition is not enough. Determining what is a hazardous waste is paramount, because only those wastes that have specific attributes are subject to Subtitle C regulation.

Making this determination is a complex task which is a central component of HW management regulations. HW is generated from many sources, ranging from industrial manufacturing process wastes, to batteries, to fluorescent light bulbs. HW may come in many forms, including liquids, solids, gases, and sludge. To cover this wide range, EPA has developed a system to identify specific substances known to be hazardous and provide objective criteria for including other materials in this universe. The regulations contain guidelines for determining what exactly a waste is (called a solid waste) and what is excluded from the hazardous waste regulations, even though it might otherwise be a solid and considered hazardous waste.

### *Important questions*

There are at least two important questions you must answer when determining whether the waste you generate is hazardous.

1. Is this material a *solid waste*?
2. Is the material excluded from the definition of solid waste or hazardous waste?

## Solid waste

The EPA uses the term solid waste to denote something that is a waste. In order for a material to be classified as HW, it must first be a solid waste. Therefore, the first step in the HAZMAT identification process is determining if a material is a solid waste. The statutory definition points out that whether a material is a solid waste is not based on the physical form of the material (i.e., whether or not it is a solid as opposed to a liquid or gas), but rather that the material is a waste. The regulations further define solid waste as any material that is discarded by being either abandoned, inherently waste-like, a certain military munition, or recycled.

## Excluded waste

Any generated waste that is not defined as solid waste is excluded from regulation as HW.

## Characteristic waste

The final step in HW identification is to determine if the waste is characteristic. There are four HW characteristics: (1) ignitability; (2) corrosivity; (3) reactivity; and (4) toxicity.

Within each, there are specific properties the chemical must possess to be characteristic. To decide if a particular waste is a characteristic waste, it must be tested according to established testing methods. Normally, a sample is collected and sent to an off-base testing facility. Your bioenvironmental engineer will interpret the results.

## 230. Shelf-life Program

Imagine being called out to perform a job where you had to bond material down with an adhesive compound. You get everything prepped and ready to go. You enter a write-up in the aircraft forms to ground the aircraft to facilitate maintenance. You remove the old material and cut the new material. You open the brand new adhesive you just received from supply and it is a solid mass in the container. Just think about the amount of time and effort that was just wasted. The Air Force Shelf Life Program has been established so that the chemicals you use to perform your job will perform the way the manufacturer designed them to perform.

Shelf-life should not be confused with service life.

- *Service life* is a general term used to quantify the average or standard life expectancy of an item or equipment while in use. When a shelf-life item is unpacked and introduced to mission requirements, installed into intended application, or merely left in storage, placed in pre-expended bins, or held as bench stock, shelf-life management stops and service life begins.
- *Shelf-life* is the total period of time beginning with the date of manufacture and terminated by the date by which an item must be used (expiration date) or subjected to inspection, test, restoration, or disposal action; or after inspection/laboratory test/restorative action that an item may remain in the storage systems and still be suitable for issue or use by the end user.

Designation of items for shelf-life management are held to a minimum since these items require specialized management, handling and continuous surveillance, which often results in higher related costs. Items are not and will not be designated for shelf-life management merely to facilitate storage control.

### Shelf-life items

A shelf life item is an item of supply possessing deteriorative or unstable characteristics to the degree that a storage time period must be assigned to ensure that it will perform satisfactorily in service. All shelf life items are classified as one of two types:

1. TYPE I - An individual item of supply, which is determined through an evaluation of technical test data and/or actual experience, to be an item with a definite non-extendible period of shelf-life.
2. TYPE II - An individual item of supply having an assigned shelf-life time period that may be extended after completion of visual inspection/certified laboratory test, and/or restorative action.

### Shelf-life codes

Each item assigned a national stock number in the Federal Supply System will be designated by a specific shelf-life code (SLC). This code identifies length of the shelf-life period. The SLC takes precedence over the manufacture expiration date (e.g., if the manufacture states an item will expire in five years however the SLC states 10 years, you must follow the assigned SLC.)

### Storage

Storage standards are critical to the proper application of storage processes, procedures and environment needed to assure material remains in a serviceable condition. Work centers control shelf-life items in accordance with Air Force Manual (AFMAN) 23–110, *USAF Supply Manual*. Your workcenter should implement controls to minimize expiration of material in storage by issuing first those stocks which have the earliest expiration date for Type I items; or the earliest date manufactured, date packed, date cured, or date assembled for Type II items, except where issue of newer stocks is justified. Under normal circumstances, this policy prescribes for a strict application of first-in/first-out (FIFO).

### Testing/inspection

Your shop will have a shelf life program to ensure the materials you use are serviceable. Once a chemical is past the shelf life, the quality status listing (QSL) shall be checked to determine if the item has been tested and extended. If the material is inspected/tested while still in condition code A and passes, the shelf life will be extended for the full period of the assigned original shelf life. During second or subsequent test/inspections, passing items will be extended for one-half of the originally assigned shelf life. Thus, an item that is assigned shelf-life code 6 (24 months) is extended for 24 months after passing the first test/inspection and 12 months after passing the second or subsequent test/inspection.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 228. Authorized materials

1. Where can you find authorized materials listed?

2. What is the primary document that you will use to determine what materials are needed?

3. What establishes uniform engineering and technical requirements for military-unique or substantially modified commercial processes, procedures, practices, and methods?

4. What is the advantage of ordering painting materials directly from GSA?

### 229. Hazardous material and waste

1. What are the two categories of hazardous materials?

2. What type of hazard can occur through inhalation, ingestion or absorption through the skin?

3. What must your shop maintain if you use or handle HAZMAT?

4. Match each definition in column B with its term in column A. Column B items may be used only once.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Able to diffuse rapidly. | a. Carbon monoxide. |
| ____ (2) Colorless, odorless, extremely poisonous. | b. Gases and vapors. |
| ____ (3) Solvents, paints and acids. | c. Liquid aerosols. |
| ____ (4) Mists and fogs. | d. Liquids. |
| ____ (5) Fumes and dusts. | e. Solid aerosols. |

5. What is the purpose of an MSDS?

6. For what chemicals in your shop should there be MSDSs on hand?

7. What are the four HW characteristics?

### 230. Shelf-life Program

1. Why has the Air Force Shelf-life Program been established?

2. What is a shelf life item?

3. How can you minimize expiration of material while in storage?

4. What do you check to determine if the shelf life has been extended?

# 4–2. Storage and Disposal

Due to past mistakes in the storing of HAZMAT, the government has had to spend billions of dollars to clean up military installations and to continue keeping them clean. Your role is critical because you're the one who uses these chemicals every day. Whom do you think will be held responsible if it is found that improper disposal of hazardous waste has occurred?

## 231. Storage and labeling

Storing HAZMAT is an important part of pollution control. To prevent harm to health or the environment, it is your responsibility to make sure HAZMAT is properly placed in the appropriate storage areas.

### Storage facilities

Site selection should be one that minimizes the threat of the hazardous waste to both human health and the environment in the event of a release of HW or HW constituents.

#### *Accumulation site*

The following factors should be considered in the selection of the accumulation site:

- EPA and state location and design requirements.
- Fire protection, worker health and safety, public health and safety, and environmental (ecological) requirements.
- Space for waste segregation requirements.
- Liability for HW cleanup.
- Sufficient area for containers that hold ignitable or reactive wastes to provide at least 50 feet from (within) the installation's property line.
- Once the accumulation site has been selected, consideration must be given to design of the container systems.

#### *90-day accumulation sites*

Considerations for the design of 90-day accumulation sites for containers include the following:

- Provide an impervious surface, free from cracks and gaps, treated with a sealant to prevent spills from contacting the ground. Containers should not be placed on dirt, sand, gravel, or grass surfaces.
- Locate accumulation sites away from any floor drains that lead to sanitary or storm water sewers.
- Provide a containment system with a capacity to either contain the volume of the largest container or 10 percent of the volume of all containers, whichever is greater.
- For incompatible wastes, provide segregated containment by using either separate containment areas, by means of separately diked areas, or by sloped containment to separate sumps.
- Control entry around the accumulation site and post signs "Danger—Unauthorized Personnel Keep Out" that can be seen from any access point, and are large enough to be read from 25 feet.

### Storage precautions

Ventilate confined areas (enclosed storage buildings) used for the accumulation of hazardous wastes. A buildup of HW vapors can present a serious health hazard for toxic hazardous waste, or a fire ignition hazard for flammable HW. Place drums on pallets to allow for ease of removal when full. If containers must be stored outdoors, store them in an area protected from precipitation and direct sunlight, whenever possible. All containers must be inspected at least weekly for potential release problems.

## Site management

You will, no doubt, have an opportunity to monitor your shop's accumulation point. Every shop that generates HW has either a satellite accumulation point (SAP) or an accumulation point (AP) depending on the amount of HW generated. Due to the large volume of HW generated in the typical low observable paint facility, you'll probably use both. This lesson gives general information, which should not be used to operate an AP. You can obtain specific guidance from the base environmental function, bioenvironmental engineer, and ground safety offices.

### *Satellite accumulation point*

Generally, an initial SAP is an accumulation area close to the generating activity. Accumulation continues at an initial SAP until 55 gallons of HW is collected. Once the 55-gallon limit is reached, the generating activity must transfer the HW container to an accumulation site within three days. At that time, a generator is required to comply with all applicable Resource Conservation and Recovery Act (RCRA) requirements with regard to 40 CFR 262.34(a). The 90-day storage period begins as soon as the three-day period has expired and the excess amount becomes subject to the 40 CFR 262.34(a) requirements. Some states do not recognize initial APs and consider the 90-day limit to begin when the first drop of HW is placed into the container. Check with your local bioenvironmental office for guidance.

### *Accumulation point*

When the generating activity is ready to transfer their HW from the SAP, the hazardous waste is transferred to the accumulation site, a centralized location where wastes are placed for up to 90 days for large quantity generators, and up to 180 or 270 days for small quantity generators. Due to the inherent risks associated with large volumes of HW, it is imperative that consideration be given to the design, selection, and management of the accumulation site.

The main differences between the AP and the SAP are the waste volume and the length of time wastes can be accumulated. At an AP, an unlimited volume of HW may be accumulated, usually up to 90 days. The SAP is not limited by time but it is limited to volume, usually 55-gallons.

### *General accumulation requirements*

An accumulation site manager and an alternate manager should be assigned to both types of HW accumulation points. They are responsible for ensuring that all regulatory requirements are met, such as storage, container marking, and record keeping.

Each container must be marked with the words "Hazardous Waste" and with the date initial accumulation began, or when the volume limit was met for SAPs. Containers should also be marked with a unique container identification number assigned by the accumulation site manager once the accumulation time limit starts. It is recommended that the waste stream contents be marked on the container. All marking should be large enough (one to two inches) to be seen from a distance.

Hazardous waste generating activities are responsible for ensuring the wastes they generate are properly characterized, accumulated, stored, and disposed of in accordance with the base hazardous waste management plan.

## Containers and labeling

Make sure all containers holding hazardous waste are clearly marked to show their contents and the date on which the waste began to accumulate. *Never* put HW in an unwashed container that previously held an incompatible waste or material. To prevent explosions, gaseous emissions, leaching, or other discharges, make sure containers holding incompatible wastes are separated from each other.

All containers storing HW must be in good condition. Good condition means there should be no severe rusting, no sharp-edged creases or dents, no bulging heads caused by over-pressuring a container (usually from overfilling), and no severe structural defects. If a container is not in good condition or begins to leak, the hazardous waste must be immediately transferred to another container or overpacked in a salvage drum. Containers with pools of HW on the top must be decontaminated or overpacked.

Supervisors will ensure labels on containers of hazardous chemicals used in their work area/shop meet HAZCOM requirements, remain affixed to their containers, and are not obliterated or covered.

At minimum, the following information will appear on container warning labels:

- The identity of the hazardous chemical(s) in the container.
- Appropriate hazard warnings that include information about the specific physical and health hazard(s), including target organ effects of the chemical(s) in the container. This may be accomplished using any combination of words, symbols, or pictures.

An installation hazardous material pharmacy (HAZMART) may affix other labels to containers for locally determined purposes. If the HAZMART label duplicates the federal HAZCOM standard requirements, the original label may be covered. If the HAZMART label does not duplicate the information required by the federal HAZCOM standard, information on the original label must remain legible.

The name and identity found on the label will help you locate the correct MSDS, where you will find additional information concerning the hazards of the contents. Labels on containers that leave the workplace must also display the name and address of the responsible party.

Affix warning labels to bags, barrels, bottles, boxes, cans, cylinders, drums, reaction vessels, storage tanks, and other chemical containers. Placards can be used for stationary containers as long as they clearly identify the applicable containers and display the same information as a hazard-warning label.

## 232. Handling and disposal

The proper handling and disposal of HW is very important. Inproper handle and disposal can lead to federal fines for you and your unit, contamination of the environment, and contamination and illness to you or your fellow Airmen. In the following section we will provide you the tools you need to prevent this from happening

### Proper handling

Do not overfill containers; fill to 90 percent of capacity. For example, only fill a 55-gallon drum to 50 gallons. Liquids expand in containers as the temperature increases. The pressure created by the expansion of the liquid in a completely filled container causes bulging heads and damages the integrity of the container. Bulging containers also create a safety hazard for personnel adding waste to or handling the containers.

Follow proper procedures when opening, filling, and handling a container. Use bung wrenches to open a closed (non-removable) head drum. Removable head drums are opened by loosening the nut on the retaining ring, removing the retaining ring, and then removing the drum head. If the material in the drum is combustible or flammable, spark-proof wrenches (made from bronze or aluminum) should be used to prevent accidental ignition of the waste due to sparks. Slowly loosen the bung or retaining ring to allow for any pressure buildup to dissipate.

Use a funnel in the bung to fill closed head containers. This will ensure that all waste is poured into the container and does not spill on the top of the container. After filling, the funnel should be removed and the container closed. If the funnel has any HW residues remaining, the residues should be rinsed into the container, or the funnel placed in a suitable closed hazardous waste accumulation container. Keep containers closed unless adding or removing waste. To prevent improper mixing, containers must be kept in a secured area.

Any time you handle HW, you have the potential for a spill. Spills can range from just a few cups on the floor to tipping an entire 55-gallon container in the AP. Because of the potential for a spill, it's imperative that emergency equipment be available; including a fire extinguisher, spill control equipment, decontamination equipment, and a water delivery system. Additionally, a telephone or other device, such as an alarm or two-way radio, must be available to immediately notify emergency personnel should something happen. Never attempt to move HW alone. Use the buddy system. If you do experience a problem, the buddy system enables you to contain the spill while someone else summons help.

Handle drums and other containers with equipment designed for the task. Secure containers to pallets before moving pallets. Use drum carts designed for the container types to reduce the likelihood of dropping a container during handling. Never balance drums on the forks of a forklift or tow motor. Do not stack drums more than two high. Drums containing flammable liquids should not be stacked. Do not allow the movement of vehicles such as trucks, fork lifts, privately owned vehicles (POV), and so forth, in or near the container storage area unless loading or unloading.

### Hazardous material disposal

The final phase of the hazardous waste life-cycle is disposal, involving the three steps of turn-in, transport, and disposal. The disposal phase begins when the generating activity is ready to turn in their HW. Turn-in is the transfer of authority to properly dispose of the HW, usually to the Defense Logistics Agency (DLA). Once turned in, the HW is transported to an RCRA-permitted facility for ultimate disposal. The disposal phase requires a coordinated effort by all installation personnel, including the generating activity, the environmental flight, bioenvironmental engineering services, accounting and finance, contracting, and the disposal agent, normally DLA. The entire disposal phase of the HW life-cycle is guided by documentation, which must be completed throughout the turn-in, transport, and disposal steps. Transportation is a critical link of the HW life-cycle management process. Correspondingly, it is highly regulated and includes packaging, marking, labeling, loading, placarding, and a manifest system for tracking the HW, especially when transported off installation, (including along public highways on the installation). While some installations operate RCRA-permitted storage facilities, most Air Force installations rely on DLA to provide this service.

Hazardous waste must be turned in before the end of the allowed accumulation time limit, unless a one-time written extension has been granted by the state authority or regional EPA. All transfers and turn-ins of HW must be conducted under the direction of and processed through the installation environmental flight.

The generating activity's responsibility for compliance does not end until the required documentation has been completed and the physical transfer of the waste to the permitted facility has been completed.

Hazardous waste generating activities are required to ensure four primary documents are completed for disposal of hazardous waste:

1. HW profile sheet.
2. AF Form 2005, Issue/Turn-In Request.
3. DD Form 1348–1, DOD Single Line Item Requisition System Document.
4. The HW manifest.

