Part 66 Cat. B1 Module 7

MAINTENANCE PRACTICES

Volume 2

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7.9 PIPES AND HOSES

Aircraft plumbing describes not only the hoses, tubing, fittings, and connectors used in the aircraft, but also the processes of forming and installing them.

Sometimes it is necessary to repair or replace damaged aircraft plumbing lines. Normally the repair is made by replacing the tubing. However, if replacements are not available, the needed parts are fabricated.

Replacement tubing should be of the same size and material as the original line. All tubing's are pressure tested prior to initial installation, and are designed to withstand several times the normal operating pressure to which they will be subjected.

If a tube bursts or cracks, it is generally the result of excessive vibration, improper installation, or damage caused by collision with an object. All tubing failures should be carefully studied and the cause of the failure determined.

Plumbing Lines

Aircraft plumbing lines usually are of metal tubing and fittings or of flexible hose. Metal tubing is widely used for fuel, oil, coolant, oxygen, instrument, and hydraulic lines. Flexible hoses are generally used with moving parts or where the hose is subject to considerable vibration. The aircraft plumbing lines made of flexible hoses are marked by symbols according to material used or line content.

Generally, aluminum alloy or corrosion-resistant steel tubing has replaced copper tubing with the last being on some older aircrafts. The high fatigue factor of copper tubing was the chief reason for its replacement. It becomes hard and brittle from vibration and finally breaks.

Nevertheless, restoration procedure of copper tubing to its soft annealed state by heating it red hot and quenching it in cold water exists. Cooling in air will result in a degree of softness but not equal to that obtained with the cold water quench. This annealing process must be accomplished if copper tubing is removed for any reason. Inspection of copper tubing for cracks, hardness, brittleness and general condition should be accomplished at regular intervals to preclude failure.

Irrespective of this possibility for restoring copper plumbing, the workability, resistance to corrosion, and lightweight of aluminum alloy are major factors in its adoption for aircraft plumbing.

In some special high-pressure (3 000 psi) hydraulic installations, corrosion-resistant steel tubing, either annealed or hardened, is used. Corrosion-resistant steel tubing does not have to be annealed for flaring or forming; in fact, the flared section is somewhat strengthened by the cold working and strain hardening during the flaring process. Its higher tensile strength permits the use of tubing with thinner walls; consequently the final installation weight is not much greater than that of the thicker-wall aluminum alloy tubing.

Tube Forming Processes

Damaged tubing and fluid lines are replaced with new parts whenever possible. In some cases replacement is impractical and repair is necessary. Scratches, abrasions, and minor corrosion on the outside of fluid lines are often considered negligible and can be smoothed out with a burnishing tool or aluminum wool. If a fluid line assembly needs replacement, the fittings can often be salvaged; then the repair will involve only tube forming and replacement.

Tube forming consists of four processes:

1. Cutting;
2. Bending;
3. Flaring, and
4. Beading.

If the tubing is small and made of soft material, the assembly can be formed by hand bending during installation. If the tubing is $^{1}/_{2}$-inch diameter or larger, the hand bending without the aid of tools is impractical.

Tube Cutting

When cutting tubing, it is important to produce a square end, free of burrs. Tubing may be cut with a tube cutter or a hacksaw. The cutter can be used with any soft metal tubing, such as copper, aluminum, or aluminum alloy. Correct use of the tube cutter is shown in **Fig. 9-1**.

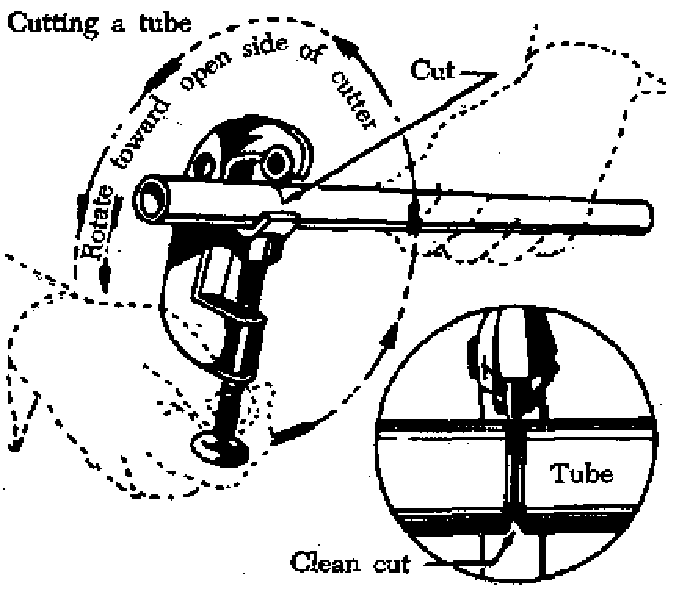


Figure 9-1. Tube cutting

A new piece of tubing should be cut approximately 10 per cent longer than the tube to be replaced to provide for minor variations in bending. Place the tubing in the cutting tool, with the cutting wheel at

Tube Flaring

The two main kinds of flares used in aircraft plumbing systems are the single flare and the double flare. Flares need to withstand extremely high pressures; therefore, the flare on the tubing must be properly shaped or the connection will leak or fail.

