**Sheet metal**

## Inspection of Damage

When visually inspecting damage, remember that there may be other kinds of damage than that caused by impact from foreign objects or collision. A rough landing may overload one of the landing gear, causing it to become sprung; this would be classified as load damage. During inspection and sizing up of the repair job, consider how far the damage caused by the sprung shock strut extends to supporting structural members.

A shock occurring at one end of a member is transmitted throughout its length; therefore, closely inspect all rivets, bolts, and attaching structures along the complete member for any evidence of damage. Make a close examination for rivets that have partially failed and for holes that have been elongated. Whether specific damage is suspected or not, an aircraft structure must occasionally be inspected for structural integrity.

The following paragraphs provide general guidelines for this inspection. When inspecting the structure Classification of Damage Damages may be grouped into four general classes. In many cases, the availabilities of repair materials and time are the most important factors in determining if a part should be repaired or replaced.

## Types of Damage and Defects

Types of damage and defects that may be observed on aircraft parts are defined as follows:

• Brinelling—occurrence of shallow, spherical depressions in a surface, usually produced by a part having a small radius in contact with the surface under high load.

• Burnishing—polishing of one surface by sliding contact with a smooth, harder surface. Usually there is no displacement or removal of metal.

• Burr—a small, thin section of metal extending beyond a regular surface, usually located at a corner or on the edge of a hole.

• Corrosion—loss of metal from the surface by chemical or electrochemical action. The corrosion products generally are easily removed by mechanical means. Iron rust is an example of corrosion.

• Crack—a physical separation of two adjacent portions of metal, evidenced by a fine or thin line across the surface caused by excessive stress at that point. It may extend inward from the surface from a few thousandths of an inch to completely through the section thickness.

Cut—loss of metal, usually to an appreciable depth over a relatively long and narrow area, by mechanical means, as would occur with the use of a saw blade, chisel, or sharp-edged stone striking a glancing blow.

• Dent—indentation in a metal surface produced by an object striking with force. The surface surrounding the indentation is usually slightly upset.

• Erosion—loss of metal from the surface by mechanical action of foreign objects, such as grit or fine sand. The eroded area is rough and may be lined in the direction in which the foreign material moved relative to the surface.

• Chattering—breakdown or deterioration of metal surface by vibratory or chattering action. Although chattering may give the general appearance of metal loss or surface cracking, usually, neither has occurred.

• Galling—breakdown (or build-up) of metal surfaces due to excessive friction between two parts having relative motion. Particles of the softer metal are torn loose and welded to the harder metal.

**Negligible Damage**

Negligible damage consists of visually apparent, surface damage that do not affect the structural integrity of the component involved. Negligible damage may be left as is or may be corrected by a simple procedure without restricting flight. In both cases, some corrective action must be taken to keep the damage from spreading. Negligible or minor damage areas must be inspected frequently to ensure the damage does not spread. Permissible limits for negligible damage vary for different components of different aircraft and should be carefully researched on an individual basis. Failure to ensure that damages within the specified limit of negligible damage may result in insufficient structural strength of the affected support member for critical flight conditions.

**Damage Repairable by Patching**

Damage repairable by patching is any damage exceeding negligible damage limits that can be repaired by installing splice members to bridge the damaged portion of a structural part. The splice members are designed to span the damaged areas and to overlap the existing undamaged surrounding structure. The splice or patch material used in internal riveted and bolted repairs is normally the same type of material as the damaged part, but one gauge heavier.

**Damage Repairable by Insertion**

Damage must be repaired by insertion when the area is too large to be patched or the structure is arranged such that repair members would interfere with structural alignment (e.g., in a hinge or bulkhead). In this type of repair, the damaged portion is removed from the structure and replaced by a member identical in material and shape. Splice connections at each end of the insertion member provide for load transfer to the original structure.

**Damage Necessitating Replacement of Parts**

Components must be replaced when their location or extent of damage makes repair impractical, when replacement is more economical than repair, or when the damaged part is relatively easy to replace. For example, replacing damaged castings, forgings, hinges, and small structural members, when available, is more practical than repairing them. Some highly stressed members must be replaced because repair would not restore an adequate margin of safety.

**Repairability of Sheet Metal Structure**

The following criteria can be used to help an aircraft technician decide upon the repairability of a sheet metal structure:

• Type of damage.

• Type of original material.