### Coating material disposal

You must also be aware of the type of coatings you are disposing and the proper way to dispose of them. Heavy metal content in conductive materials obviously poses a risk to the environment. High isocyanides paints are very hazardous and have shown to lead to asthma in adults with continued unprotected exposure. Be familiar with federal, state, county, and base environmental laws that pertain to the handling and disposal procedures of these materials.

The protection of all classified material is very important to national security and is everyone's responsibility. All low observable coating material must be separated as classified or unclassified. Material that is unclassified and non-hazardous waste may be discarded along with normal trash. The classified material must be safeguarded and secured in an approved special access facility (SAF) and disposed of by proper authorities.

Some coating materials may also need to be demilitarized prior to disposal. Demilitarization is the act of destroying the military offensive or defensive advantages inherent in certain types of equipment or material. When you demilitarize something, low observable coating materials for instance, you must mutilate, cut, incinerate or alter the material in such a way as to prevent the further use of the material for its originally intended purpose.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 231. Storage and labeling

1. How large should storage containment capacity be?

2. What precautions should be followed if containers have to be stored outside?

3. What is the limiting factor at a SAP?

4. How should you mark HW accumulation barrels?

5. What action do you take if a HW container is not in good condition or it is leaking?

6. When can you use placards for stationary containers?

### 232. Handling and disposal

1. How far should you fill HW containers?

2. How do you open a removable head drum?

3. When handling HW, what types of devices should be available to contact emergency personnel?

4. When the generating activity is ready to turn in their HW, to whom do they usually submit the HW?

5. How should low observable coating materials be separated?

6. What must you do to a low observable coating material to demilitarize it?

## Answers to Self-Test Questions

**228**

1. Applicable technical orders, military specification/standards, and current qualified products lists or databases.
2. Aircraft specific TOs.
3. A military standard.
4. You will receive only products listed on the current QPL.

**229**

1. Health hazards and physical hazards.
2. Health hazard.
3. A Hazard Communication Program.
4. (1) b.
   (2) a.
   (3) d.
   (4) c.
   (5) e.
5. It identifies the hazards of specific chemicals.
6. Every chemical used in the shop.
7. Ignitability, corrosivity, reactivity, and toxicity.

**230**

1. So that the chemicals you use will perform the way the manufacturer designed them to perform.
2. An item possessing deteriorative or unstable characteristics to the degree that a storage time period must be assigned to ensure that it will perform satisfactorily in service.
3. By first issuing stock that has the earliest expiration date for Type I items; or the earliest date manufactured, date packed, date cured, or date assembled for Type II items.
4. The QSL.

**231**

1. Large enough to either contain the volume of the largest container or 10 percent of the volume of all containers; whichever is greater.
2. Store them in an area protected from precipitation and direct sunlight, whenever possible.
3. 55 gallons.
4. With the words “Hazardous Waste,” the date initial accumulation began/or when the volume limit was met for SAPs, with a unique container identification number, and waste stream contents.
5. Immediately transferred to another container or overpacked in a salvage drum.

6. When they clearly identify the applicable containers and display the same information as a hazard-warning label.

**232**

1. To 90 percent capacity.
2. Loosen the nut on the retaining ring, remove the retaining ring, and then remove the drum head.
3. A telephone or other device, such as alarm or two-way radio.
4. Usually to DLA.
5. As classified or unclassified.
6. Mutilate, cut, incinerate or alter the material in such a way as to prevent the further use of the material for its originally intended purpose.

**Do the unit review exercises before going to the next unit.**

## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

**Do not return your answer sheet to AFCDA.**

70. (228) Standards for paint such as color, drying time, and adhesion are stipulated by the
    a. aircraft specific TO.
    b. general aircraft TO.
    c. Military specification.
    d. Qualified products list (QPL).

71. (229) Solid waste can be any material that is essentially waste-like, abandoned, or
    a. frozen.
    b. recycled.
    c. excluded.
    d. nonliquid.

72. (229) At a *minimum*, material data safety sheets (MSDS) are made available to
    a. everyone.
    b. shop chiefs.
    c. shift supervisors.
    d. immediate supervisors.

73. (229) The four characteristics of hazardous waste are ignitability, corrosivity, reactivity, and
    a. toxicity.
    b. volatility.
    c. flammability.
    d. accessibility.

74. (230) An individual item of supply that has a definite non-extendible period of shelf-life is considered Type
    a. I.
    b. II.
    c. III.
    d. IV.

75. (230) An individual item of supply that has an extendable shelf-life is considered Type
    a. I.
    b. II.
    c. III.
    d. IV.

76. (231) 90-day accumulation sites for hazardous waste (HW) containers should be able to contain the volume of
    a. 50% of all containers.
    b. the largest container only.
    c. the largest container and 10% of the volume of all containers.
    d. the largest container or 10% of the volume of all containers, whichever is greater.

77. (231) How often should hazardous waste (HW) containers be inspected for release problems?
   a. Weekly.
   b. Monthly.
   c. Biweekly.
   d. Bimonthly.

78. (232) What percentage of low observable coatings must be separated as classified or unclassified prior to disposal?
   a. 25%.
   b. 50%.
   c. 75%.
   d. 100%.

**Please read the unit menu for unit 5 and continue ➔**

# Unit 5. Coatings and Markings



SURFACES OF AEROSPACE EQUIPMENT are subjected to many natural and man-made environments. Protecting surfaces from these environments is one of the most important functions of structural maintenance. Inadequate control of corrosion can shorten equipment life, hinder mission accomplishment, and endanger personnel. To enable metallic surfaces to resist their environments, the surfaces are coated with an organic coating. This organic coating is a liquid or semi-liquid material applied to the surface by mechanical means. When dried—a process we call cured—the coating provides an adherent film that tends to isolate the metal from its environment. This unit covers the procedures and equipment used for preparing and applying protective coatings. This unit also includes information on specific aircraft markings, methods of application, and appropriate placement on the aircraft.

## 5–1. Protective Coating Removal

Another important aspect of your job as a structural maintenance journeyman is protective coating removal. The most important factor in removal of organic coatings is complete removal without damaging the underlying surface. There are numerous chemicals and mechanical tools you can use. This section covers the procedures associated with the chemical and mechanical removal of coating as well as abrasive blasting.

### 233. Chemical paint removal

In most cases, chemical strippers are fast and take less physical effort than mechanical sanding, but they bring increased hazards. They are hazardous to personnel, so special protective equipment is required to prevent injury. The chemical and its residue generate hazardous waste, so it too requires special handling. As you can see, along with the ease of removal, there are some drawbacks to chemical strippers. If you have considered these points and have decided that chemical removal is the right method, it is essential that you understand the techniques of coating removal.

#### Choosing a chemical

Chemical removal procedures are essentially the same for all types of finish systems, but the type of chemical remover to be used depends on the type of organic finish system you are trying to remove. Before you chemically remove any organic finish, you must first consult aircraft and equipment specific TOs to determine the type of organic finish system to be removed so you can choose the proper chemical. Then find the approved types of chemical removers for each of these organic finish systems in TO 1–1–8, *Application & Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment;* also find the precautions used for each type.

Other variables when choosing a chemical remover include the type and age of the finish system, type of surface to which it will be applied (metal, large/small, horizontal/vertical), local climate, capabilities of local industrial waste treatment facilities, Environmental Protection Agency restrictions, and medical authority.

Regardless of the type of paint remover you use, do not limit yourself. Changing guidance and environmental sensitivity will occasionally drive the need to change chemicals. All approved chemicals will be identified on a current QPL. You can contact the Air Force Corrosion Program Office for further guidance dealing with chemical removers.

### Environmental friendly paint removers

In these times of environmental awareness, many new materials are on the market that remove paint and are environmentally safe. These products are based on benzyl alcohol and alternate alkaline materials. Environmental friendly chemicals offer the advantage of reducing hazardous waste generation, and they contain ingredients not listed as hazardous materials. Although not environmentally hazardous, eye and skin protection is still required when you use these products. Also, the local environmental coordinator will have to establish proper handling and disposal procedures for the stripper and the process waste. They are generally effective for topcoat removal but give differing degrees of effectiveness and efficiency with primers. TO 1–1–8 contains a list of approved environmentally friendly paint removers.

### General chemical removal procedures

As always, your first step should be to protect yourself. Chemical removers are toxic to skin, eyes and respiratory tract. Contact the local bioenvironmental office for determination of need for respiratory protection and selection of proper type when required. The steps below list the general procedures for chemical paint removers. Remember you should always consult your aircraft or equipment specific TO before performing maintenance.

1. Determine the type of organic finish to remove. Select and obtain the proper chemical remover for the finish system involved in accordance with TO 1–1–8.
2. Ensure the aircraft or equipment has been properly cleaned, dried, and masked in accordance with TO 1–1–8.
3. Mix the chemical remover well with a mechanical mixer or a wooden paddle immediately before use. Do not mix before you are ready to apply; chemical removers tend to separate on standing.
4. Apply the paint remover in a smooth, even coat, using a long-handled brush or non-atomizing sprayer, beginning at the highest point of any vertical or sloping surface and working down. For an effective removal operation, chemical removers must be applied progressively and in a logical sequence. Apply strippers to areas no larger than those that can be effectively worked by personnel on hand
5. Allow the chemical to dwell on the surface for the time specified in TO 1–1–8 and then agitate several spots on the surface with an abrasive mat or a stiff bristled brush, to determine if the finish has been loosened down to bare metal.. If not, repeat the dwell and spot agitation procedure until the finish is down to bare metal.

   **NOTE**: Never let the paint remover dry on the metal surface; rinse it off immediately after the paint system has lifted. Letting the stripper dry makes it hard to remove, and it will corrode the metal surface.

6. Once the finish is lose, thoroughly agitate the entire area with a stiff bristled brush and scrape all loosened finish system residue and chemical remover from the surface with a rubber bladed squeegee.
7. Clean the area in accordance with TO 1–1–8 and remove all masking materials.

You can remove paint in confined areas with ethyl acetate, aircraft coating thinner, 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 soft bristle brush, keeping the area wet with 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 is removed. Then dry the area with a clean lint-free cloth.

### Shelf life

All chemical removers have a shelf life of six months from the date of manufacture unless otherwise specified, if they are stored and maintained under the proper conditions. They should be ordered in quantities and intervals that allow all chemical removers on hand to be used before their shelf life expiration date. They shall be stored in a protected area (out of direct sunlight) capable of maintaining a temperature of 40° F to 100° F to prevent them from freezing or being exposed to excessively high temperatures. Chemical removers rapidly deteriorate at temperatures exceeding 100°F and many of them become corrosive. Exposure to freezing temperatures causes them to separate in such a way that the components cannot be remixed to a homogeneous solution. In either case, they become ineffective.

### Removing paint from composites

Chemical removers used for finish system removal from metal surfaces should not be used on any composites, unless approved by the aircraft or equipment specific TO. These strippers can degrade the composite resin system so they should be used only when authorized.

## 234. Mechanical paint removal

Mechanical removal is recommended when the use of chemical removers is impractical. Mechanical removal methods vary from the use of hand-held wire brushes, bonded abrasive paper/cloth and abrasive mats to motor-driven abrasive removal and abrasive blasting. Just as with chemical strippers, you should select one that is appropriate for your work situation. When choosing a removal method, a compromise between maximum removal power and maximum protection for the equipment being stripped must be made.

### Preparation for paint removal

These are some basic preparations outlined in the TO 1–1–8. Clean and inspect surfaces, position aircraft and equipment in a covered facility, mask or cover all areas as directed in system peculiar TO.

### Precautions

Mechanical removal techniques are very effective for removing organic finishes but they can cause severe damage to structure and equipment if improperly used. Abrasive blasting and motor-driven paint removal techniques create airborne and noise hazards that are harmful to the eyes, skin, respiratory tract and hearing. Minimum recommended personal protective equipment (PPE) for hand-held or motor-driven abrasive paint removal is listed in TO 1–1–8; also, the base bioenvironmental engineer can provide a list of required PPE. Dust generated during these procedures has the potential risk of causing dust explosion; thus, pneumatic motor-driven equipment should be used. During the mechanical paint removal process, properly ground all equipment, work stands, and work pieces. Avoid all sources of ignition and provide adequate ventilation in the area. Do not use compressed air to remove dust. Performing mechanical paint removal on steel and titanium alloy surfaces may cause sparking. Only work on these parts in well-ventilated areas.

### Nonpowered removal

Nonpowered tools consist of hand-held wire brushes, bonded abrasive paper/cloth, metallic wools, and abrasive mats. Nonpowered tools are designed for either initial removal of loosened paint on small areas, or when it is impractical to use powered equipment due to limited space, and so forth. Remember, nonpowered techniques are slow, so use powered tools if possible. Refer to TO 1–1–8, for hand-held abrasives and grits for use on specific metals. After the finish system has been removed, use high efficiency particulate air (HEPA) vacuums with appropriate attachments to vacuum dust from aircraft and facility floors. Do not use compressed air unless necessary to remove dust from very narrow cracks and crevices.

### Powered removal

Power tools consist of drills, sanders, or grinders that have been loaded with an appropriate abrasive medium. Motor-driven wire brushes, bonded abrasive paper/cloth, cloth discs, abrasive mats, or flap brushes may be used for coating removal. While these methods are very effective for finish system removal, they can cause severe damage to structure and equipment in a very short period of improper use. Hold the tool firmly in your hands at all times during use. Keep sander heads flush against the surfaces being sanded and apply the least amount of pressure necessary to effectively remove the finish system topcoat and not go through the primer and gouge or abrade the metal substrate. All areas where the paint system is nicked, scratched, chipped, and any edges of the paint system around areas where paint removal was done, are to be feathered-out. Abrade the primer from the surface with the same methods used for the topcoat, but with finer grade abrasives. After the finish system has been removed, use HEPA vacuums with appropriate attachments to vacuum dust from aircraft and facility floors. Do not use compressed air unless necessary to remove dust from very narrow cracks and crevices. Refer to TO 1–1–8 for appropriate motor-driven abrasives and grits used on specific metals. Always wear the appropriate PPE when you work with or around powered equipment.

### Removing paint from composites

Hand tools and powered abraders may be used to remove paint from composite surfaces, but in a limited manner. A pneumatic drill motor fitted with the medium grade “Scotch-Brite,” aluminum oxide, surface conditioning disc can be used to remove topcoats from fiberglass, aramid fiber, graphite or boron fiber composite surfaces, because it gives a fast removal rate with low possibility of damage to the composite substrate. A fine grade “Scotch-Brite,” aluminum oxide surface conditioning disk can be used to remove the primer coat from these composite surfaces. Apply the least amount of pressure necessary to remove the finish system effectively and not go through or gouge the composite surface. Just as with metallic surfaces, removal of sanding dust is required once the finish system removal is complete. Refer to TO 1–1–8 for other authorized hand-held and motor-driven abrasives.

## 235. Abrasive blasting

The abrasive blaster is operated by compressed air that bombards the surface with an abrasive that is projected at a high velocity. The abrasive holding tank used in direct pressure equipment is a pressure vessel that forces the abrasive medium through a metering device, into the pressurized blast line, and to the blast nozzle. Portable abrasive blasters are effective in removing corrosion and paint from metal surfaces.

Corrosion control facilities today are usually equipped with a walk-in plastic media blasting (PMB) booth and a freestanding PMB cabinet blaster, commonly referred to as a *glove box*.

Abrasive blasting equipment is simple to operate, but each type of equipment has its own peculiarities. Therefore, you must follow the operating instructions for the type of equipment you use to prevent damage to it or the material being blasted.

### Plastic media blasting removal

PMB is an excellent and rapid method for paint removal, but it can cause severe damage to structure and injury to personnel if not done correctly. Proper waste management must be ensured. Certain types of materials and material thicknesses cannot be plastic media blasted. The procedures in TO 1–1–8 are general and are to be used in conjunction with the aircraft or equipment specific TO.

### *Media type*

Media used in PMB shall be made from plastic, which is free from high-density particle contamination and impurities. The media shall have a particle shape, which is irregular with sharp, angular edges and corners. Plastic media is classified by type, which specifies the hardness, plastic, and performance characteristics. The following types are listed in TO 1–1–8:

| | | |
|---|---|---|
| Type I | – | Polyester plastic |
| Type II | – | Urea formaldehyde based plastic |
| Type III | – | Melamine formaldehyde plastic |
| Type IV | – | Phenol formaldehyde plastic |
| Type V | – | Acrylic plastic |
| Type VII | – | Starch-g-acrylic |

Types I, II, V and VII are authorized for use on aerospace structures

**NOTE:** PMB Type VI is not authorized for use on aircraft and is not listed in TO 1–1–8.

### *Plastic media blasting cabinet blaster*

The cabinet blaster (fig. 5–1) is used for small pieces of equipment and removed parts. The pressure method of cabinet blasting removes paint by propelling a mixture of media and compressed air through a nozzle at the component surface. After striking the surface, the spent media is reclaimed and recycled for continued use. Airborne spent media and dust within the work chamber is drawn into the dust collector and the filtered air is exhausted into the environment.