A flare made too small produces a weak joint, which may leak or pull apart. If a flare is made too large it interferes with the proper engagement of the screw thread on the fitting and will cause leakage. A crooked flare is the result of the tubing not cut squarely. If a flare is made improperly, flaws cannot be corrected by applying additional torque when tightening the fitting. The flare and tubing must be free from cracks, dents, nicks, scratches, or any ether defects.

The flaring tool used for aircraft tubing has male and female dies ground to produce a flare of 35° to 37° (**Fig. 9-8**).

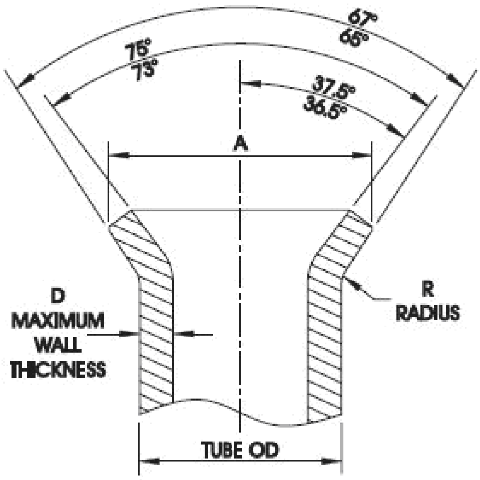


Figure 9-8. Tube flaring

CAUTION: It is not permissible to use an automotive flaring tool, which produces a flare of 45°

Before flaring the appropriate connectors (sleeve and a nut) are put on a tube parts prepared to be connected. The sleeve has a straight taper, which corresponds to flare of 35° to 37° and a nut has a back taper. This prevents flare thickness reduction during the tightening.

Single Flare

A hand-flaring tool similar to that shown in **Fig. 9-9** is used for flaring tubing. The tool consists of a flaring block or grip die, a yoke, and a flaring pin. The flaring block is a hinged double bar with holes corresponding to various sizes of tubing. These holes are countersunk on one end to form the outside support against which the flare is formed. The yoke is used to center the flaring pin over the end of the tube to be flared.

The hand-beading tool is used with tubing having ¼ in. to 1-inch outside diameter. The bead is formed by using the header frame with the proper rollers attached (**Fig. 9-12A**). In addition, a small vice (tube holder) is furnished with the kit (**Fig. 9-12B**).

A

B

Figure 9-12. The hand-beading tool (A) and tube holder (B)

The inside and outside of the tube is lubricated with light oil to reduce the friction between the rollers during beading. The sizes, marked in sixteenths of an inch on the rollers, are for the outside diameter of the tubing that can be beaded with the rollers.

Separate rollers are required for the inside of each tubing size, and care must be taken to use the correct parts when beading. The hand-beading tool works somewhat like the tube cutter in that the roller is screwed down intermittently while rotating the beading tool around the tubing.

Other methods and types of beading tools and machines are available, but the hand-beading tool is used most often. As a rule, beading machines are limited to use with large-diameter tubing, over 1