• Location of the damage.

• Type of repair required.

• Tools and equipment available to make the repair. The following methods, procedures, and materials are only typical and should not be used as the authority for a repair

**Inspection for Corrosion**

Corrosion is the gradual deterioration of metal due to a chemical or electrochemical reaction with its environment. The reaction can be triggered by the atmosphere, moisture, or other agents. When inspecting the structure of an aircraft, it is important to watch for evidence of corrosion on both the outside and inside. Corrosion on the inside is most likely to occur in pockets and corners where moisture and salt spray may accumulate; therefore, drain holes must always be kept clean. Also inspect the surrounding members for evidence of corrosion.

Damage Removal to prepare a damaged area for repair:

1. Remove all distorted skin and structure in damaged area.

2. Remove damaged material so that the edges of the completed repair match existing structure and aircraft lines.

3. Round all square corners.

4. Smooth out any abrasions and/or dents. 5. Remove and incorporate into the new repair any previous repairs joining the area of the new repair

**Inspection of Riveted Joints**

Inspection consists of examining both the shop and manufactured heads and the surrounding skin and structural parts for deformities. During the repair of an aircraft structural part, examine adjacent parts to determine the condition of neighboring rivets. The presence of chipped or cracked paint around the heads may indicate shifted or loose rivets. If the heads are tipped or if rivets are loose, they show up in groups of several consecutive rivets and are probably tipped in the same direction. If heads that appear to be tipped are not in groups and are not tipped in the same direction, tipping may have occurred during some previous installation.

**Rivet Selection**

Normally, the rivet size and material should be the same as the original rivets in the part being repaired. If a rivet hole has been enlarged or deformed, the next larger size rivet must be used after reworking the hole. When this is done, the proper edge distance for the larger rivet must be maintained. Where access to the inside of the structure is impossible and blind rivets must be used in making the repair, always consult the applicable aircraft maintenance manual for the recommended type, size, spacing, and number of rivets needed to replace either the original installed rivets or those that are required for the type of repair being performed.

**Rivet Spacing and Edge**

Distance The rivet pattern for a repair must conform to instructions in the applicable aircraft manual. The existing rivet pattern is used whenever possible.

**Patches**

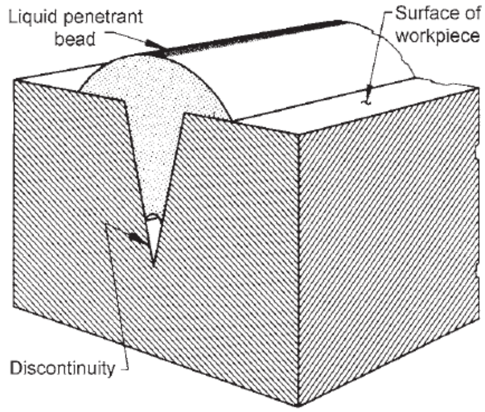
Skin patches may be classified as two types: • Lap or scab patch • Flush patch Lap or Scab Patch The lap or scab type of patch is an external patch where the edges of the patch and the skin overlap each other. The overlapping portion of the patch is riveted to the skin. Lap patches may be used in most areas where aerodynamic smoothness is not important.

Flush Patch A flush patch is a filler patch that is flush to the skin when applied it is supported by and riveted to a reinforcement plate which is, in turn, riveted to the inside of the skin. Figure 4-177 shows a typical flush patch repair. The doubler is inserted through the opening and rotated until it slides in place under the skin. The filler must be of the same gauge and material as the original skin. The doubler should be of material one gauge heavier than the skin.

**Nondestructive Testing**

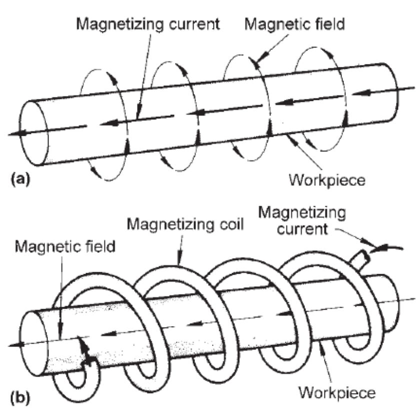
Nondestructive testing (NDT) and inspection techniques are commonly used to detect and evaluate flaws (irregularities or discontinuities) or leaks in engineering systems. Of the many different NDT techniques used in industry, liquid penetrant and magnetic particle testing account for about one-half of all NDT, ultrasonics and x-ray methods about another third, eddy current testing about 10%, and all other methods for only about 2%. It should be noted that the techniques reviewed in this book are by no means all of the NDT techniques utilized.