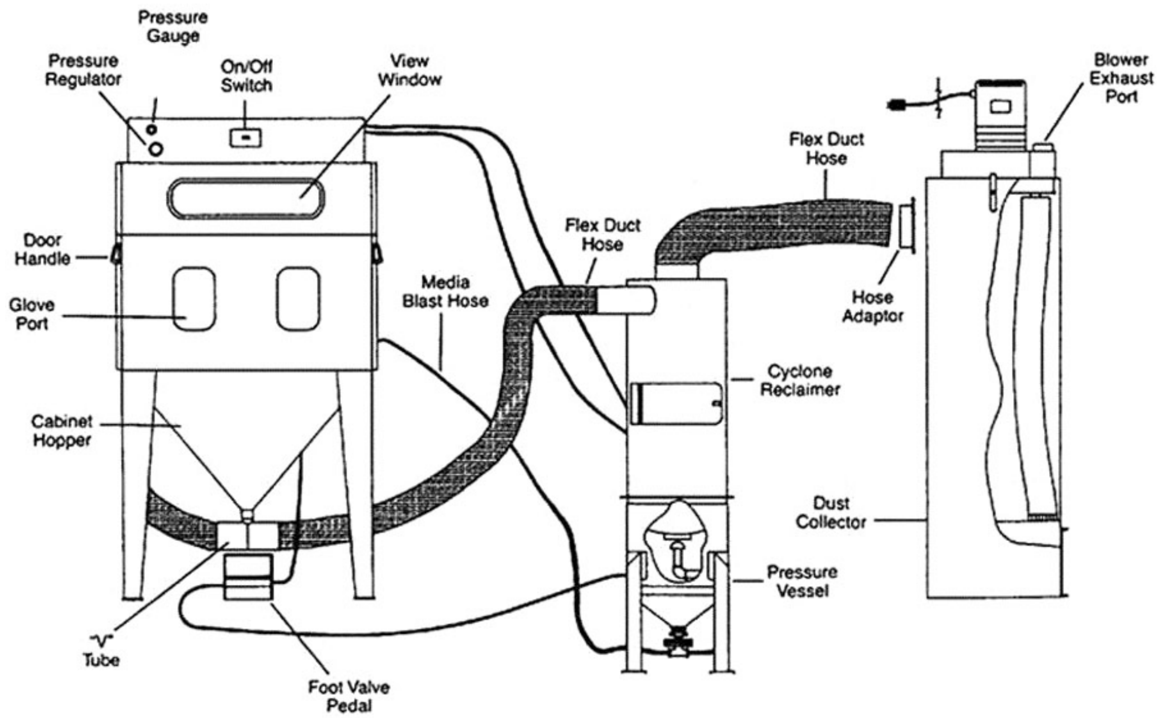



**Figure 5–1. Cabinet blaster.**

Check the media level before the operation. Consult the machine specific owner's manual for proper media operating level range. Never operate the blaster with less than recommended amount of media.

Make certain the cabinet doors, reclaimer door, and dust collector doors are securely fastened prior to engaging the operating foot pedal.

Most shops have a “startup” and “shut down” checklist. If one is not available, consult the owner’s manual for proper start and stop procedures. For very small objects, place a piece of fine screen over the grate to prevent them from falling through. Do not hold small parts that will require blasting directly into the glove. Do not open the doors until the cabinet chamber is clear of airborne dust.

#### *Plastic media blasting booth blaster*

PMB is an excellent method of paint removal. PMB removes paint; but unlike sand, it will not remove corrosion. In reality, the PMB booth is just like the cabinet blaster; it uses a blast gun assembly and is built on a much larger scale. It operates on the same principles. In a cabinet, spent media falls through a grate on the bottom of the assembly. In the booth, spent media falls into or is swept into a floor grate. In both instances, the media is reclaimed through a cyclone and recycled for further use.

Unlike the cabinet blaster, using the PMB booth requires the use of additional PPE. In the booth, you are required to wear coveralls, boots, gloves, and a hooded, forced-air respirator. Even though the medium seems harmless, it can still cause severe damage to the structure and injury to personnel if the work is not done correctly. Paint removal using plastic media is authorized at depot and field units, contingent upon approval of the facility, trained personnel, and processes used.

Before beginning the stripping operation, firmly grip the nozzle, aim, and depress the trigger. Use the same blasting parameters as the cabinet blaster with one exception, the nozzle is held at a farther distance from the surface.

### Blasting parameters

Blasting parameters are simply guidelines on nozzle pressure, angle of incidence, surface distance, and dwell. The operator must follow these parameters to prevent damage to the substrate.

#### *Nozzle pressure*

The blasting pressure of the medium should be adjusted to prevent component damage. The nozzle pressure will depend on the blast media type and the substrate thickness.

#### *Angle of incidence*

The angle of incidence is the angle the medium strikes the surface being abrasively blasted (fig. 5–2). It is a critical factor in paint removal. An incorrect angle of incidence could result in damage to the surface or slower paint removal. Actual angles are in TO 1–1–8.

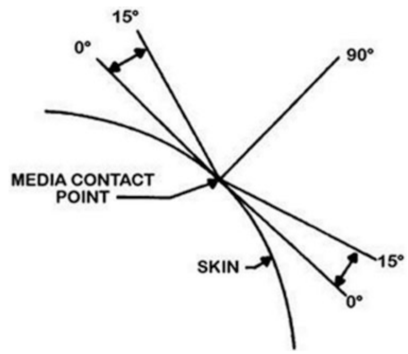



**Figure 5–2. Angles of incidence.**

#### *Surface distance*

Surface distance is the distance the nozzle is held from the surface being abrasive blasted, and is critical to proper blasting. Holding the nozzle too close can damage the surface; if held too far away, the surface will not be stripped of its coating. Generally, this distance depends on the media type, substrate thickness, and material of component.

#### *Dwell*

Dwell refers to the time the operator holds the nozzle on one spot. Generally, you should keep the nozzle moving. Working in the same spot for too long can cause the surface to develop stress concentrations and ultimately warp.

### Substrates blasted

There is no limitation in blasting metal except the substrate's thickness. PMB shall not be used on metal structures having a thickness less than 0.016 inch. Many surfaces may be blasted with plastic media. Before blasting, check the specific technical order/manual for thickness limitations.

PMB may be used on advanced composite materials if the SPM approves. When using PMB, remove only the paint from the composite surface; the underlying primer is a "flag" to signal that the paint coat has been removed. When you begin to see the primer, direct the PMB blast elsewhere on the surface of the substrate. This technique is essential to avoid damaging the composite material.

### Surface preparation

When blasting, your first step is to thoroughly clean the substrate to remove grease, oil, fluids, and dirt. Before masking areas that you do not want to be blasted, make every effort to stop all fluid leaks, and let the surface dry fully before masking. Water and other fluids contaminate blasting media, and may damage separation equipment. Before starting PMB, mask the area properly. Failure to properly mask may result in media intrusion into interior areas and can contaminate or damage equipment.

### Postblast cleaning

After using PMB, vacuum all surfaces of the component thoroughly with a heavy duty, pneumatic type, wet/dry HEPA filtered vacuum cleaner to remove all finish system dust and media residue. As an alternative, use compressed air or water wash to remove dust and media residue. However, avoid the use of compressed air to remove dust and media residue, unless necessary. Make sure to start with a clean, empty vacuum because plastic media needs to be recovered for recycling. Check local guidance for recycling plastic media. Use compressed air or water wash as an alternate method. As a last step, remove all masking materials and inspect the interior surfaces for media intrusion.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 233. Chemical paint removal

1. What steps do you take to determine the correct chemical remover to use?

2. What variables other than organic finish type should you consider when choosing a chemical remover?

3. What do you use to agitate softened paint to help loosen it?

4. What happens if you let paint remover dry?

5. After loosening the paint in confined areas, what do you use to remove it?

6. How should you store chemical removers?

**234. Mechanical paint removal**

1. When choosing a paint removal method, what compromise must you make?

2. List some basic paint removal preparations.

3. Where can you find PPE requirements for mechanical paint removal?

4. What are nonpowered tools designed to accomplish?

5. What is the procedure for removing paint with a power tool such as a sander?

**235. Abrasive blasting**

1. What two types of media blasting equipment are in most aircraft structural maintenance shops?

2. Since the procedures in TO 1–1–8 are general, what other instructions should be used with them?

3. Which types of media are authorized for use on aerospace structures?

4. When blasting very small objects why would you place a piece of fine screen over the grate?

5. What factors dictate the nozzle pressure?

6. What is name used to describe the distance the nozzle is held from the surface?

7. What is the substrate thickness limitation in blasting with sand?

8. Why must you thoroughly clean the substrate to remove grease, oil, fluids, and dirt, stop all fluid leaks and let the surface dry before masking?

## 5–2. Protective Coatings

The basic objective of any coating system is protection of exposed surfaces against deterioration. A faded, stained, unattractive, but well-bonded coating is better than a fresh one improperly applied. There are a few factors you need to consider before applying a coating. For example, how long do you want the coating to last? What are the service requirements? How often will it need to be removed? What function will the coating serve? These are all questions you can answer if you are familiar with the composition and use of coating systems.

### 236. Preparing protective coatings

Customarily, finishing materials are classed as paints, enamels, lacquers, epoxies and polyurethanes. The word "paint" is loosely used to mean all finishing materials. Modern coatings now include quite different components in combinations that do not fall into the old categories.

#### Components

Modern paint is a mixture of many things, but the pigments, vehicles and solvents are the primary components. Secondary components may be extenders, driers, antioxidants, surfactants, light-filtering agents, and/or other additives. Materials can also be added when special properties are required such as luminescence, fluorescence, fire retardant, and so forth.

##### *Pigments*

Pigments are finely divided, substantially insoluble, and usually opaque materials incorporated into paints to provide color, hiding power, and specific qualities such as light and heat reflectance (or heat absorption), corrosion-inhibition and certain flow characteristics. Pigments are either organic or inorganic. They also are either natural or synthetic. We use a limited number of pigments as corrosion inhibitors in paints. The specific pigment we use depends on the metal that it protects and the subjected environment. Examples of pigments and the colors they produce are zinc oxide for white paints, zinc chromate for yellow, chromium oxide for green, and iron oxide for red.

##### *Vehicle*

The vehicle is the liquid portion of the coating. The vehicle is perhaps the most important part of the coating, as the vehicle furnishes the desired qualities of adhesion, toughness, flexibility, and resistance to environments. The primary constituents of the vehicle are the volatile and nonvolatile portions. The nonvolatile includes resins, drying oils, and plasticizers that become the binding agent in the cured film. Upon evaporation of the volatile portion, the nonvolatiles form the actual film on the surface together with the pigment, if one is present.

#### Solvents, diluents, and thinners

At ordinary room temperatures, the consistency or viscosity of mixtures of oils, pigments, and resins that make up coating materials is too high to allow spreading them effectively over surfaces in the desired thickness. In addition, most resins are solids and need to be dissolved in a liquid before they can be dispersed. Although the terms solvent, diluent, and thinner are often used interchangeably to describe a liquid, it should be understood that the words have different meanings. Further, the mechanism of solvents and diluents or thinners is different. For example, a solvent will thin incidentally while performing its prime purpose of dissolving something whereas a diluent or thinner is used to reduce viscosity and/or regulate evaporation and is not required to, and/or may be unable to, dissolve any constituents of the coating.

#### *Solvents*

A solvent has the essential function of reducing the viscosity of the vehicle portion of the material to the point where it can be managed. A liquid may dissolve one substance well, another poorly, and still others not at all. There is no universal solvent in coating technology. Solvents do not react chemically with coating constituents or dissolve pigments; and ultimately, they are lost from the coating by evaporation having served their purpose.

Most solvents are organic materials and are classified by their chemical structure as alcohols, esters, ketones, and so forth. In practice, they must be considered from the standpoint of their powers of solvency as expressed in reference to some material. Generally, the solvent portion of a coating is itself a blend of solvents, each one chosen for its power to dissolve a particular constituent of the coating, and each present in proper proportion to regulate evaporation to a rate that prevents premature segregation of any single dissolved constituent.

#### *Diluents and thinners*

To distinguish between diluents and thinners, the material added by the manufacturer to adjust viscosity is called *diluent;* the same material added by the painter for the same purpose is called *thinner*. Solvents and diluents are frequently used together in coating formulations, and the purpose of a liquid determines whether it is a “solvent” or “diluent.” Diluents and thinners are also normally less expensive than solvents.

Of course, thinners must be compatible with the coating with which they are combined. Compatibility is beyond determination at the field level; hence, only authorized thinners specifically called out for use with a given coating shall be used to thin it. TO 1–1–8 lists approved thinners and the coatings they are used with.

### Traditional coating systems

We use organic coatings to protect equipment. We also use such coatings for specific purposes like color-coding, insulating, or camouflaging parts and equipment. There are a large number of traditional coatings approved for the Air Force. It is beyond the scope of this course to cover all of them, instead we will discuss a few of the most common ones. We will discuss low observable coatings in a later section. The traditional coatings we will discuss are primers, polyurethane topcoats, and rain erosion coatings.

#### *Primers*

There are many types of primers that match various military specifications. Each has its own characteristics and uses; ensure that you always use the primer that the specific technical order calls for. Probably the most common type of primer used on aircraft today is an epoxy primer.

##### *Epoxy primer*

Epoxy primer is a two-component, pigmented epoxy primer particularly formulated for its excellent adhesive properties. It is very resistant to chemicals, lubricants, and corrosive atmospheres; however, it has only fair weathering characteristics. Because it is an epoxy and has excellent adhesion, it is difficult to remove with standard paint removers. Although epoxy primers are primarily intended for spray application, you can apply them by brush to small areas.

##### *Elastomeric, polysulfide primer*

Elastomeric, polysulfide primer is a two-component primer formulated for its corrosion resistance and flexibility. It is a superior material for protection of relatively flexible aircraft structures because it will not crack or peel away from fasteners in highly stressed areas. The physical properties of this primer increase the longevity of the paint system as well as decrease maintenance and corrosion rework during the service life of the coating system.

#### *Volatile organic compounds compliant, epoxy primer*

Volatile organic compounds (VOC) compliant, epoxy primer is a two-component, lead-free, water-reducible, corrosion-inhibiting epoxy primer formulated to meet most environmental pollution regulations. It is a suitable replacement for epoxy primer in areas where low VOC regulations are in force.

#### *Polyurethane primer*

This is a two-component, low VOC, solvent-borne, high-flexible elastomeric polyurethane primer. Because of its high flexibility, use this primer in areas of high impact such as leading edge slats and the entire exterior surface on large, flexible cargo and bomber aircraft.

### ***Polyurethane topcoats***

Polyurethane coatings are catalyzed two-component high solids coating formulated for compliance with air quality regulations. These coatings are characterized by their very high gloss retention in gloss finishes and its flatness in camouflage finishes. This coating has superior toughness, outdoor durability and good chemical resistance. The Air Force recommended polyurethane topcoat comes in two types:

1. Type I is intended for use on aerospace weapons systems.
2. Type II is intended for use on ground support equipment and shall not be used on aircraft due to is low flexibility.

### ***Polyurethane rain erosion***

Polyurethane rain erosion material is available in two types. Each type has two classes. Primer and topcoat components are furnished together as a kit.

1. Type I is an electrically nonconductive rain erosion resistant coating.
2. Type II is an antistatic rain erosion resistant coating.

The two classes are as follows:

1. Class A material is not dependent on moisture or high relative humidity for curing.
2. Class B is dependent on them.

Classes A and B, Types I and II coatings are intended for protection of exterior laminated plastic parts of high-speed aircraft and missiles from rain erosion while in flight

Classes A and B, Type II coatings also discharge and dissipate static electricity, to prevent radio and radar interference.

## **Preparation**

Your first steps in preparing coating materials for use is to check the shelf life date and let the materials come to room temperature. Remove the lids of the containers and inspect the coating materials for skins, jelling, and lumps. If skins are present, carefully remove and discard them. Do not use gelled, lumpy, or deteriorated coating materials. Discard them at once. If you use pigmented primers or paint with non-sealable lids, run the cans through a cycle of agitation in a mechanical shaker before you open them for inspection. Do not mix materials made by different manufacturers, even if the materials have the same specifications. Such mixing presents problems of incompatibility in the liquid and in the drying phases. Since epoxy primer and polyurethane topcoat cure by chemical reaction rather than dry by evaporation, use only clean equipment to mix and apply the coatings. Clean your equipment immediately after use with a compatible solvent to prevent the coating setting up.