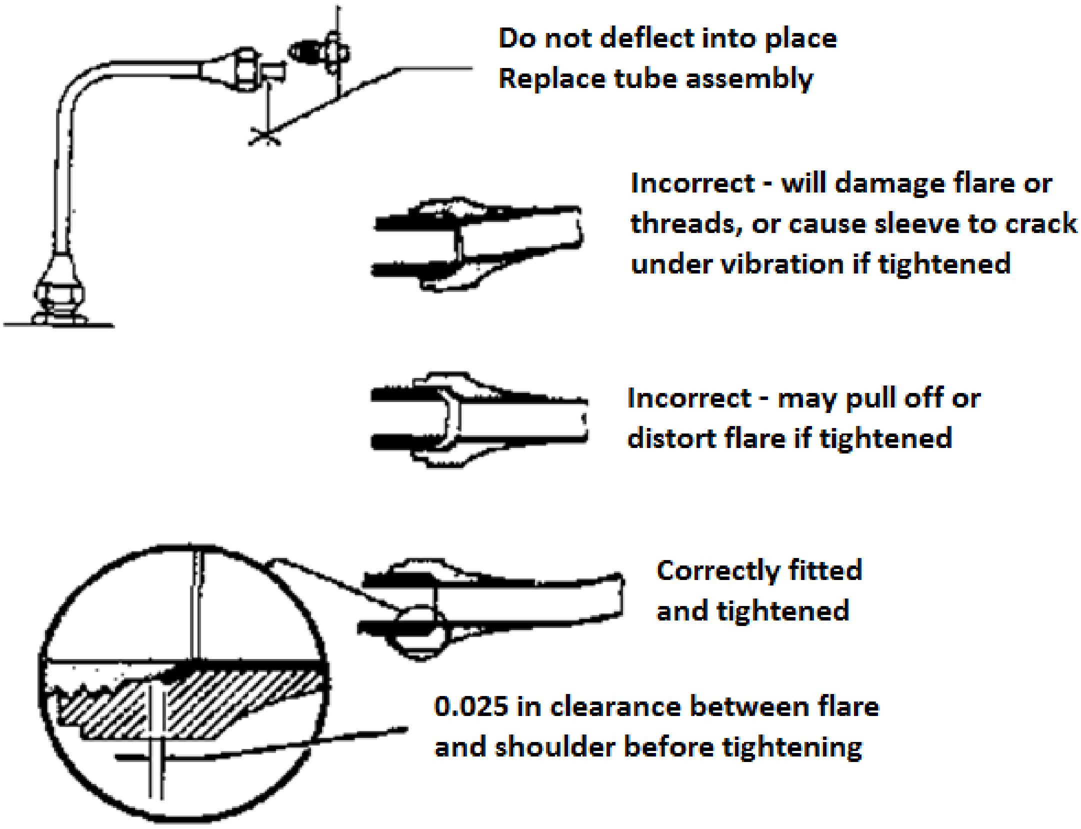


Figure 9-16. Correct and incorrect methods of tightening flared fittings

Flareless Tube Installation

Tighten the nut by hand until an increase in resistance to turning is encountered. If it be impossible to run the nut down with the fingers, use a wrench, but be alert for the first signs of bottoming. It is important that the final tightening commence at the point where the nut just begins to bottom[1].

With a wrench, turn the nut by $^{1}/_{6}$ turn (one flat on a hex nut). Use a wrench on the connector to prevent it from turning while tightening the nut. After the tube assembly is installed, the system should be pressure tested. Should a connection leak, it is permissible to tighten the nut an additional 1/6 turn (making a total of 1/3 turn). If, after tightening the nut a total of 1/3 turn, leakage still exists, the assembly should be removed and the components of the assembly inspected for scores, cracks, presence of foreign material, or damage from over tightening.

CAUTION: Do not in any case tighten the nut beyond 1/3 turn (two flats on the hex nut); this is the maximum the fitting may be tightened without the possibility of permanently damaging the sleeve and nut

[1] Over tightening a flareless-tube nut drives the cutting edge of the sleeve deeply into the tube, causing the tube to be weakened to the point where normal in-flight vibration could cause the tube to shear. After inspection (if no discrepancies are found), reassemble the connections and repeat the pressure test procedures.