**Liquid Penetrant Inspection** Liquid penetrant inspection is a nondestructive method used to find discontinuities that are open to the surface of solid, essentially nonporous materials. Indications of flaws can be found regardless of the size, configuration, internal structure, and chemical composition of the workpiece being inspected, as well as flaw orientation. Liquid penetrants can seep into (and be drawn into) various types of minute surface openings (as fine as 0.1 μm or 4 μin. in width) by capillary action, as illustrated in Fig. 8. Therefore, the process is well suited to detect all types of surface cracks, laps, porosity, shrinkage areas, laminations, and similar discontinuities. It is used extensively to inspect ferrous and nonferrous metal wrought and cast products, powder metallurgy parts, ceramics, plastics, and glass objects.




**Magnetic Particle Inspection**

Magnetic particle inspection is used to locate surface and subsurface discontinuities in ferromagnetic materials. The method is based on the fact that when a material or part being tested is magnetized, discontinuities that lie in a direction generally transverse to the direction of the magnetic field cause a leakage field to form at and above the surface of the part. The presence of the leakage field; and, therefore, the presence of the discontinuity, is detected by the use of finely divided ferromagnetic particles applied over the surface. Some of the particles are gathered and held by the leakage field. The magnetically held particles form an outline of the discontinuity and generally indicate its location, size, shape, and extent. Magnetic particles are applied over a surface either as dry particles or as wet particles in a liquid carrier such as water and oil.

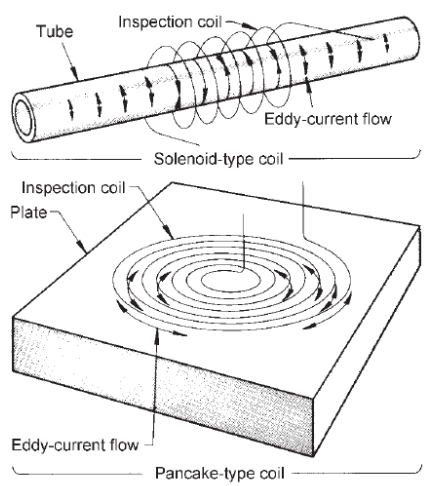



***Eddy Current Inspection***

Eddy current inspection is based on the principles of electromagnetic induction and is used to identify or differentiate a wide variety of physical, structural, and metallurgical conditions in electrically conductive ferromagnetic and nonferromagnetic metals and metal parts. The part to be inspected is placed within or adjacent to an electric coil in which an alternating current is flowing. As shown in Fig. 10, this alternating current, called the exciting current, causes eddy currents to flow in the part as a result of electromagnetic induction.

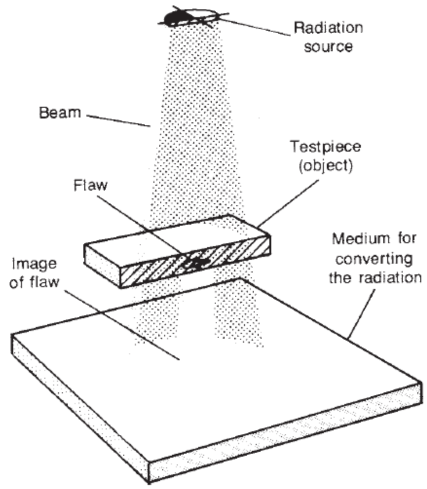
Eddy current inspection is used:

- To measure and identify conditions and properties related to electrical conductivity, magnetic permeability, and physical dimensions (primary factors affecting eddy current response)
- To detect seams, laps, cracks, voids, and inclusions
- To sort dissimilar metals and detect differences in their composition microstructure, and other properties, such as grain size, heat treatment, and hardness
- To measure the thickness of a nonconductive coating on a conductive metal, or the thickness of a nonmagnetic metal coating on a magnetic metal




### *Radiographic Inspection*

Three basic elements of radiography include a radiation source, the testpiece or object being evaluated, and a sensing material. These elements are shown schematically in Fig. 11. Radiography is based on differential absorption of penetrating radiation−either electromagnetic radiation of very short wavelength or particulate radiation−by the part or test piece (object) being inspected. Because of differences in density and variations in thickness of the part, or differences in absorption characteristics caused by variations in composition, different portions of a testpiece absorb different amounts of penetrating radiation.