### *Mixing*

All coating materials require preparation prior to application, and problems with color, gloss, hiding power, film application characteristics, adhesion, and curing can be expected if materials are not adequately prepared.

Mix in controlled areas that are well ventilated and away from open flame, sources of ignition, and direct sunlight. A forced air ventilation system, preferable with the airflow from the back of the personnel to an exhaust in front of them, is recommended. For two component materials, an organic vapor-type respirator shall be worn as a minimum, with the air-supplied respirator being preferred.

For two-component materials, the components must be thoroughly mixed with each other and in the exact specified proportions or curing and adhesion problems will occur. Pigments, which give color and other desirable characteristics to coatings, are generally insoluble and heavier than the liquid portion of the coating material, so they eventually settle out of suspension. The consistency or viscosity of the liquid portion determines the rate of settling; for example, pigments mixed with a thinner alone would settle out in a few minutes; but in a paint vehicle, it might take months.

Settled material usually redisperses readily unless the material is over-aged or has become exposed to the atmosphere. In some materials, such as some vinyl-based materials, settling may be accompanied by a change in chemical structure after storage of only a few months. Such changes are not reversible; therefore, judgment should be employed whenever using them.

### *Methods of mixing*

You can mix the coating material by either manual or mechanical methods. Following are three methods to mix coating material in containers:

1. Hand-mix single-component materials and the catalyst component of two-component materials in cans and drums, per the manufacturer’s instructions, using wooden or plastic paddles.
2. Mix one-component materials and the base component only of two-component materials in containers up to 5 gallons is best accomplished by using a mechanical shaker.
3. Accomplish mixing of one-component materials and the base and catalyst components of two-component materials with low speed mechanical paddles.

A simple way to test for complete mixing is to flow samples of mixed paint samples down an inclined piece of glass. Irregularities of color or flow will indicate incomplete mixing. Compare samples from the top and bottom of the container to ensure complete mixing of the paint.

### *Paint shaker*

A mechanical paint shaker is a piece of equipment that can be either floor mounted or bench mounted and is used to vibrate or shake the unopened material containers. They are especially important when working with materials for low observable applications. Due to the incorporation of metallic solids in many of the paint, ceramic and caulk products used in low observable applications: an industrial grade mixer is required.

Although mechanical shakers are standard equipment in a paint facility, there are many different styles available. The two main types are single and dual arm models with options of six, 15, and 60 minute run times. Many manufacturers also offer the shakers in either pneumatic or electrical models to suit your specific needs.

Even though there are many different types of shakers, they all basically work the same:

1. Place the unopened container onto the shaker.
2. Secure the clamping mechanism. Ensure that the container is secured snugly without crushing the container.

3. Set the timer to the time required by the coating manufacturer. When the shaker stops, remove the container and continue the mixing process as required.

### *Measuring viscosity*

Viscosity is a measure of a liquid's resistance to flow. Very viscous or thick liquids flow very slowly, while low viscosity liquids flow very quickly.

Maintaining the proper viscosity is very important for proper primer and paint spray applications. Too high a viscosity produces poor spray patterns and poor coverage, while too low a viscosity produces a film that sags and runs easily.

Various methods and instruments measure viscosity, and it is expressed in various units of measurement. The method most frequently cited in the coating industry use the No. 2 Zahn cup (fig. 5–3). Viscosity is expressed in seconds through the cup. The seconds indicate the length of time it takes at a given temperature for a known quantity of the coating material to flow through a certain size orifice in the cup.

### *No. 2 Zahn cup*

After the primer or paint coating is properly mixed, fully immerse the cup in the liquid so it is completely filled, and lift the cup out of the liquid. Using a stopwatch, measure the time, in seconds, it takes the material to flow out of the hole in the bottom of the cup from the moment the cup clears the liquid surface to the point where the first break in the flow stream is noted. This time is the viscosity in No. 2 Zahn seconds. The No. 2 Zahn cup does not work well for high-solid coatings.

**Figure 5–3. No. 2 Zahn cup.**

### *Adjustments*

If the viscosity measured is not within the specified range, thin the material per the thinning instructions for the primer or paint coating listed in the applicable technical data. Next, measure the viscosity again after cleaning the cup with thinner. Repeat as necessary until the viscosity is within the specified range. Once your coating is within acceptable range, strain all material to be used in spray equipment through fine-mesh strainers or cheesecloth.

## 237. Operating coating application equipment

To enable metallic surfaces to resist their environments, the surfaces may be coated with an organic coating. This organic coating is a liquid or semi-liquid material applied to the surface by mechanical means. When dried, a process called *cured*, the coating provides an adherent film that tends to isolate the metal from its environment.

Spray application is the standard for painting Air Force aircraft and most other equipment. It is fast and, in the hands of skilled operators, produces films of good uniformity and quality. Methods other than spraying are useful in special cases, particularly in nonaeronautical or less critical applications. Brush or roller applications have their place and should be considered as alternate methods when used with suitable materials. The painter's discretionary use of brush or roller for painting aerospace equipment should be based on local circumstances such as health or fire hazards. Additionally, there are some requirements that demand brush application, such as painting porous surfaces that require brushing-in for adequate coverage and penetration.

### Identifying and using application equipment

The Air Force uses several hand-operated spray methods. Included in this classification is the high volume, low-pressure (HVLP) method. These spray guns (fig. 5–4) are equipped with an airtight container and use various air cap assemblies (fig. 5–5).

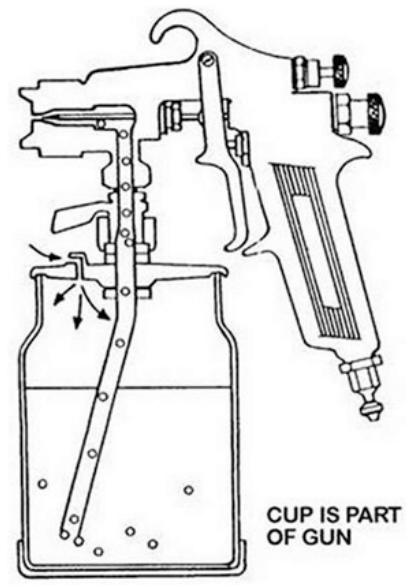



**Figure 5–4. Spray gun.**

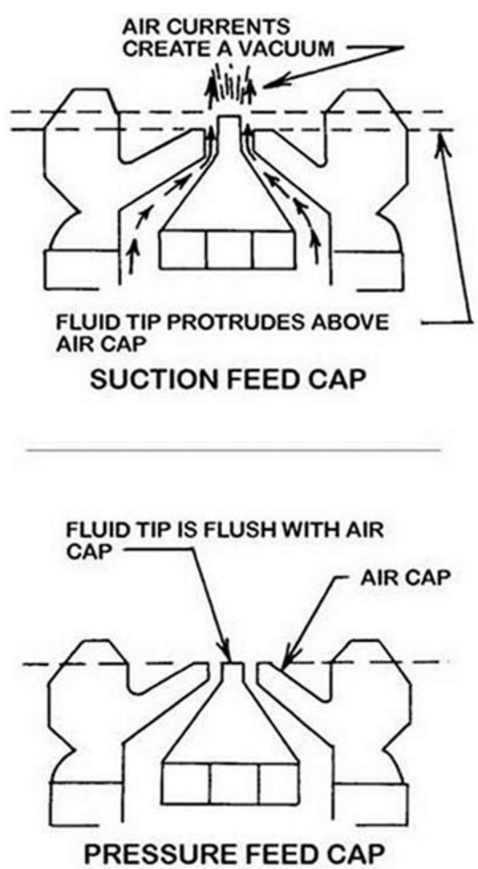



**Figure 5–5. Air cap assemblies.**

### *High volume, low pressure*

The HVLP method is now the standard spray method used in the Air Force and meets the requirements of environmental regulations. In the HVLP method, a high volume of low-pressure air through a spray gun atomizes the coating material. The air pressure is reduced to between minimum of 1.0 and maximum 10 psi, and is used to atomize the coating material.

A high volume of air is used to push, not propel, the material into a very soft, low-velocity pattern. This soft spray will generally provide a more consistent coverage and a better overall finish. The HVLP method is preferred because it can spray a high volume of heavy materials when supplied with a low volume of air.

Unlike the common conventional spray gun, the HVLP gun should be held closer to the surface because of the lower speed of the paint particles. The gun should be held 6–10 inches from the work piece. The film thickness is often greater than the conventional air spray systems. In addition, because of the low pressure, the various types of equipment will require very little maintenance. This equipment shall not be used above 10 psi nozzle pressure; otherwise, the derived benefits of the HVLP will be negated. Pressure should be checked regularly with a nozzle pressure gauge (fig. 5–6). HVLP spray guns are classed in three general types: suction feed, gravity and pressure feed.

**Figure 5–6. Nozzle pressure gauge.**

#### *Suction feed*

The suction feed cup gun is usually fitted with a fluid cup. Its nozzle assembly is designed to feed paint into the air stream by the vacuum created from the air flowing past the fluid tip, which protrudes into the air stream beyond the air cap. Because the amount of spraying is limited to the contents of the cup, this gun is commonly used in painting small areas usually in the confines of a spray booth (fig. 5–7).

#### *Gravity feed*

The gravity feed gun is designed with the cup located on the top of the spray gun. This allows paint to completely drain, minimizing paint waste. Gravity feed guns supply paint to the orifice solely by means of gravity. The air pressure at the orifice of these guns is typically 40 to 50 psi.

#### *Pressure feed*

The pressure-feed spray gun operates with the fluid being supplied under pressure to the gun from an external airtight tank via a hose. These set-ups are commonly called *pressure pots*. The air cap and fluid tip are flush with each other and no siphoning effect is necessary. The pressure feed system is especially useful for high volume painting.

#### *Material containers*

The cup and the tank are the two paint reservoirs used for spray guns. Both types are available with agitators to provide constant mixing to keep materials in suspension during painting operations. Agitators are mechanically operated by either an air or electric powered motor. Cup containers are used when small quantities of paint are to be sprayed.

**Figure 5–7. Cup container.**

Pressure feed tanks (fig. 5–8) are used for high-volume painting. The containers are tightly closed metal containers that can be as large as 120 gallons; they provide material at a uniform pressure and constant rate of flow. Compressed air is directed into the tank to force the material out. Air pressure must be adjusted to change the rate of flow.

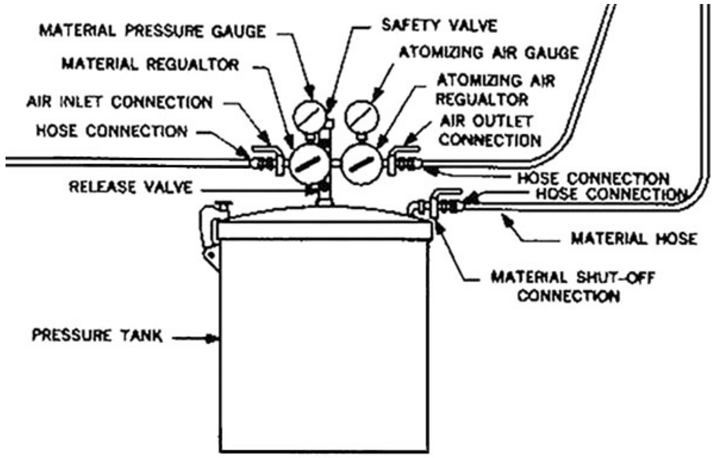



**Figure 5–8. Pressure feed tank.**

### *Gun techniques*

Spray guns are designed to be used with certain spray techniques. They are gun adjustments, distance, stroking and triggering. The quality of finish is determined by how well you use these techniques.

#### *Adjustments*

The flow of air and fluid must be adjusted to obtain proper atomization and other desired spray characteristics. The proper combination of air cap and fluid tip is the first step in ensuring a proper balance of air and fluid flow. The fluid adjusting screw permits restriction of fluid flow relative to the volume of air being used (fig. 5–9). It is limited since it puts tension on the trigger and can hinder feathering at the start and end of a stroke. Adjustments of tank pressure on pressure feed equipment is more effective for obtaining the proper air to fluid balance. The air adjustment screw can be adjusted to spread out the spray pattern, which, in combination with the increased airflow, is equal to reducing the flow of fluid.

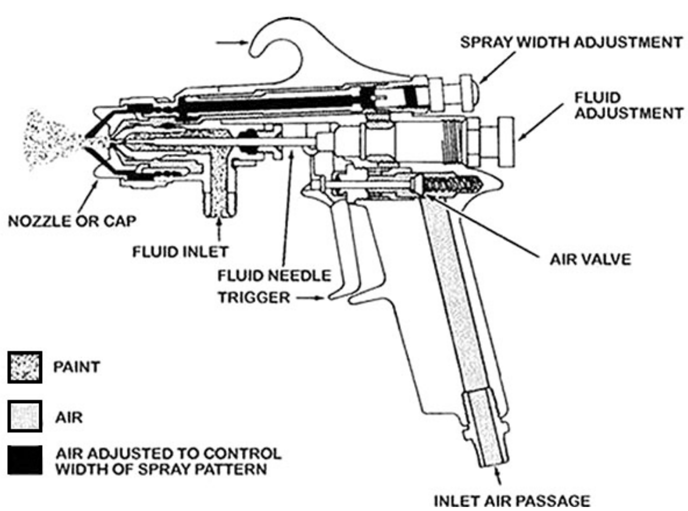



**Figure 5–9. Spray gun (sectional view).**

The correct atomized pressure depends on the type of coating and the length and diameter of the air line from the regulator to the gun. Excessive amount of air pressure can cause a split spray pattern and too little pressure can cause a heavy centered spray pattern.

### *Distance*

The distance the spray gun is held from the surface depends on the desired width of the spray pattern and the type of gun used. When all adjustments are correct and the gun is held too far from the surface, it will result in a dry spray, (dusting) and excessive overspray. If the gun is too close to the surface, a heavy coating with a tendency to run and sag will be the outcome.

### *Stroking*

You should always try to maintain the same distance, speed and perpendicularity of the gun to the surface being painted on each pass (fig. 5–10).

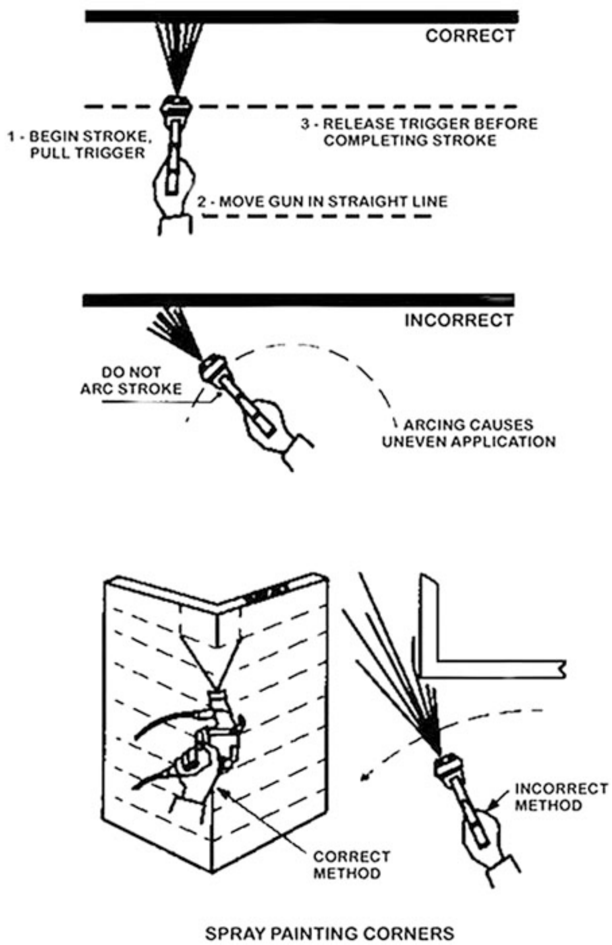



**Figure 5–10. Correct/incorrect spraying methods.**

The natural tendency for painters, particularly when fatigued or in an uncomfortable position, is to arc the gun. *This must be avoided at all costs*. Wrist movement must be eliminated during stroking. The result of arcing is a thicker coating in the middle of the stroke. An exception to this rule is during spot touch-ups. In this situation, you can fan/arc the gun to produce an area which is thinner at the edges in order to blend into the surrounding painted area. When applying coatings with poor flow characteristics, special efforts must be taken to hold the gun perpendicular to all surfaces (flat or contoured). If this is not done, the irregular spray pattern will cause uneven thicknesses and uneven drying. Protrusions like screw heads will require facing the gun in several directions. It is recommended that you paint these areas in advance.