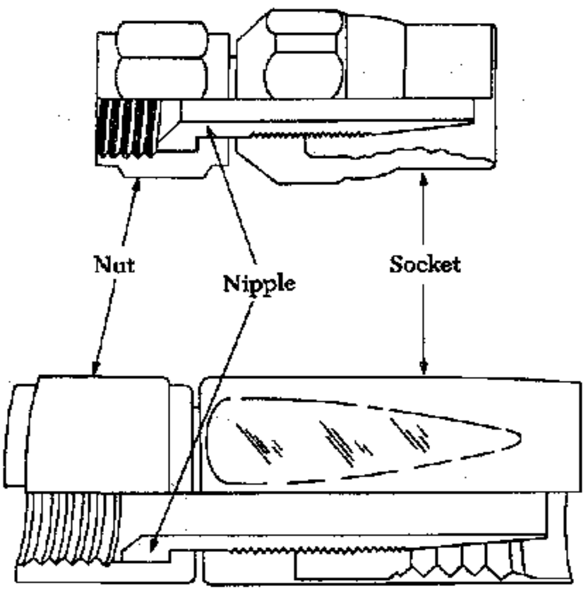


Figure 9-19. Sleeve-type fittings

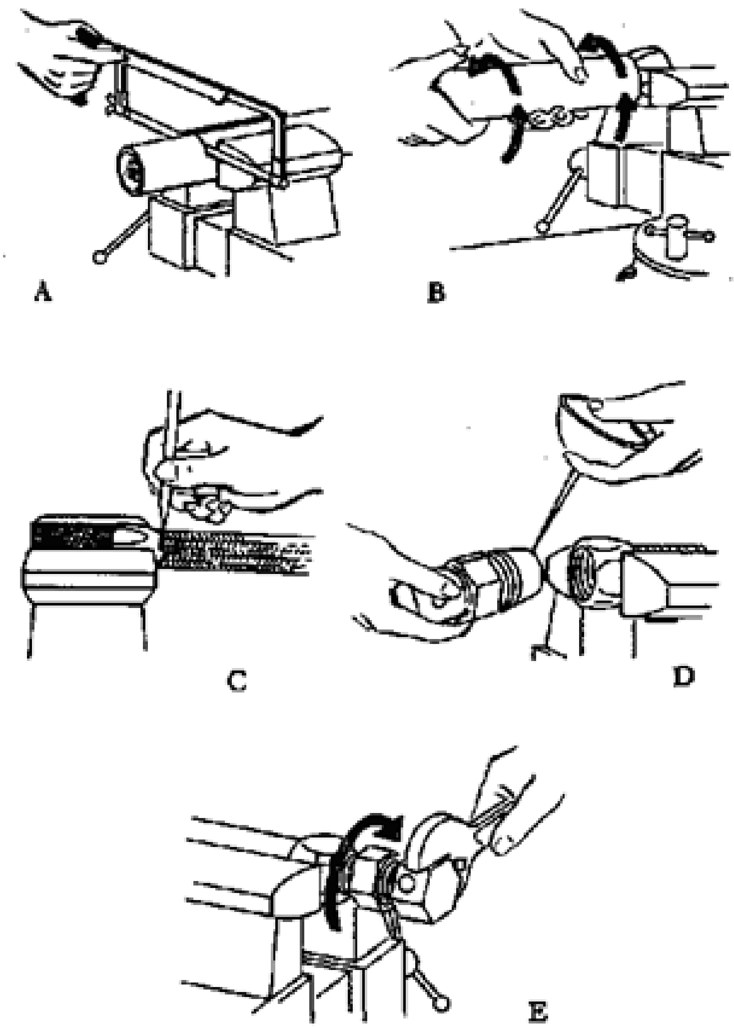


Figure 9-20. Assembly of MS fitting to flexible hose

7.10 SPRINGS

Springs on aircraft are widely used in flight control and brake systems, as well as in many other places. Springs are very simple devises. Nevertheless, they also require a lot of care.

Inspection and testing of springs

Springs will generally require little maintenance. Those that are in exposed areas become corroded over time and those in areas of high temperature can, if they become overheated, lose their temper and cease to have the necessary mechanical compliance to satisfy the task for which they were designed.

Corrosion, which occurs on static springs, can reduce the loads that the spring can carry, whilst if a spring that carries cyclic loads becomes corroded, then the combination of fatigue and corrosion can result in a serious loss of fatigue strength.

Overheating, usually shown as blistering of the surface protection can, in extreme circumstances, show a change of colour of the metal due to the loss of temper. It must be assumed in this event that the spring is not suitable for the designed task. It is important that any exposed springs are carefully inspected for signs of either of the problems of corrosion and overheating.

In some instances, springs have to be checked against figures or graphs to prove whether they are in a suitable condition to continue in service. Some checks have to be done out at prescribed intervals whilst others are done on an “opportunity basis”, such as when a brake unit a hydraulic actuator is dismantled for overhaul.

When testing springs, load is meaningless without length. Inaccurate length measurements can drastically affect results, especially for stiff springs. The spring testing machines needs to be designed to be very stiff and measure true load and frame deflection and corrects length measurements accordingly, resulting in more accurate spring rates and „load at height“ readings.

The most common check done on coil springs is on its static measurement. The manufacturer will publish the exact dimension of the unloaded spring with some small tolerance, whilst the servicing technician will accurately measure the spring's length and compare the two dimensions. Providing that the spring is within the published figures the spring is considered to be serviceable.

The other check, usually completed in a workshop environment, is the load/deflection check. This check is done on the springs, which are used in more critical services, such as piston engine valve springs. A special test rig is used, to load the spring with either a compressive, tensile or a torsional loading and a meter on the rig will display the load versus deflection figures. A series of loads are subsequently applied to the spring and the relevant deflections noted. On completion, the figures are compared to a graph, published by the spring manufacturer, to establish the serviceability of the spring. If a spring fails any of these checks it is simply replaced with a serviceable item.

The spring is tested in stretch range (**Fig. 10-1**) in accordance with Hooke's law

$$F = -kx$$

to avoid crush and axial bending. The tension springs are tested in opposite to compression spring manner.

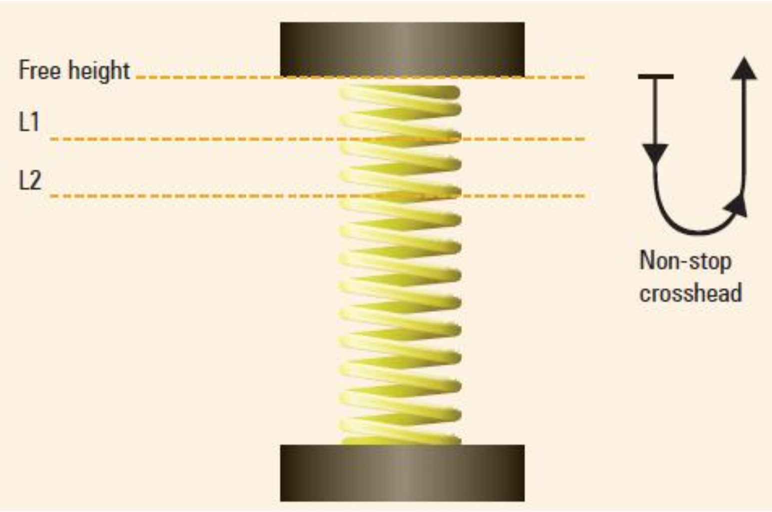


Figure 7.10.1. The diapason the spring is tested spans between L_1 and L_2

For example, the Boeing-737 aileron power control compression spring is tested as follows:

(a) Load should be between 112.5 to 137.5 pounds when spring is compressed to 10.5-inch length.