### *Ultrasonic Inspection*

Ultrasonic inspection is a nondestructive method in which beams of high frequency acoustic energy are introduced into a material to detectsurface and subsurface flaws, to measure the thickness of the material, and to measure the distance to a flaw. An ultrasonic beam travels through a material until it strikes an interface or discontinuity such as a flaw. Interfaces and flaws interrupt the beam and reflect a portion of the incident acoustic energy. The amount of energy reflected is a function of (a) the nature and orientation of the interface or flaw; and, (b) the acoustic impedance of such a reflector. Energy reflected from various interfaces and flaws can be used to define the presence and locations of flaws, the thickness of the material, and the depth of a flaw beneath a surface.

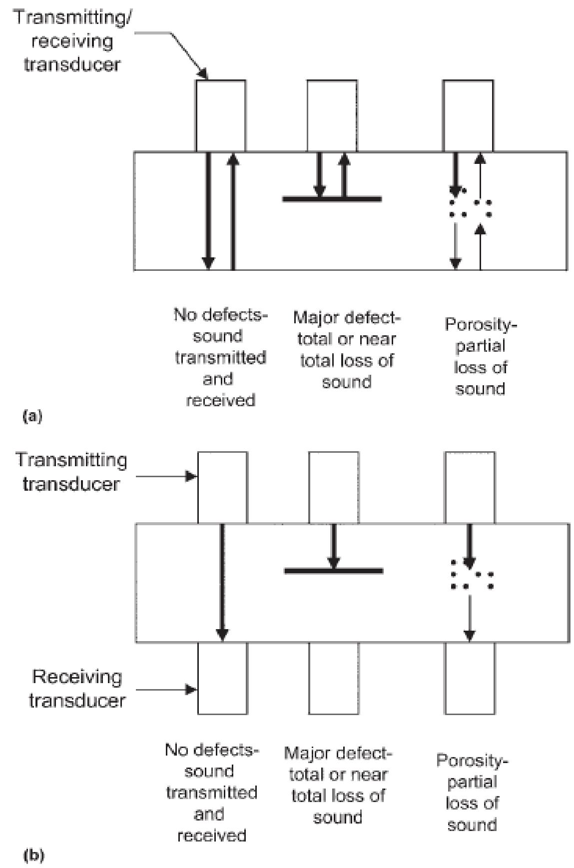

Transmitting/
receiving
transducer
No defects-
sound
transmitted
and
received
Major defect-
total or near
total loss of
sound
Porosity-
partial
loss of
sound
(a)
Transmitting
transducer
Receiving
transducer
No defects-
sound
transmitted
and
received
Major defect-
total or near
total loss of
sound
Porosity-
partial
loss of
sound
(b)

**Table 3 Comparison of some nondestructive testing methods**

| Application | Characteristics detected | Advantages | Limitations | Example of use |
|---|---|---|---|---|
| Ultrasonics | Changes in acoustic impedance caused by cracks, non-bonds, inclusions, or interfaces | Can penetrate thick materials; excellent for crack detection; can be automated | Normally requires coupling to material either by contact to surface or immersion in a fluid such as water. Surface needs to be smooth. | Adhesive assemblies for bond integrity; laminations; hydrogen cracking |
| Radiography | Changes in density from voids, inclusions, material variations; placement of internal parts | Can be used to inspect wide range of materials and thicknesses; versatile; film provides record of inspection | Radiation safety requires precautions; expensive; detection of cracks can be difficult unless perpendicular to x-ray film. | Pipeline welds for penetration, inclusions, and voids; internal defects in castings |
| Visual optical | Surface characteristics such as finish, scratches, cracks, or color; strain in transparent materials; corrosion | Often convenient; can be automated | Can be applied only to surfaces, through surface openings, or to transparent material | Paper, wood, or metal for surface finish and uniformity |
| Eddy current | Changes in electrical conductivity caused by material variations, cracks, voids, or inclusions | Readily automated; moderate cost | Limited to electrically conducting materials; limited penetration depth | Heat exchanger tubes for wall thinning and cracks |
| Liquid penetrant | Surface openings due to cracks, porosity, seams, or folds | Inexpensive, easy to use, readily portable, sensitive to small surface flaws | Flaw must be open to surface. Not useful on porous materials or rough surfaces | Turbine blades for surface cracks or porosity; grinding cracks |
| Magnetic particles | Leakage magnetic flux caused by surface or near-surface cracks, voids, inclusions, or material or geometry changes | Inexpensive or moderate cost, sensitive both to surface and near- surface flaws | Limited to ferromagnetic material; surface preparation and post-inspection demagnetization may be required | Railroad wheels for cracks; large castings |