Stroking should be in parallel passes with each stroke aimed for a 50 percent overlap, or so that the middle of the spray pattern strikes the wet bottom edge of the previous stroke (fig. 5–11). This assures a full wet coat without streaks. Cross coating should always be used when applying multiple coats. This is done by applying each layer using the 50 percent overlap and cross coating with each alternate layer of the coating, usually after a drying or curing period between coats. Cross coating can be used for applying a single coat system by applying a thin, wet coat immediately with another thin cross coat to obtain one full wet coat.

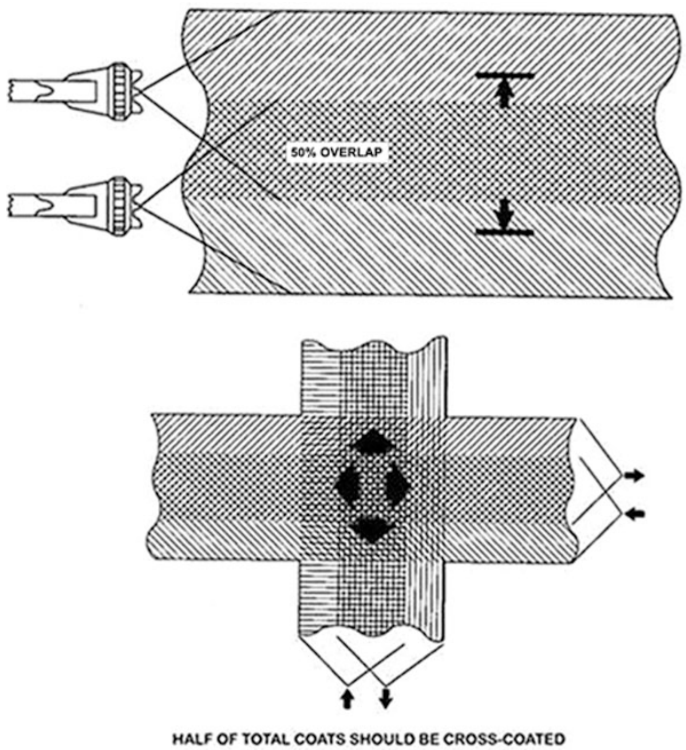



**Figure 5–11. Overlapping.**

### *Triggering*

Proper triggering of the gun is difficult to learn. It can only be developed by practice. You should start the stroke before triggering and release the trigger before stopping the stroke (fig. 5–12). This tends to feather out the end of a stroke so that the end of a succeeding overlapping stroke blends into it.

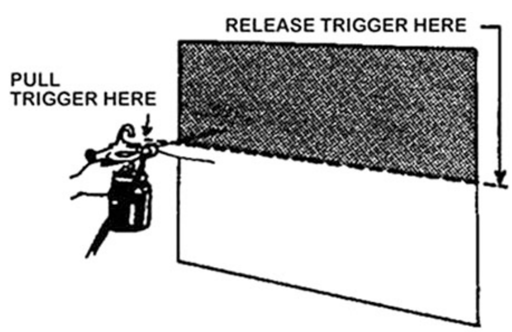



**Figure 5–12. Triggering.**

## Cleaning

Proper maintenance of spray guns is necessary to preserve the life of the gun and ensure high quality results. The gun requires little other maintenance if kept clean. Basic maintenance consists of occasional lubrication (fig. 5–13). The packing surrounding the air valve stem should receive a few drops of light oil to maintain easy movement of the air valve. The packing enclosed in the packing nut around the fluid needle should be lubricated for easy movement of the fluid needle assembly. Coat the spring for the fluid needle assembly with petrolatum. In addition to lubrication, parts that experience wear, such as air nozzles, fluid nozzles, and needle assemblies, should be periodically replaced.

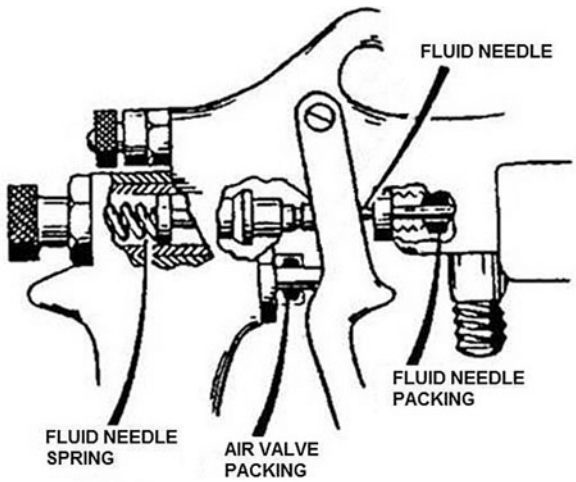



**Figure 5–13. Lubrication points.**

In addition, it is equally important to clean them immediately after use before the coating materials have a chance to harden. You must use an Air Force approved solvent to clean your paint equipment. In all cases, be sure you are wearing the safety equipment required. Eye, skin, and respiratory protection are necessary.

### *Suction feed*

To clean the gun, unscrew the air cap and release the cup from around the siphon tube at least 1 to 2 inches. Hold a cloth over the air cap and pull the trigger. Air will be sent into the passageways, forcing any excess paint back into the loosened paint cup. Discard any excess paint in the cup and clean the inside with an approved solvent. Fill the clean cup a quarter full with an approved solvent. Remove the air nozzle and place it in the cup. Using a nonmetallic bristle brush, clean the fluid nozzle openings and other parts of the gun that are difficult to reach, such as around the packing nuts and controls. Dampen a cloth with an approved solvent; wipe the entire gun and cup until they are clean. Use the nonmetallic brush to clean the air nozzle and openings. Reassemble the gun and spray clean approved solvent through the gun until a fan of clear solvent is produced. Remove any excess solvent and wipe the cup and gun with a clean dry rag.

### *Pressure feed*

To clean the pressure-feed gun, proceed as follows: back off the fluid needle adjusting screw. Release the pressure from the pressure tank by means of the relief/safety valve. Hold a cloth over the air cap and operate the gun trigger. This forces the spray material back into the pressure tank. Remove the fluid hose from the gun and pressure tank. Attach the hose cleaner to the hose and run thinner through to clean the hose. Remove the excess paint from the container and clean with an approved cleaner or solvent. Remove the air cap and follow the steps as stated above for the siphon feed gun.

Never immerse an entire spray gun in cleaning solvents. These materials dissolve the oil from leather packings inside the gun, thus drying out the packings and causing the gun to have an unreliable spray pattern. In addition, dismantling a spray gun after each use will cause excessive damage to the gun and its seals. Dismantle a spray gun only when a proper spray pattern cannot be produced.

#### *Spray gun cleaning unit*

The most effective method for cleaning paint spray guns, paint fluid hoses, and paint pots/cups is by using a mechanical paint gun washer. These washers use a mil-spec approved thinner, or other low vapor pressure solvent that contains some VOCs but no hazardous air pollutants (HAP).

The solvents are contained in a closed-loop system consisting of a cover, reservoir, sump, pneumatic pump, spray nozzles, pneumatic controls, and either a filtration or a distillation system. The container has devices installed inside of it so that you can connect your paint guns. The spray nozzles are situated in a way so that internal as well as external surfaces are cleaned.

Since these washers are closed-loop systems, their use reduces hazardous waste, VOC emissions, solvents required to manually clean the paint equipment, and hazards to the personnel. Use of paint gun washers is required to comply with National Emissions Standards for Hazardous Air Pollutants (NESHAP) rules when applicable.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 236. Preparing protective coatings

1. What are reasons for adding pigments to paints?

2. What is the vehicle of a coating?

3. How are most solvents classified?

4. What is the difference between diluents and thinners?

5. How are polyurethane coatings characterized?

6. What are the first steps in preparing coating materials?

7. What can be expected if coating materials are not adequately prepared?

8. List three methods of mixing material in containers.

9. Why is an industrial grade mixer required for LO materials?

10. What unit of measurement is used when determining viscosity?

11. What must be done to all material to be used in spray equipment?

**237. Operating coating application equipment**

1. What is the standard for painting Air Force aircraft?

2. How far from the surface of the work piece should the HVLP spray gun be held?

3. Why is the suction feed gun commonly used in painting small areas?

4. How is the paint flow adjusted on pressure feed tanks?

5. What is the first step of ensuring the proper balance of air and fluid flow when making gun adjustments?

6. What causes a split spray pattern?

7. If the air pressure supply to a spray gun is too low, what is the effect?

8. What is the result of arcing the spray gun when painting?

9. Why is it important to use overlapping strokes while operating a spray gun?

10. What type of brush do you use to clean the fluid nozzle openings?

11. How long should you spray clean approved solvent through the gun after cleaning and reassembly?

12. Why should you never immerse an entire spray gun in solvent during cleaning?

13. When should a spray gun be completely dismantled?

14. What is the most effective method for cleaning paint spray guns?

## 5–3. Protective Coating Application

Surfaces of aerospace equipment are subjected to many natural and man-made environments. Protecting surfaces from these environments is one of the most important functions of structural maintenance. Inadequate control of corrosion can shorten equipment life, hinder mission accomplishment, and endanger personnel.

### 238. Applying protective coatings

The method you choose to apply protective coatings to aerospace equipment must be developed and adjusted to provide film integrity, optimum adherence, smoothness and good appearance. Achieving acceptable finishes on airframe surfaces requires training and adherence to operational principles. Pre-planning for painting is an absolute requirement to provide a logical schedule of operations, arrange for a cleared working area, and have available painting aids such as scaffolding and cleanup materials and equipment, and so forth. Correctly preparing coating materials and maintaining painting equipment in good operating condition are as important as knowing the techniques of applying coatings.

Painting operations are hazardous and require control or preventive measures. Vapors produced, particularly in spray painting, are usually highly flammable, as are the accumulated dried coating materials deposited on walls, floors, and equipment in the painting area. In addition, coating materials and their thinners very often contain toxic substances, which are injurious to health by inhalation and, to a lesser degree, by skin contact. Painting operations also involve hazards of physical injury due to improper use of work stands, ladders, hoists, etc. As directed by the local safety and the bioenvironmental engineers, all painting personnel shall observe all safety precautions regarding toxicity, other health, and flammability hazards specified by existing instructions and regulations.

#### Atmospheric conditions for painting

Normally, coatings should not be applied under unfavorable atmospheric conditions such as high humidity, strong drafts or extremes of temperature. Painting should be accomplished whenever possible in an environmentally controlled facility capable of maintaining a range of 30 to 80 percent relative humidity and 60° F to 90° F. Some coatings may be applied outside these ranges without significant adverse effects, but you should always watch for adverse effects when applying paint outside of these ranges. You should develop painting decisions based upon local experiences for the particular types of coatings used and the local climate. Consider the following factors:

- The temperature of surfaces being painted should be considered in any painting decision since it is a major factor in the drying or cure of coatings.
- Low humidity retards the cure of moisture curing coatings.
- Low temperatures cause slow drying, or cure, longer tack time, and occasionally incomplete cure. If the temperature is 50° F or lower, painting operations should be suspended.
- High temperatures cause too rapid an evaporation of solvent, which leads to premature skinning, pinholes or solvent pop, blisters, cracked finish, or excessive dry spray. If the temperature exceeds 95° F, painting operations should be suspended.
- The aircraft skin temperature must be at least 60° F prior to any application of coatings. During extremely cold weather, this may require placing the aircraft in a heated paint facility several days in advance to ensure proper skin temperature.

### Test panels

To test suitability of materials, conditions, etc., spray test panels prior to beginning operations. Use a test panel that is approximately 10 × 32 inches in size and coat it with the finish system that is to be applied under prevailing conditions. If the finish system applied to the experimental panel is satisfactory, then full-scale operations may begin. Defects found in the experimental application such as blushing, poor adhesion, excessive orange peel, sagging, and so forth, should be corrected prior to large-scale application. Application of catalyzed (two-component) coatings having a long drying time usually cannot await inspection of completely cured and dry films, so use the best information available from the test panels at the beginning of the application. Test panels are not required for component/part or maintenance painting (touch-up).

### Part and equipment painting operations

You always want to position parts and equipment in the spray booth so that you are not improperly exposed during the painting operation. Whenever possible, place the parts on roll around tables or hang them from roll around racks to allow for their repositioning in the paint booth during the painting operation. Always spray into the face of the booth with the airflow from your back. When you are painting complex parts change the position of the part being painted so that you are never spraying into the airflow. Remove painted parts from the spray booth as soon as possible after the spraying has been completed and the vapors have been removed. When painting large equipment, start at the front or exhaust end of the booth and work toward the back or air supply end. This is to ensure that you remain out of the flow of the paint overspray.

### Aircraft painting process

When applying coatings to aircraft by conventional spraying methods, it is best that at least two painters do the job. Helpers to handle hoses, stands, and so forth, as required, are supported by these individuals. Four painters are sometimes employed on larger aircraft. Make sure that you develop and follow a plan of action when painting aircraft. A solid plan will ensure that the job is done safely, efficiently and effectively. Incorporate the following precautions in your plan:

- Prime and paint aircraft so that your exposure to the spray mist or cloud is minimized.
- Always spray with your back or side upwind, and never direct spray upwind.
- Two or more painters spraying at the same time shall never spray directly at each other and shall be positioned as far apart as possible or on opposite sides of the aircraft.
- When priming, start at the end of the aircraft near the exhaust filter bank and move toward the air supply.

### Surface preparation

The condition of the surface to be painted is of utmost importance to prevent early failure of the organic coating. Adhesion of the coating is best when the surface is clean, dry, and slightly rough.

It is always better to start a paint system from bare metal; however, when authorized in TO 1–1–8, it is feasible to overspray existing paint systems. Since painting aircraft at field level is limited to maintenance painting operations, you most likely will be painting over an existing paint system. The surface must be free of dirt, oil and grease, corrosion deposits, loose paint, and any other substances that affect adhesion. Aircraft exterior surfaces shall be cleaned in accordance with TO 1–1–691, *Cleaning and Corrosion Prevention and Control, Aerospace and Non-Aerospace Equipment*, and thoroughly inspected to determine the soundness of the paint film. Areas of severely deteriorated paint shall be stripped in accordance with TO 1–1–8.

Mask all areas that may be damaged during the cleaning and sanding operations. Completely scuff-sand the entire exterior surface of the aircraft, excluding any bare metal areas, using abrasive paper no coarser than 120-grit. Scuff sanding shall include roughing up 100 percent of the painted surface, as well as removal of oxidized paint and feathering-out (blend smooth) all flaked paint. It is not intended to remove a sound paint system. Do not sand through bare metal as damage to the aircraft may occur.

All areas where the paint system is nicked, scratched, chipped, and any edges of the paint system around areas where paint removal was done, are to be feathered-out. All sanding should be accomplished using either a random orbital tool or pneumatic drill motor (10,000 revolutions per minute (rpm) max) fitted with an approved sanding disc. Apply the least amount of pressure necessary to accomplish feathering of the paint. All sanders and grinders should be attached to a high efficiency vacuum system.

A clean surface is one of the most critical process requirements that must be met to ensure coating adhesion. Solvent selection should be made from the approved solvents listed in TO 1–1–8. A solvent wipe-down should be done if the surface becomes contaminated after chemical treatment, after all scuff sanding operations and if the coating needs reactivation. A hand solvent wipe-down shall be performed each time the coating sequence is broken and the surface has had the chance to accumulate contaminates like dust, dirt, fingerprints, overspray, etc. This can happen after conversion coating application, priming, or between topcoats.

A solvent wipe-down or “tack ragging” must be done just prior to any primer or top coatings. Do not tack rag an entire large structure at one time. Each area to be painted should be tack ragged immediately prior to the application of finishing material to that area. Surfaces are gently wiped with the tack rag, removing accumulations of dust and other foreign matter. One form of tack rag that you can use is a clean cotton or cotton synthetic cloth dampened with an approved solvent. Always pour fresh solvent onto the cloth and dispose of the cloths as they become dirty. Frequently changing the cloth prevents smearing of soils or transferring the soils back onto the surface. Other commercially available forms of tack rag, which are designed for the purpose of removing surface contamination from an area receiving paint, may also be used. Follow local environmental requirements when disposing of the contaminated rags/cloths.

### Curing of finishes

After painting, allow aircraft finish system to cure in a dust-free temperature controlled atmosphere for a sufficient time prior to placing in service. In the absence of a temperature-controlled facility, the aircraft should not be flown for at least 72 hours after painting. In general, all painted aircraft should be handled, taxied, and so forth, as little as possible during the first week after painting.