(b) Load should be between 100 and 116 pounds when spring is compressed to 11.25-inch length. No permanent set should result when spring is compressed to 11.25-inch length.

(c) Load should be between 96 to 104 pounds when spring is compressed to 13.75-inch length.

(d) Load should be between 76 and 84 pounds when spring is compressed to 14.70-inch length.

7.11 BEARINGS

Reducing friction in bearings is often important for efficiency, to reduce wear and to facilitate extended use at high speeds and to avoid overheating and premature failure of the bearing. Essentially, a bearing can reduce friction by virtue of its shape, by its material, or by introducing and containing a fluid between surfaces exploits the low viscosity of a layer of fluid, such as a lubricant or as a pressurized medium to keep the two solid parts from touching, or by reducing the normal force between them.

Aerospace Bearings

Aerospace bearings is a term used to describe bearings installed in aircraft and aerospace systems including commercial, private, military or space applications.

Materials include M50 tool steel (AMS6491), carbon chrome steel (AMS6444), the corrosion resistant AMS5930, 440C stainless steel, silicon nitride (ceramic) and titanium carbide-coated 440C.

Typically special attention is given to the material specification, non-destructive testing and to the traceabity of the bearing. The later term describes a system of documents that enables an engineer to trace a bearing, typically back to its manufacturing batch and material supply.

Jet engine shaft bearings and accessory drive shaft bearings normally use single piece or two piece machined retainers. The pressed steel or moulded retainers found on mass produced bearings are not used.

Temperature and moisture resistant oils, greases and lubricants are normally specified. If the lubricant is not correct the performance of the bearing will be compromised.

Application

In jet engines bearings can operate at over 200°C (400°F) and at speeds over 10 000 rpm for the turbine shafts to over 30 000 rpm in the accessory drives. In wing control surface applications temperatures as low as −55°C (−67°F) may be encountered.

Monitoring

Bearings are a vital factor in many products and assemblies and their performance is often monitored continuously. In jet engines, either the oil supply is monitored to detect the presence of metallic debris that could identify a failure of the bearings or of other components, whose failure may contaminate the bearings.

Main Aircraft Bearings

The main bearings have the critical function of supporting the main engine rotor. The number of bearings necessary for proper engine support will be decided by the length and weight of the engine

The principles of bearing fitting are described on **Fig. 11-3.**

Figure 11-3. Bearing fitting

Bearing Lubrication Requirements

One of the major contributing factors to achieving reliability of bearings is proper lubrication. Bearings operate on very thin films of lubricant, which have to be maintained to ensure that design life is achieved.

The ways of ensuring this, and to maximising bearing life, are to:

A) Select the correct lubricant;
B) Apply it properly, and
C) Maintain it in a clean condition.

Neglect or failure in any of these areas will seriously increase the risk of premature bearing failures and interfere with the trouble free running that is now of such crucial importance in ultra-competitive global markets.

The increased speeds and higher temperatures, at which modem bearings routinely operate, combined with the demands placed upon them for improved accuracy and reliability, mean that the process of selecting a suitable bearing lubrication, today, is more critical than it has ever been.

Properly selected lubricant will:

- Reduce friction and wear by providing a hydrodynamic film of sufficient strength and thickness to support the load and separate the balls from the raceways, preventing metal-to-metal contact;
- Minimise cage wear by reducing sliding friction in cage pockets and land surfaces;
- Prevent oxidation/corrosion of the bearing rolling elements;
- Act as a barrier to contaminants;
- Serve as a heat transfer agent in some cases, conducting heat away from the bearing.

Feel Test

A bearing is tested for roughness by turning the bearing slowly and hand feeling and listening for any defect. The bearing must NOT be spun in an unlubricated state.

Run Test

Running smoothness may be checked by mounting it on a shaft and rotating at 500 -1,000 rpm and applying alternate axial and radial loads in either direction.

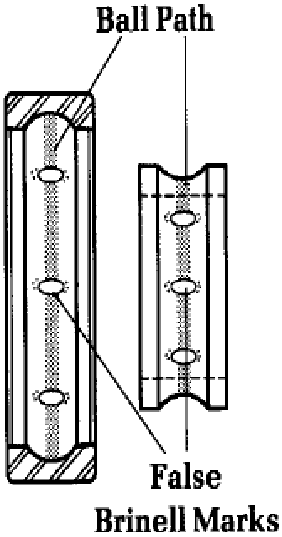
Bearing Defects

Bearing defects with the signs pointing to possible defect that can be obtained during inspections are presented in **Fig. 11-5**.

Fault	What to look for
Worn races	Excessive clearance radially/axially, flaking of raceway groove
Worn balls/rollers	Excessive axial/radial clearances, misshapen rolling elements
Creep	Shiny marks on outside of outer race caused by incorrect interference fit in housing
	Shiny marks on inside of inner race caused by incorrect interference fit on shaft
Worn cage	Soft metal dust in and around the bearing. Inspect for loose rivets
Overheating	Look for bluing of elements and raceways
Brinelling	Indentation of raceways may be seen or felt in a dismantled bearing. Roughness will be present on a spin test of an assembled bearing. Caused by 'skidding' of the rolling elements due to sudden increases in speed under high load (wheel bearings on landing for example)
False Brinelling	Indentation of raceways may be seen or felt in a dismantled bearing. Caused by vibration transmitted through the bearing when the machine is stationary (in transit for example).
Corrosion	Pitting of elements and raceways
Chipping	Roughness and clicking on spin test.
Spalling	The separation/flaking of the surface layer of the raceway caused by thermal or mechanical stresses.