**Advantages of plastics** | Every extra pound a plane weights costs energy to move it and thus money. The use of modern polymer materials and reinforcing fibres makes it possible to achieve lightweight constructions and hence fuel savings | Plastic components can normally be fabricated economically | Plastics are approx. 50% lighter than aluminium | Compared to metals, plastics do not corrode | Plastics provide a high degree of freedom in design | Plastics with modified sliding properties are best suited for use in dry operation under extreme conditions | Transparent plastics serve as lighter and more impact resistant alternatives to glass

1) They are lightweight. Some plastic components can be as much as ten times lighter than their metal counterparts. For each pound of weight reduced on a plane, $1,000 is saved in fuel over the life of the airplane.
2) Plastics can generally be fabricated economically.
3) They are not prone to corrosion. Many plastics do well in very chemically harsh environments.
4) Transparent plastics are more impact resistance than glass, which increases safety.

**Properties of high-performance plastics** | High thermal and mechanical stability | Inherent flame resistance | Low degree of thermal expansion | High chemical resistance even at raised temperatures | Low level of outgassing in vacuum | Good electrical insulation

**Equipment and systems** For materials used in the propulsion elements, control units or landing gear, good electrical and thermal properties are essential. Controlled fire behavior, low fume toxicity, good sliding properties and high chemical resistance are also a requirement.

**Cabin interior** Because plastics are used in lighting systems, seats, the on-board kitchen and cooling systems, in the oxygen supply, drinking water and disposal systems, as well as freight loading facilities, in some cases supplementary specifications such as FDA, fungus test and drinking water approvals are additionally required. Propulsion systems For applications in machines, components or housings, materials are required above all to offer good thermal resistance and sliding properties

## Transparent Plastics

Plastics cover a broad field of organic synthetic resin and may be divided into two main classifications: thermoplastics and thermosetting plastics.

a. Thermoplastics—may be softened by heat and can be dissolved in various organic solvents. Acrylic plastic is commonly used as a transparent thermoplastic material for windows, canopies, etc. Acrylic plastics are known by the trade names of Lucite® or Plexiglas® and by the British as Perspex®, and meet the military specifications of MIL-P-5425 for regular acrylic and MIL-P-8184 for craze-resistant acrylic.

b. Thermosetting plastics—do not soften appreciably under heat but may char and blister at temperatures of 240-260 ° C (400-500 ° F). Most of the molded products of synthetic resin composition, such as phenolic, urea-formaldehyde, and melamine formaldehyde resins, belong to the thermosetting group. Once the plastic becomes hard, additional heat does not change it back into a liquid as it would with a thermoplastic.

### Composite Laminated Structures

Composite materials consist of a combination of materials that are mixed together to achieve specific structural properties. The individual materials do not dissolve or merge completely in the composite, but they act together as one. Normally, the components can be physically identified as they interface with one another. The properties of the composite material are superior to the properties of the individual materials from which it is constructed

Applications of composites on aircraft include:

- Fairings
- Flight control surfaces
- Landing gear doors
- Leading and trailing edge panels on the wing and stabilizer
- Interior components
- Floor beams and floor boards
- Vertical and horizontal stabilizer primary structure on large aircraft
- Primary wing and fuselage structure on new generation large aircraft
- Turbine engine fan blades
- Propellers

## Manufacturing and In-Service Damage

### Manufacturing Defects

Manufacturing defects include:

- Delamination
- Resin starved areas
- Resin rich areas
- Blisters, air bubbles
- Wrinkles
- Voids
- Thermal decomposition

### In-Service Defects

In-service defects include:

- Environmental degradation
- Impact damage
- Fatigue
- Cracks from local overload
- Debonding
- Delamination
- Fiber fracturing
- Erosion