### Coating thickness measurements

Attaining proper coating thickness by spraying is a matter of technique plus checking. To ensure that your coating thicknesses are within acceptable ranges you can use either wet or dry film gauges. Wet and dry film gauges are available as local purchase items from various laboratory supply houses.

### *Dry film gauge*

If an electronic dry film gauge-measuring instrument is not available, you can use small (2 × 6 inches) anodized aluminum panels for measurement of the paint thickness after drying.

1. Apply these panels to each side of the fuselage with a section of 1-inch-wide masking tape doubled back on itself with adhesive contacting the panel and the aircraft surface prior to the painting operation.
2. Mask one end of the panel with tape for a distance of approximately 2 inches to provide a comparison of the original panel thickness and the thickness after painting.
3. Remove the panel after application of the primer so that immediate maintenance painting can be used to cover those areas previously protected by the panel.
4. Measure the paint thickness with an ordinary micrometer possessing flat contact surfaces. Micrometers with pointed or rounded contact surfaces are not recommended.
5. At least six readings should be taken on both painted and unpainted portions of each panel to provide an average paint thickness measurement.

Each aircraft should use a set of panels for each different operation employed on the aircraft identified by the name of the painter, aircraft model, and the date of painting, to provide follow-on data during any subsequent service evaluation. Slight errors in paint thickness measurements can be expected when using this method due to thickness tolerances for the basic aluminum sheet.

### *Wet film gauge*

Frequent checks with a wet film thickness gauge (fig. 5–14) should be made during painting to ascertain and control film thickness. When using a wet film gauge, a minimum of six readings should also be taken. Take readings in a 1 square foot area that is representative of the entire area being painted.

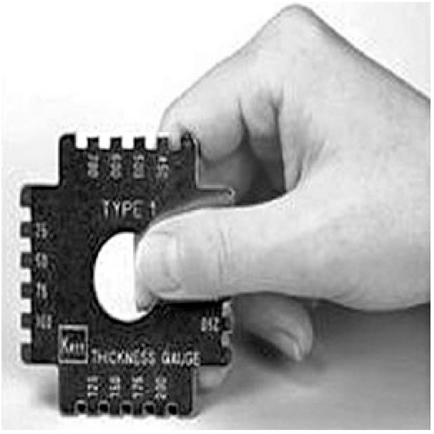



**Figure 5–14. Wet-film gauge.**

Rejection of the coating should only be made if the average of the six readings falls outside of the thickness range for that particular paint system. To use a wet film gauge, use the following steps:

1. Apply an initial coat of paint.
2. Hold the gauge at a 90-degree angle to the surface and press firmly. Both corners of the gauge must touch the substrate. Take all readings within 10 seconds of spraying. Paint solvent begins to evaporate as soon as it is applied. The longer you wait, the less accurate your reading.

3. Remove the gauge and inspect the edge. The last notch with paint on the surface reflects the thickness of the paint. The number directly above the last painted notch is the thickness reading.
4. Clean the gauge with a clean rag immediately after reading.
5. The gauge must be free of solvents, old paint or debris to give an accurate reading.

Gauge readings will leave paint defects in paints with a high solid ratio. Painting a piece of scrap with the same surface characteristics as your project can give you a reasonably accurate reference. In addition, the gauge must be placed on a flat surface to give an accurate reading. When painting an irregular surface, turn the gauge as necessary to take your readings from a good reference point.

## 239. Causes of and correcting spray pattern defects

Obtaining a proper spray pattern and eliminating premature coating failures are your major objectives in the application of protective coatings. Most defects in spray patterns are the result of the technician doing something incorrectly or using outdated materials. Now, look at a few common problems that result in spray pattern defects and coating failures.

### Inadequate surface preparation

You are familiar with the methods of removing corrosion. Anytime you apply a coating over a surface that has not been reworked properly, the damage continues. After rework is complete and you do not correctly prepare the surface, the possibility of applying a coating that adheres to the surface is greatly decreased.

Inadequate surface preparation is the most common cause of coating failure. Thus, as you might realize by now, surface preparation is the key to successful application of coating materials.

### Improper application

Allowing poorly trained personnel to apply coatings, particularly to aerospace equipment, is costly. Incorrect application techniques can result in spray pattern defects and coating failures. Again, as the technician, you are responsible for the problem. Improper application techniques include not keeping the correct distance from the surface, incorrect triggering of the spray gun, or using an incorrect stroke while applying the paint.

### Unusual climatic conditions

Under most circumstances, do not attempt to apply a coating to an aerospace surface if the atmospheric conditions are unsatisfactory. Sometimes you do not have control over these problems. Unusual climatic and atmospheric conditions, to some extent, can be remedied or compensated for by heating or controlling humidity in the painting area, or shielding the component from the elements. It is part of your job to do as much as possible to select an area that provides the greatest potential for satisfactory task performance. Do what you can and work around the rest.

### Pattern and coating defects

Unsuitable or faulty equipment can only be remedied by obtaining proper equipment or having damaged items repaired. In most cases, the cause of defects is a dirty or loose component on the gun assembly. If you encounter problems, stop and correct them before proceeding with the task. The following table shows some common troubles and remedies of pattern and coating defects.

| Trouble | Possible Causes | Preventive Measures or Remedies |
|---|---|---|
| Defective Spray Patterns (Heavy Center) | 1. Setting too low on fan adjustment (increase pressure).<br>2. Air cap; atomizing pressure too low.<br>3. Pressure feed: fluid pressure too high for normal capacity of air cap.<br>4. Nozzle too large for fluid used. | 1. Adjust fan-adjusting valve.<br>2. Adjust atomizing pressure.<br>3. Adjust fluid pressure.<br>4. Replace nozzle with correct size. |
| Defective Spray Patterns (Split Spray) | Air and fluid feeds not properly balanced. | Reduce width of spray pattern by means of the spreader adjusting valve, and if condition is not remedied, increase fluid pressure. The latter increases rate of material flow. Readjust atomizing pressure, fluid pressure, and spray width until desired spray is obtained. |
| Defective Spray Patterns<br>(Heavy Top or Bottom) (Heavy Right or Left) | 1. Horn holes partially clogged. Obstruction on top or side of nozzle.<br>2. Dirt on air-cap seat or nozzle fluid tip seat. | 1. Determine location of obstruction by rotating air cap one-half turn and spray a new pattern. If defect is reversed, obstruction is in air cap; if not or reversed, it is on the nozzle of fluid tip.<br>2. Clean air cap. Check for burrs and dried paint in opening. |
| Starving the Spray Gun | 1. Insufficient air because of waste filter in transformer too tightly packed or clogged.<br>2. Airlocks, hose or pipelines too small.<br>3. Inadequate air supplies from too small a compressor or a break in the system. | 1. Repack or replace filter.<br>2. Replace with units of adequate size.<br>3. Obtain a compressor of adequate size or repair leakage. |
| Spray Gun Will Not Spray Paint | 1. Out of paint (gun begins to sputter).<br>2. Settled, cake pigment blocking gun tip.<br>3. Grit, dirt, paint skins, etc., blocking gun tip, fluid coat valve or strainer. | 1. Add paint, correctly thinned out and strained.<br>2. Remove obstruction, stir paint thoroughly.<br>3. Clean spray gun thoroughly and strain the coating material. Always strain materials before using. |
| Spray Gun Leaks Paint | 1. Fluid needle packing nut too tight.<br>2. Packing for fluid needle dry.<br>3. Foreign particle blocks fluid tip.<br>4. Damaged fluid tip or needle. | 1. Loosen nut; lubricate packing.<br>2. Lubricate this part daily.<br>3. Remove tip and clean.<br>4. Replace both tip and needle. |

| Trouble | Possible Causes | Preventive Measures or Remedies |
|---|---|---|
| Sags and Runs<br>(fig. 5–15) | 1. Dirty air cap and fluid tip (distorted spray pattern).<br>2. Gun stroked too close to the surface.<br>3. Trigger not released at end of stroke (when stroke does not go beyond object).<br>4. Gun stroked at wrong angle to surface.<br>5. Coating material too cold.<br>6. Coating applied on too heavily.<br>7. Coating material thinned excessively. | 1. Remove air cap and clean tip and air cap carefully.<br>2. Maintain 6 to 10 inches for HVLP gun distance from surface.<br>3. Release the trigger after every stroke.<br>4. Keep gun at right angle (perpendicular) to surface during stroke.<br>5. Heat material by approved methods.<br>6. Develop ability to apply correct thicknesses by panel practice.<br>7. Add the correct amount of solvent by measure or determine by viscosity. |

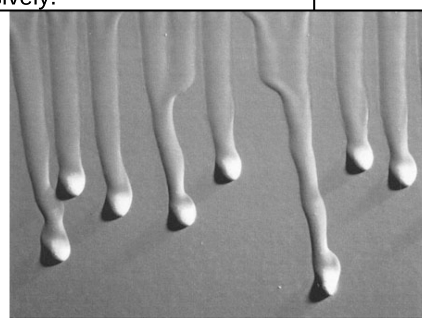
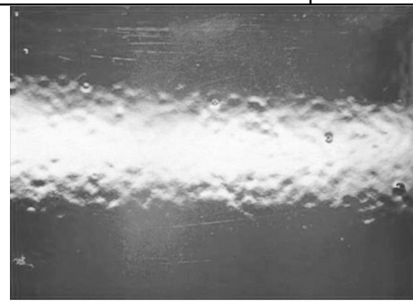
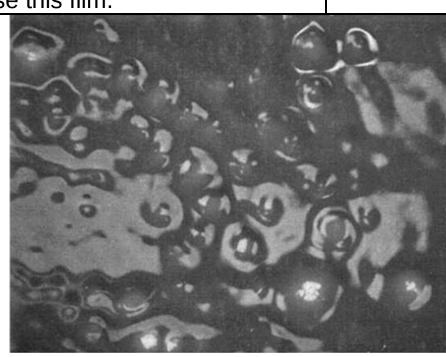


**Figure 5–15. Sags and runs.**

| Trouble | Possible Causes | Preventive Measures or Remedies |
|---|---|---|
| Streaks | 1. Dirty air cap and fluid tip (distorted spray pattern).<br>2. Insufficient or incorrect overlapping of strokes.<br>3. Gun stroked too rapidly (dusting of the paint).<br>4. Gun stroked at wrong angle to surface.<br>5. Stroking too far from surface.<br>6. Too much air pressure.<br>7. Split spray. | 1. Remove air cap and clean tip and air cap carefully.<br>2. Follow the previous stroke accurately. Deposit a wet coat maintaining a 50 percent overlap.<br>3. Avoid whipping. Make deliberate, slow strokes.<br>4. Keep gun at right angle (perpendicular) to surface during stroke.<br>5. Maintain 6 to 10 inches for HVLP gun from surface.<br>6. Use least air pressure necessary.<br>7. Clean the fluid tip and air cap. |
| Orange Peel<br>(fig. 5–16) | 1. Coating material not thinned out sufficiently.<br>2. Coating material too cold.<br>3. Insufficient air pressure.<br>4. Using wrong air cap or fluid nozzle.<br>5. Gun stroked too far from the surface.<br>6. Overspray striking a previously sprayed surface. | 1. Add the correct amount of solvent by measure or viscosity.<br>2. Heat material to get flow-out.<br>3. Increase air pressure or reduce fluid pressure.<br>4. Select correct air cap and nozzle for the material and feed.<br>5. Stroke the gun 6 to 10 inches for HVLP gun from surface.<br>6. Spray detail parts first. End with a wet coat. |

| Trouble | Possible Causes | Preventive Measures or Remedies |
|---|---|---|
| <br>**Figure 5–16. Orange peel.** | | |
| Sandpaper Finish | 1. Unsatisfactory wash primer or primer.<br>2. Excessive dirt contamination from painting area.<br>3. Insufficient scuff sanding of primer.<br>4. Improperly cleaned paint lines.<br>5. Dried overspray, gun too far from surface. | 1. Laboratory analysis to verify acceptability of the material; check wash primer and primer application procedures.<br>2. Provide cleaner painting areas.<br>3. Scuff-sand primer using No. 320 and No. 400 wet or-dry sandpaper.<br>4. Flush paint lines frequently with solvent.<br>5. Sand the complete finish until smooth to the fingertips. Stroke gun 6 to 10 inches for HVLP gun from the surface. |
| Wrinkling | Caused by applying too thick a coating, this prevents uniform drying of the coat and thus results in formation of ridges and furrows. | Material should be applied in thin uniform coats. If a thick coating is necessary, it should be applied by spraying several thin coats until the desired thickness is obtained. Allow each coat to set before applying the next. |
| Fish-Eyes (fig. 5–17) | Use of waxes or sealants and adhesives containing silicones. Presence of other types of oils, greases, or hydraulic fluids on the surface.<br>**NOTE:** Minute quantities of silicones can cause this film. | Solvent clean with silicone-removing compounds. |
| <br>**Figure 5–17. Fish eyes.** | | |
| Pinhole Cavities | Improper surface treatment or lack of surface treatment; entrapped oils and/or solvents; insufficient primer drying times; excessive alcohol additions to wash primer; use of improper thinner. | Apply manual surface treatment and ensure complete coverage with surface chemical film, before wash primer and/or primer application; check mixing instructions to eliminate use of improper thinners. |

TO 1–1–8 lists the most common spray coating troubles and their remedies. If you look at the trouble and possible causes, in most cases you find the painter is responsible. If you follow the techniques outlined in TO 1–1–8 for application, the number of improperly applied coatings traced to you will be limited.

## 240. Aircraft markings and application

All Air Force aircraft and equipment is identified by some method. The individual MAJCOM has its own marking requirements. In addition to identification, aircraft markings provide safety information, operating information, and maintenance instructions. We will focus our discussion on the standard Air Force markings and their application, with the use of stencils and decals.

### Some standard markings

Standard markings for Air Force aircraft are national star insignia, USAF, U.S. AIR FORCE, serial number, aircraft radio call numbers, and American flag. Aircraft markings on camouflaged aircraft are slightly different from those on non-camouflaged aircraft. Refer aircraft specific TO for more guidance. In addition, TO 1–1–8 states that Headquarters Air Combat Command (HQ ACC) is responsible for developing paint schemes and markings for low observable aircraft.

#### *National star insignia*

Install the national star insignia, as illustrated in figure 5–18, on all USAF aircraft. The insignia consists of a five-pointed star located within a circumscribed circle. On fixed-wing aircraft, normally, you locate the national star insignia on the upper left wing, lower right wing, and both sides of the fuselage.

**Figure 5–18. National star insignia.**

On the fuselage, locate the national star midway between the wing trailing edge and the leading edge of the stabilizer. The insignia may be moved forward or aft the minimum distance required to avoid transparent material, or areas exposed to extreme heat or fluids, which would scorch, deteriorate or otherwise damage the insignia. The insignia will be the standard size closest to, but not exceeding, 75 percent of the fuselage height at the point of application. The diameter of the blue circle will not exceed 50 inches, nor be less than 15 inches. Symmetry will be maintained when applying the insignia on each side of the fuselage.

On helicopters, apply the national star insignia on the aircraft fuselage. Locate the star so that the insignia is visible from the side, from above, and from below.

#### *USAF*

Locate the USAF marking on the lower left and upper right wings. Make the height of the USAF marking the same as that of the national star insignia applied on the opposite side of the wing. When properly applied, the tops of the letters are near the leading edge of the wing.

#### *Aircraft radio call numbers/serial number*

The radio call number will be applied to each side of the vertical stabilizer. On aircraft with multiple vertical stabilizers, the radio call number will be applied to the outboard side of the outer most vertical stabilizer. Refer to specific aircraft guidance for aircraft without vertical stabilizers.

Each MAJCOM uses different methods to mark their aircraft with the radio call numbers. For example, Global Strike placed the two letter base designator on the main landing gear door and the aircraft number on the nose door, the B–2 bombers. Whereas, ACC uses a distinctive two-place alphanumeric in conjunction with the first two and last three numbers of the aircraft serial number (fig. 5–19).

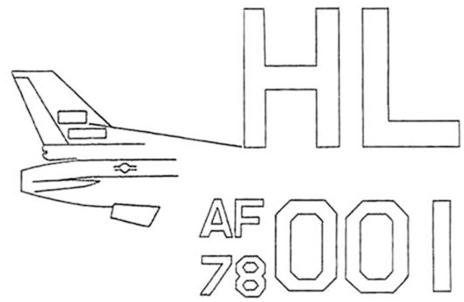



**Figure 5–19. Distinctive unit, serial number and ACC standard sample**

### *Servicing, ground handling, and hazard warnings*

Servicing, ground handling, and hazard warnings shall be in contrasting colors. Lettering shall be in accordance with TO 1–1–8. Symbols for the identification of service points, ground handling, and hazard warnings shall be applied to the required locations on all USAF aircraft. Location is dependent on the amount of available space. The marking may be on or adjacent to the equipment or service point. The markings provide the following:

- Rapid identification of servicing points.
- Identification of the type of ground servicing required.
- Hazard warning or safety precautions, which will prevent injury to personnel or damage to equipment.
- Rapid exit from air vehicle under emergency conditions.