Figure 11-5. Bearing defects


A



B

Figure 11-11. True Brinell (A) and False Brinell (B) marks

False brinelling is not related to excessive loads. False brinelling is caused by ambient vibration. Even a brand new bearing, sealed in a box on a shelf, is subject to false brinelling if it is exposed to environmental vibrations for an extended period. When a bearing is not operating it is subject to false brinelling in the box or in the machine.

When a bearing is operating, there is an oil film between the rolling elements and the raceways. This is called elasto-hydro-dynamic (EHD) film. When a bearing operates with the proper lubrication and at the right speed the balls or rollers lift off the raceway slightly (this is good). This extremely thin film protects and lubricates the bearing while it is running.

When the bearing is stopped there is no EHD film and there is metal to metal contact. That is when false brinelling can quietly attack your bearings. The combination of metal to metal contact and vibration create a wear and corrosion pattern that mimics brinelling.

The prevention is to rotate spindles routinely if they are not in use to reposition the rolling elements and lubrication. Take steps to reduce vibration or isolate machines from each other through properly designed mounting pads. Store bearings and spindles in a clean dry area free from vibration.

7.12 TRANSMISSIONS

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission. They can produce a mechanical advantage through a gear ratio and thus are considered as a simple machine. Geared devices can change the speed, magnitude, and direction of a power source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping.

When two gears of unequal number of teeth are combined, a mechanical advantage is produced, with both the rotational speeds and the torques of the two gears differing in a simple relationship.

As the primary purpose of a gear is the transmission of force through motion; therefore, stress and wear occur continually. For that reason, it is important to visually examine all gears for cracked or chipped teeth and the presence of pitting or excessive wear.

Deep pit marks or excessive wear on gear teeth are reasons for rejecting and replacing a gear. Minor scratches and abrasions on a gear's bearing surfaces can normally be dressed out with a fine abrasive cloth, however, deep scratches or scoring is unacceptable.

Correct gear backlash must be checked and maintained to ensure proper gear mesh with the aid of DTI and special fixture for the particular gear box.

Gear Lash and Pattern

The lash and pattern of a gear is determined by how the teeth of one gear mate with the teeth of another gear (**Fig. 12-1**).

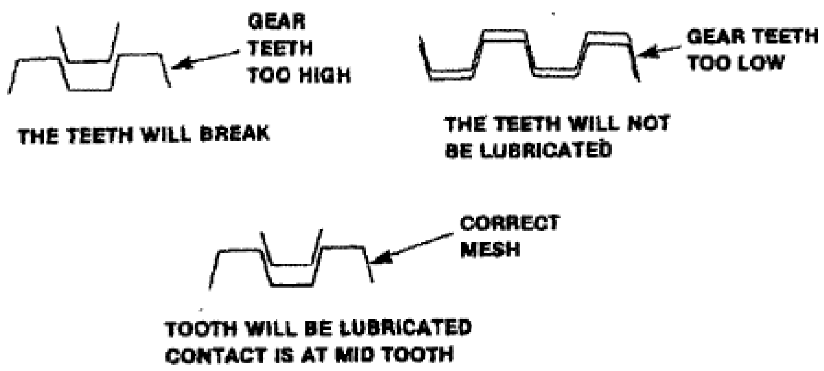


Figure 12-1. Teeth positions with mating gears

If the teeth of one gear are set too tightly into the teeth of another (too low), there will be no lash and the gears will not be properly lubricated because a film of oil must be present between the teeth of the gears as they mesh.

Chains should be measured when clean, but before any oil is applied, by being placed on a flat surface and stretched by application of a tensile load.

Measurement is made between bearing pin centres, and elongation is calculated by the formula

$$\text{Percentage extension} = \frac{M-(X \times P)}{X \times P} \times 100$$

where:

M - Measured length under load, in inches;

X - Number of pitches measured;

P - Pitch of chain in inches.

If the extension is in excess of 2% on any section of the chain the whole run of the chain must be replaced.

The chain must be checked for kinks and twists by suspending it freely and sighting along its length.

CAUTION: Reject chains found to be twisted or kinked

Chains should also be checked for normal faults that can befall most mechanisms; these include damage, corrosion, cleanliness and insufficient lubrication.

One other inspection, which could be done on a chain assembly, might be for correct articulation. This check involves the chain being drawn over the plain shank of a screwdriver.

Tight joints, found by this method, should be carefully inspected and the chain rejected if there are any doubts as to its serviceability.

Levers

Levers can be found in numerous places within an aircraft and maintenance of these items can vary, depending on their location and purpose. As a rule, levers will be used to transmit thrust from one medium to another. For example, a push/pull system may drive a lever that operates a service, with an increase or decrease of mechanical advantage or a change of direction.

Apart from the bearings of the lever requiring lubrication, (unless they are sealed-for-life bearings), there is little maintenance required, other than physical checks for damage, distortion and cracks.

7.13 CONTROL CABLES

Cables are the most widely used linkage in primary flight control systems. Cable-type linkage is also used in engine controls, emergency extension systems for the landing gear, and various other systems throughout the aircraft.

Cable-type linkage has several advantages over the other types. It is strong and light in weight and its flexibility makes it easy to route through the aircraft. An aircraft cable has a high mechanical efficiency and can be set up without hack-lash, which is very important for precise control.

Cable linkage also has some disadvantages. Tension must be adjusted frequently due to stretching and temperature changes.

Swaging of End Fittings

Cables may be equipped with several different types of fittings such as terminals, thimbles, bushings, and shackles.

Terminal fittings are generally of the swaged type. They are available in the threaded end, fork end, eye end, single-shank ball end, and double-shank ball end. The threaded end, fork end, and eye end terminals are used to connect the cable to a turnbuckle, bellcrank, or other linkage in the system. The ball-end terminals are used for attaching cables to quadrants and special connections where space is limited. **Fig. 13-1** illustrates the various types of terminal fittings.

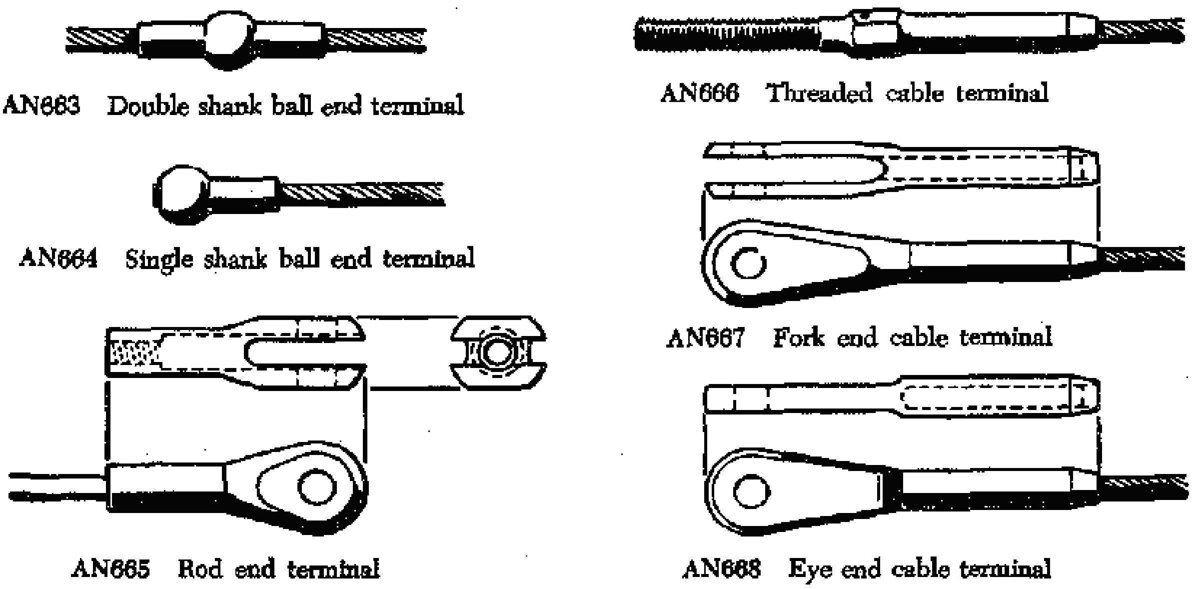


Figure 13-1. Types of terminal fittings

During control cable maintenance operation the terminal fittings are replaced by swaging. Swaging is an operation in which a metal end fitting is secured to the end of the cable by plastic deformation of the hollow shank of the fitting.

Inspection of Swaged Fittings[3]

On completion of the swaging operations, the following inspection should be carried out:

1. Check that the correct combination of cable and fittings has been used;
2. Re-check the diameter of the swaged shank, using a GO/NOT GO gauge or a micrometre. If the diameter of the fitting is too small, it has been over-swaged and as such the cable and the fitting must be rejected. Excessive work hardening of the fitting will cause it to crack and may also damage the cable;
3. Check, by means of the inspection hole or paint mark, that the cable is correctly engaged in the end fitting;
4. Check that the swaging operation has not disturbed the lay of the cable, where the cable enters the end fitting;
5. Ensure that the shank is smooth, parallel and in line with the head of the fitting and that the swaged shank length is correct;
6. Proof loads of the completed cable assembly in accordance with the appropriate manual.
7. Inspect the fittings for cracks using a lens of l0x magnification, or carry out a crack detection test, using magnetic or dye processes, as appropriate;
8. Check that the cable assembly is the correct length and ensure that any required identification marking, including evidence of proof loading, has been carried out and that any specified protective treatment has been applied.