These markings may be applied using paint or decals. Symbols shall be approximately 4 inches in size but may be smaller depending on the area or item being marked. Figures 5–20, and 5–21 show some service points, ground handling, and hazard warning markings.

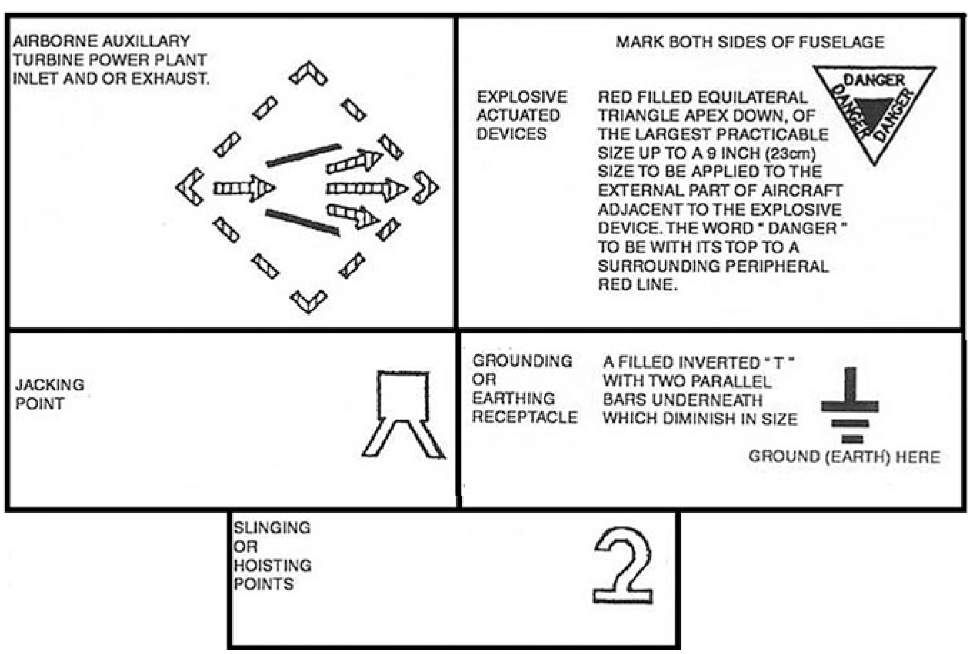



**Figure 5–20. Standard markings.**

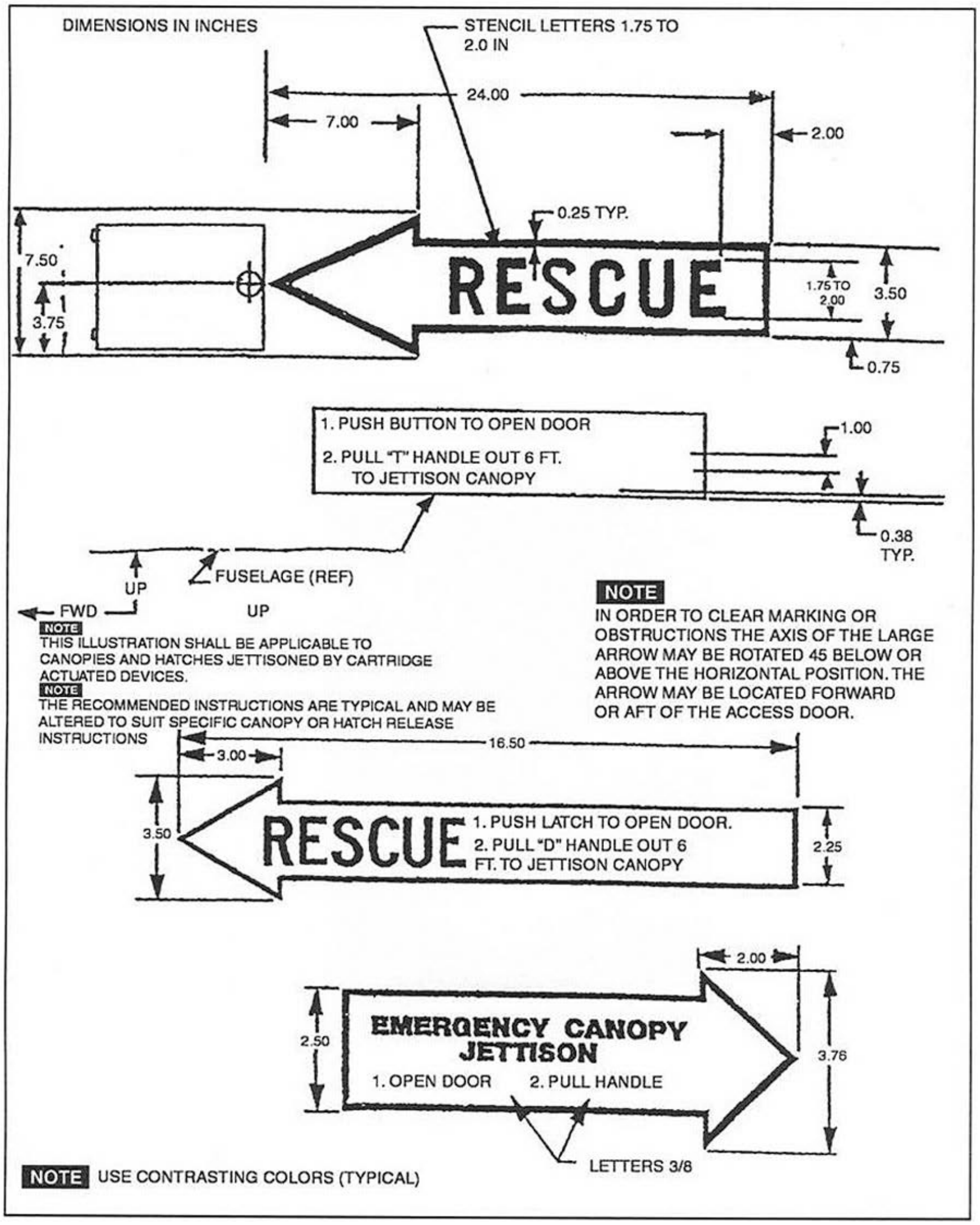



**Figure 5–21. Hazard warning markings.**

### *Other markings*

The following markings are ones that you will usually have to fabricate. Each base will have different paint facility/finish identification block and tail letters.

### *Lettering*

Use vertical block type letters/style font/Arabic numerals for markings on aircraft. Similar computer-generated font is also authorized.

These instructions come from TO 1–1–8, which is considered a general TO. Consult your aircraft-specific TO for more in-depth guidance. If a conflict arises between the basic TO and the aircraft-specific TO, as always, the aircraft-specific TO takes precedence.

## Stencils and decals

A stencil is a sacrificial material that has numbers, letters or symbols cut out of it. You then transfer the markings to the surface of the equipment using painting techniques and dispose of the stencil material. A decal on the other hand is a specially prepared film containing design, words, letters, or numerals and is intended to be permanently affixed to the aircraft. Decals may be used in lieu of paint for all external markings and insignia where the contact surfaces are of sufficient smoothness to permit good adhesion.

In the past, hand-operated stencil machines were a common sight in the paint shop. These machines were used to create informational stencils but their use was limited to numbers and words. If you needed symbols, such as the national star, you would have to layout and cut the symbol by hand. This was very complicated and time consuming.

Computerized stencil machines are now widely available for use. In fact, most if not all Air Force paint facilities use some form of computerized stencil machine. The computerized machines are normally purchased as a complete system. Others are as simple as adding specialized software and peripherals to an existing computer system.

Computerized machines are able to create stencils and decals of nearly any size and design. The primary benefits of the computerized system include ease of use, the ability to store designs in an electronic format and the ability to produce them on demand. These benefits eliminate the need to manually recreate designs each time they are needed, or produce several for stock. It is the specialized software that gives the machines these capabilities. A typical system consists of the following items:

| Item | Use |
|---|---|
| Computer System | With installed specialized software, capable of designing decals and stencils. |
| Plotter | Cuts the decal/stencil material to its finished size. |
| Scanner | Scans readily available designs so they may be converted to a stencil or decal. |

### *Manufacture*

You use the computer-based program to easily design the stencils or decals that you need. The process of designing stencils and decals is essentially the same. Designing a stencil or decal can be as simple as a few keystrokes for a text-only marking or as complex as scanning a color graphic and converting it into a useable product. Most graphics software includes all the shapes, character fonts and icons you will need. You can also create designs of your own using the built-in design tools.

When you are confident the design on your computer screen is what you want, you need only send it to the plotter. The plotter is a tool designed to cut your design out of various colors of highly durable adhesive vinyl, which can be applied rapidly. Plotters are very similar to an older-type computer printer. Instead of having a print head that moves back and forth across the paper, a plotter has a cutting assembly that moves about the vinyl.

There are also plotters available that work similar to a color laser printer. All you need to do is either design or select the multi-color decal that you need and change out the color cartridges as needed. Since there are many different makes and models of stencil programs and equipment, you always need to follow the manufacturer’s directions.

After the plotter is finished cutting and before you can use the stencil/decal, you must remove the unneeded vinyl. This process is commonly referred to as weeding. Weeding can be accomplished by using tweezers, razor blades, scribes, or even your fingernails. To weed a decal, begin by removing the insides of any closed characters, such as the inside pieces of the letter B. The more intricate the design, the more difficult it will be to properly weed it. Once all these pieces have been removed, you can remove the remaining large pieces. Be careful not to remove more than you want to. Weeding stencils is identical to weeding a decal, with one exception. Instead of removing the vinyl inside any closed characters, and then removing the remainder of the unneeded vinyl, you reverse the process. Using the letter B example, instead of removing the insides of the letter, you would remove the letter and leave everything else.

### *Application*

Stencils and decals are applied using application tape. Application tape is a low tack tape that is designed to help you transfer the stencil/decal material to the equipment without damaging the coating or the material. The process of applying stencils and decals is essentially the same with a few differences.

#### Decals

Sometimes it is more convenient and quicker to apply markings with decals instead of using stencils and paint. The length of time the decal will last is largely dependent on the degree of surface preparation. Areas designated for decal application must be cleaned thoroughly to remove all contaminants that might prevent proper adhesion. In areas where the decal is to be applied, buff lightly with a fine aluminum oxide abrasive mat. Wipe down the area using a clean lint-free cotton cloth and isopropyl alcohol.

There are two types of decals: solid and perforated films. Apply solid, premasked decals to the primer before applying the topcoat. Do not apply these decals to unpainted surfaces. Leave a $^{1}/_{16}$-inch lip around the edges of the decal. This lip allows the paint to seal the edge of the decal, thus eliminating the need for edge sealing. Remove the premasked material after the topcoat has thoroughly dried. However, the perforated decals shall only be applied over fully painted surfaces. You can apply small decals by removing the backing from the adhesive side of the decal. Align the decal in the desired location and press an edge to the surface with your fingers. Hold the remainder of the film taut and slightly away from the surface until you press it down with a plastic squeegee. Use firm, overlapping strokes to provide a smooth surface and good adhesion. There are two methods used to apply large decals: hinge and tape.

1. Hinge method - Apply large decals using the hinge method, as shown in figure 5–22. Tape the decal into position with small pieces of masking tape. Apply 1 to 2 inches along one edge to serve as a hinge. To finish the application, fold the entire decal back over the hinge. Start removing the backing at the hinge point. Hold the decal away from the surface with one hand and allow the adhesive to touch only as pressure is applied. Squeegee or roll the decal to the surface with firm, overlapping strokes. Be sure the edges are firmly adhered.
2. Tape method - Large or intricately shaped decals can be applied with application tape, as shown in figure 5–23. If you receive a decal that is not already pre-masked, place the application tape, with the adhesive side up, on a flat, rigid surface. Align the decal and place it with the film side down on the adhesive tape. Starting in the middle of the decal, squeegee the application tape with firm strokes. As mentioned earlier, decals created on a computerized machine are applied using transfer tape. After you remove the unneeded vinyl, or weed it, place it face up on a hard surface and apply transfer tape directly to the front of the decal, being careful to avoid bubbles or wrinkles. Once you have a decal with application tape applied to it, you can apply the decal to the surface using the hinge method.

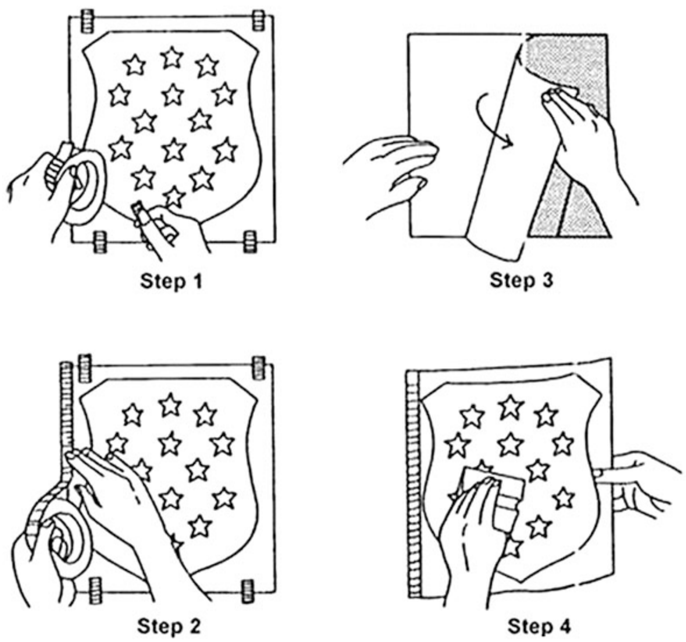



Figure 5–22. Large emblem application.

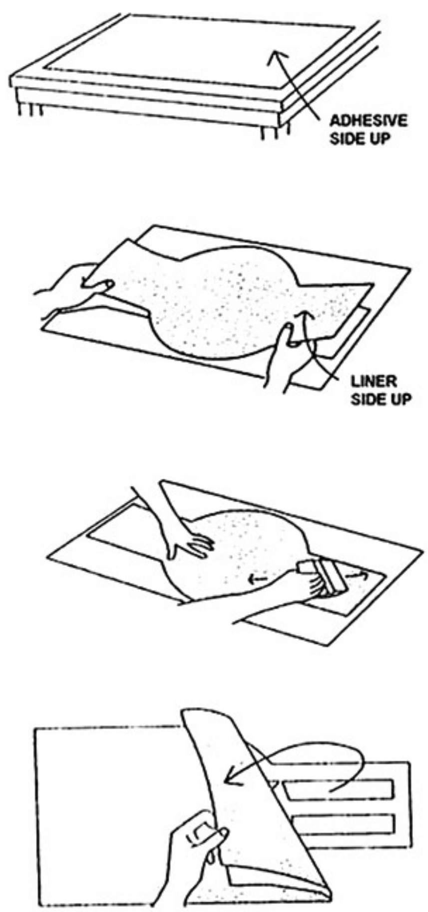



Figure 5–23. Use of application tape.

Before you apply the decal, clearly mark the area using masking tape or some other method of ensuring you have a straight line. When you are ready to apply the decal, remove the application tape with the decal from the backing paper. Carefully line up the application tape with your mark and apply the decal using a squeegee. To avoid bubbles or wrinkles, slowly apply and squeegee the decal from left to right or top to bottom. After you finish, slowly remove the application tape.

After you apply the decal, you will need to apply edge-sealing compound to all edges of decals applied over the topcoat of paint. This procedure provides abrasion resistance to the decal. Use the felt wick applicator attached to the screw-top can, or use a stripping brush. Apply enough sealer to create a feathered edge along the decal edge, as shown in figure 5–24. You do not have to edge seal decals that have been pre-masked, applied to the primer coat and later top coated.


**Figure 5–24. Edge sealing.**

### *Stencils*

Use basically the same process to apply stencils as you do decals:

1. Apply stencil to surface using transfer tape. You should use the hinge method for larger stencils.
2. Use a squeegee to ensure the stencil is securely attached to the surface.
3. Carefully remove the transfer tape. Be careful, the small insides of letters have a tendency to stay stuck to the transfer tape. If that happens, you can peel them off with tweezers and place them back on the surface.
4. Mask around the stencil to protect adjacent surfaces.
5. Stencils can be painted using spray equipment, brushes or rollers. It is up to you to determine which method is most feasible.
6. After the paint has dried, carefully remove the stencil material from the surface.

### ***Removal***

The process that you use to remove decals is going to depend on whether it is a perforated or non-perforated decal. You can remove perforated decals with an approved paint remover. Keep in mind that the perforated decal film is highly solvent resistant polyester and that the paint remover must penetrate through the perforations to soften the adhesive. It may be necessary to use repeated applications of remover to remove the film from adhesive. Another application of remover on the adhesive may also be required. Scrape off the bulk of the softened adhesive with a non-metallic scraper and wipe off any remaining adhesive residue with an approved thinner on a cotton cloth.

To mechanically remove decals, use a pneumatic drill and an approved adhesive removal disc system to remove both decal material and adhesive from the area. Non-perforated decals can only be removed by mechanical methods or by applying steam or dry heat to the decal and physically removing the film. Wipe off any remaining adhesive residue with an approved aircraft thinner on a cotton cloth until the cloth no longer shows residue.

## Self-Test Questions

**After you complete these questions, you may check your answers at the end of the unit.**

### 238. Applying protective coatings

1. Whenever possible, where should painting operations be conducted?

2. How do you test the suitability of materials and conditions prior to beginning spray operations?

3. Where should the painter’s back or side always be while spraying?

4. What must the surface be free of before you paint it?

5. What grit of abrasive paper should be used to scuff the exterior surface?

6. Why do you use tack rags?

7. What can you use to measure dry film thickness if an electronic instrument is not available?

8. What is the minimum number of measurements that you must take using a wet film gauge?

9. How soon after spraying a coating do you take readings using a wet film gauge?

### 239. Causes of and correcting spray pattern defects

1. What are your major objectives in the application of protective coatings?

2. What is the key to successful application of coating materials?

3. Match the corrective actions in column B with the spray pattern defect or difficulty in column A. Column B will only be used once.

| *Column A* | *Column B* |
|---|---|
| ____ (1) Heavy top or bottom spray. | a. Clean air cap. |
| ____ (2) Split spray pattern which is heavy on each end. | b. Solvent clean. |
| ____ (3) Spray pattern is heavy in the middle. | c. Increase pressure. |
| ____ (4) Sags and runs. | d. Use 50 percent overlap. |
| ____ (5) Fish-eyes. | e. Reduce width of spray pattern. |
| ____ (6) Streaks. | f. Keep gun perpendicular. |

### 240. Aircraft markings and application

1. What are the purposes of placing markings on USAF aircraft?

2. What are the standard AF markings?

3. What fonts are used for letters and numerals on aircraft?

4. What are the primary benefits of the computerized stencil and decal machines?

5. What are the three main components of a computerized stencil machine?

6. What type of material is used to produce computerized decals and stencils?

7. What do you have to do after the plotter is finished cutting and before you can use the stencil/decal?

8. What is the only type of surface perforated decals may be applied over?

9. What tool is used to apply small decals to the surface?

10. What methods are used to apply large decals?

11. When is edge sealing not required?

12. How do you remove the softened adhesive when removing decals?

## Answers to Self- Questions

**233**

1. Determine the type of organic finish you are trying to remove. Find the approved types of chemical removers for that organic finish in TO 1–1–8.
2. Type and age of the finish system, type of surface to which it will be applied, local climate, capabilities of local industrial waste treatment facilities, EPA restrictions, and medical authority.
3. An abrasive mat or stiff-fiber bristle brush.
4. It makes it hard to remove and will corrode the metal surface.
5. A clean damp cloth.
6. In a protected area (out of direct sunlight) capable of maintaining a temperature of 40°F to 100°F to prevent them from freezing or being exposed to excessively high temperatures.

**234**

1. Complete removal without damaging the underlying surface.
2. Clean and inspect surfaces, position aircraft and equipment in a covered facility, mask or cover all areas directed in system peculiar TO.
3. TO 1–1–8; also the base bioenvironmental engineer.
4. Either initial removal of loosened paint on small areas, or when it is impractical to use powered equipment due to limited space.
5. Hold the tool firmly in your hands at all times during use. Keep sander heads flush against the surfaces being sanded and apply the least amount of pressure necessary to effectively remove the finish system topcoat and not go through the primer and gouge or abrade the metal substrate.

**235**

1. (1) Walk-in PMB booth.
   (2) Free-standing PMB cabinet blaster.
2. The system peculiar TO/manual.
3. Types I, II, V and VII.
4. To prevent them from falling through.
5. The blast media type and the substrate thickness.
6. Surface distance.
7. Sheet metal 0.016 inch or thinner must not be blasted.
8. Water and other fluids contaminate blasting media, and may damage separation equipment.

**236**

1. To develop color and hiding power, inhibit corrosion, absorb heat, reflect light and heat, and develop flow characteristics.
2. The liquid portion.
3. By their chemical structure as alcohols, esters, ketones, etc.
4. Diluents are added by the manufacturer and the painter adds the thinners.
5. These coatings are characterized by their very high gloss retention in gloss finishes and its flatness in camouflage finishes.

6. Check the shelf-life date and let the materials come to room temperature.
7. Problems with color, gloss, hiding power, film application characteristics, adhesion, and curing.
8. Hand mix using wooden or plastic paddles, use a mechanical shaker, and use low speed mechanical paddles.
9. Because of the incorporation of metallic solids in many of the paint, ceramic and caulk products.
10. Seconds through the cup.
11. Strained using a strainer or cheesecloth.

**237**

1. Spray application.
2. The gun should be held 6–10 inches from the work piece.
3. The amount of spraying is limited to the contents of the cup.
4. Adjusting tank air pressure.
5. Using the proper combination of air cap and fluid tip.
6. Excessive air pressure.
7. Heavy centered spray pattern.
8. A thicker coating in the middle of the stroke.
9. Assures a full wet coat without streaks.
10. Nonmetallic bristle brush.
11. Until a fan of clear solvent is produced.
12. These materials dissolve the oil from leather packings inside the gun; thus drying out the packings and causing the gun to have an unreliable spray pattern.
13. Only when a proper spray pattern cannot be produced.
14. By using a mechanical paint gun washer.

**238**

1. In an environmentally controlled facility capable of maintaining a range of 30 to 80 percent relative humidity and 60 °F to 90 °F.
2. Spray test panels prior to beginning operations.
3. Upwind.
4. Free of dirt, oil, grease, corrosion deposits, loose paint and any other substances that affect adhesion.
5. No coarser than 120-grit.
6. To remove accumulations of dust and other foreign matter.
7. Small (2 × 6 inches) anodized aluminum panels.
8. Six.
9. Within 10 seconds.

**239**

1. Obtaining a proper spray pattern and eliminating premature coating failures.
2. Surface preparation.
3. (1) a.
   (2) e.
   (3) c.
   (4) f.
   (5) b.
   (6) d.

**240**

1. In addition to identification, aircraft markings provide safety information, operating information, and maintenance instructions.
2. National Star insignia, UASF, U.S. AIR FORCE, serial number, aircraft radio call number and the American flag.
3. Vertical block type letters/style font/Arabic numerals.
4. Ease of use and ability to store designs in an electronic format and produce them on demand.
5. Computer system, plotter, and scanner.
6. Adhesive vinyl.
7. Remove the unneeded vinyl.
8. Fully painted surfaces.
9. A plastic squeegee.
10. Clearly mark the area using masking tape or some other method to ensure you have a straight line.
11. Decals that have been applied to the primer coat premasked and later top coated.
12. Scrape off the bulk of the adhesive with a non-metallic scraper and wipe off any remaining adhesive residue with an approved thinner on a cotton cloth.

## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

**Do not return your answer sheet to AFCDA.**

79. (233) The type of chemical remover to be used depends on the
    a. barometric pressure during removal procedures.
    b. type of organic finish system to be removed.
    c. color of the finish system to be removed.
    d. humidity during removal procedures.

80. (233) When do you mix chemical paint remover?
    a. 1 hour before use.
    b. 2 hours before use.
    c. 30 minutes before use.
    d. Immediately before use.

81. (234) What special requirement(s) *must* be met when mechanically removing coatings on steel and titanium alloy?
    a. Forced air respirator must be worn and part must be grounded.
    b. Part must be grounded and area must be well ventilated.
    c. Area must be well ventilated only.
    d. Part must be grounded only.

82. (235) When using the plastic media blasting (PMB) cabinet blaster, check the media level
    a. prior to use.
    b. during use.
    c. immediately after use.
    d. 5–10 minutes after use allowing the media settle.

83. (235) What is the *first step* when preparing a part for blasting in the plastic media blasting booth?
    a. Mask areas you don’t want blasted.
    b. Thoroughly clean the substrate.
    c. Decide what media to use.
    d. Remove all small parts.

84. (236) The purpose of adding pigment to paint is to develop
    a. color.
    b. adhesion.
    c. flexibility.
    d. toughness.

85. (236) After checking the shelf life of your coating material you should
    a. remove the lid and inspect the catalyst.
    b. allow the material to reach room temperature.
    c. mix the material per manufacturer’s instructions.
    d. place the material in a paint shaker and agitate for 10 minutes.

86. (236) What will happen if two-component materials are *not thoroughly mixed* with each other and in the exact specified proportions?
    a. Nothing.
    b. Resin will curdle.
    c. Catalyst will become suspended.
    d. Curing and adhesion problems will occur.

87. (236) When using a #2 Zahn cup, how is the viscosity expressed?
    a. Minutes through the container.
    b. Seconds through the container.
    c. Minutes through the cup.
    d. Seconds through the cup.

88. (237) What type of spray gun is made with an external airtight container?
    a. Internal-mix.
    b. External-mix.
    c. Pressure-feed.
    d. Suction-feed.

89. (237) The distance that you hold the spray gun nozzle from the surface depends upon the
    a. temperature and the type of gun used.
    b. air pressure used and the type of paint.
    c. temperature and the consistency of the paint.
    d. desired width of the spray pattern and type of gun used.

90. (237) When using parallel strokes with a spray gun, the spray pattern should
    a. not overlap the previous stroke.
    b. overlap 25 percent of the previous stroke.
    c. overlap 50 percent of the previous stroke.
    d. overlap 75 percent of the previous stroke.

91. (237) When should you dismantle a spray gun?
    a. Never, only a factory representative is authorized to dismantle equipment.
    b. If a proper spray pattern cannot be produced.
    c. Every 30 days.
    d. After each use.

92. (238) What effect does low humidity have on moisture curing coatings?
    a. Nothing.
    b. It stops the cure process.
    c. It slows the cure process.
    d. It accelerate the cure process.

93. (238) What is the *coarsest grit* of abrasive paper that should be used to scuff-sand an already coated aircraft?
    a. 400 grit.
    b. 200 grit.
    c. 180 grit.
    d. 120 grit.

94. (238) When painting, what must you do *just prior to* primer or topcoating?
    a. Nothing, surface is ready for coating.
    b. Blow off area with compressed air.
    c. Perform a solvent wipe down.
    d. Rinse with fresh water.

95. (238) What is the *minimum* number of readings you need to take when using a wet film gauge to measure coating thicknesses?
    a. 4.
    b. 5.
    c. 6.
    d. 7

96. (239) What is the *most common* cause of coating failure?
    a. Unusual climatic conditions.
    b. Inadequate surface preparation.
    c. Using faulty finishing materials.
    d. Incorrect techniques during application.

97. (239) The probable cause of a protective coating spray pattern with a split spray is
    a. a loose fluid nozzle.
    b. excessively high cup pressure.
    c. incorrect viscosity of the paint.
    d. air and fluid feeds not properly balanced.

98. (239) What is a common cause of streaking when spray painting?
    a. Dirty air cap.
    b. Misaligned fluid needle.
    c. Dirt seated in fluid tube.
    d. Excessive fluid adjustment setting.

99. (240) On fixed-wing aircraft, the national star insignia is located on the
    a. upper left and lower right of wings, and left side of the fuselage.
    b. lower left and lower right of wings, and right side of the fuselage.
    c. upper left and lower right of wings, and both sides of the fuselage.
    d. lower left and upper right of wings, and both sides of the fuselage.

100. (240) What is the next step after the plotter cuts your vinyl?
    a. The decal is applied to the equipment.
    b. The desirable material must be weeded.
    c. Transfer tape is applied to the equipment.
    d. The undesirable material must be weeded.

# Glossary

## Abbreviations and Acronyms

| | |
|---|---|
| **ACC** | Air Combat Command |
| **AF** | Air Force |
| **AFI** | Air Force Instruction |
| **AFMAN** | Air Force Manual |
| **AFOSH** | Air Force Occupational Safety and Health |
| **AFTO** | Air Force Technical Order |
| **AGE** | aircraft ground equipment |
| **ALIS** | Autonomous Logistics Information System |
| **AP** | accumulation point |
| **BL** | buttock lines |
| **CBR** | chemical, biological, or radiological |
| **CDC** | career development course |
| **CL** | checklist |
| **CPC** | corrosion preventive compound |
| **CRES** | corrosion-resistant steel |
| **CWR** | clear water rinse |
| **°C** | degrees Celsius |
| **°F** | degrees Fahrenheit |
| **DLA** | Defense Logistics Agency |
| **DN** | document number |
| **EPA** | Environmental Protection Agency |
| **ETIMS** | Enhanced Technical Information Management System |
| **eTO** | electronic technical order |
| **FIFO** | first in/first out |
| **FS** | fuselage station |
| **FSC** | federal supply class |
| **FSN** | federal stock number |
| **GCSS** | Global Combat Support System |
| **G-E** | ground communication-electronic |
| **GHS** | Globally Harmonized System |
| **GSA** | General Services Administration |
| **GV** | general vehicle |

| | |
|---|---|
| **HAP** | hazardous air pollutants |
| **HAZCOM** | hazardous communication |
| **HAZMART** | hazardous material pharmacy |
| **HAZMAT** | hazardous material |
| **HCP** | Hazard Communication Program |
| **HEPA** | high efficiency particulate air |
| **HVLP** | high volume, low pressure |
| **HW** | hazardous waste |
| **IAW** | in accordance with |
| **IMDS** | Integrated Maintenance Delivery System |
| **IMIS** | Integrated Maintenance Information System |
| **IPB** | illustrated parts breakdown |
| **IPE** | industrial plant equipment |
| **JCN** | job control number |
| **JG** | job guide |
| **LO** | low observable |
| **LOAP** | List of Applicable Publications |
| **LOEP** | List of Effective Pages |
| **LOASM** | low observable aircraft structural maintenance |
| **MAJCOM** | major command |
| **MDD** | Maintenance Data Documentation |
| **MDS** | mission/design/series |
| **MIDAS** | Maintenance Integrated Data Access System |
| **mil-spec** | military specifications |
| **mil-std** | military standards |
| **MPTO** | method and procedure technical order |
| **MSDS** | material data safety sheet |
| **NDI** | nondestructive inspection |
| **NESHAP** | National Emissions Standards for Hazardous Air Pollutants |
| **NIIN** | national item identification number |
| **NSN** | national stock number |
| **O&M** | operations and maintenance |
| **PE** | periodic inspection |
| **ph** | potential of hydrogen |

| | |
|---|---|
| **PI** | product improvement |
| **PMB** | plastic media blasting |
| **POV** | privately owned vehicle |
| **PPE** | personal protective equipment |
| **psi** | pounds per square inch |
| **QA** | quality assurance |
| **QPD** | qualified products database |
| **QPL** | qualified products list |
| **QSL** | quality status list |
| **RAM** | radar absorbent material |
| **RCRA** | Resource Conservation Recovery Act |
| **RCS** | radar cross section |
| **RPC** | reparable processing center |
| **rpm** | revolutions per minute |
| **SAF** | special access facility |
| **SAP** | satellite accumulation point |
| **SDS** | safety data sheet |
| **SE** | support equipment |
| **SLC** | shelf-life code |
| **SMR** | source, maintenance, and recoverability |
| **SPD** | system program director |
| **SPM** | system program manager |
| **SRD** | standard reporting designator |
| **TCTO** | time compliance technical order |
| **TM** | type maintenance or technical manual |
| **TMDE** | test measurement and diagnostic equipment |
| **TNP** | Touch-N-Prep |
| **TO** | technical order |
| **TODA** | Technical Order Distribution Account |
| **TODCR** | technical order data correction request |
| **TODO** | Technical Order Distribution Office |
| **TODPS** | Technical Order Distribute and Print Service |
| **UAS** | unmanned aircraft systems |
| **VOC** | volatile organic compounds |

| | |
|---|---|
| **WC** | workcards |
| **WL** | waterline |
| **WP** | work packages |
| **WS** | wing station |
| **WUC** | work unit code |
| **U/I** | units of issue |

# Student Notes

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