Swaged Splices

A number of proprietary methods are used to secure cable in the form of a loop, which may then be used to attach the cable to a terminal fitting or turnbuckle. The Talurit swaged splice (**Fig. 13-3**) is approved for use on some British aircraft control cables and is also widely used on ground equipment. The process provides a cable assembly which has strength equal to approximately 90% of the breaking strength of the cable. It may only be used to replace cables employing the same type of splice, or hand splices and must not be used where swaged end fittings were used previously.

To make this type of splice, the end of the cable is threaded through a ferrule of the appropriate size, looped and passed back through the ferrule. A thimble is fitted in the loop and the ferrule is squeezed between swages (dies) in a hand-operated or power-operated press. The metal of the ferrule is extruded between the two parallel lengths of cable and around the cable strands firmly locking the cable without disturbing its lay.

[3] The first swaged fitting in a production batch is usually sectioned after proof loading, so that the interior surface can be examined for cracks. If this check is satisfactory, the settings on the swaging machine should be noted and used for completion of the batch.

the reel to rotate. Cable should not be unwound by paying off loose coils, or by pulling the cable away from a stationary reel laid on its side.

When a long length of cable has been cut from a reel and it is necessary to coil the cut piece, the coil diameter should be at least 50 times the cable diameter, with a minimum diameter of 150 mm (6 in). Care must be taken to prevent dust, grit and moisture, from coming into contact with the coiled cable. The ends of stored cable are whipped to prevent fraying and if a length has been cut from the reel, the remaining free end should be whipped. When a coil is being unwound, the coil should be rotated so that the cable is paid out in a straight line.

Cutting Cable

Cable should always be cut using mechanical methods. Cable cutters or heavy duty pliers should normally be used, alternatively, the cable may be laid on an anvil and cut with a sharp chisel and hammer blows. Cable should not be cut by flame. If a non-preformed cable is being cut, it should be whipped with waxed cord on both sides of the cut, prior to being cut. With a preformed cable it will normally only be necessary to bind the cable temporarily with masking tape.

Cleaning of Cables

Cables should not be immersed in grease solvent for cleaning purposes, the correct way to clean a cable is to moisten a cloth in grease solvent and remove surface dirt etc. If a cable is immersed in grease solvent, the solvent will wash out the grease which is put in the cable during manufacture. The outcome would be that the life of the cable will be reduced.

Corrosion of Cables

No corrosion is allowed on cables in aircraft. If corrosion is found on a cable the cable must be rejected.

Cable Wear

Critical areas for strand breakage are where the cable passes over pulleys or through fairleads. Examination of cables will normally involve passing a cloth along the length of the cable, which will both clean any dirt from it and detect broken strands if the cloth “snags” on the projecting wires.

There will be limits, published by the manufacturer, which say how many strands per unit length can be broken. Removed cables can be bent through a gentle radius, which may show up broken internal strands that would not be visible when installed and tensioned.

External wear (**Fig. 13-4**) will extend along the cable, equal to the distance the cable moves at that location and may occur on one side of the cable or over its entire circumference. The limits of permitted wear will be found in the AMM.

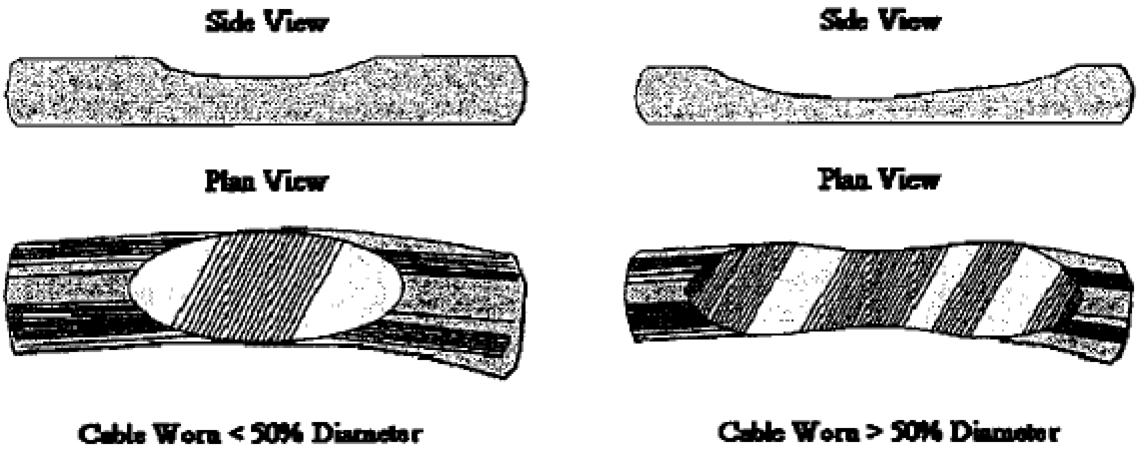


Figure 13-4. Cable wear

Internal wear occurs in similar places in the wire to external wear, around pulleys and fairleads and is much more difficult to detect. Separating the strands, after removing the cable, is the only way to detect internal wear and this only permits limited inspection.

Generally any signs of internal wear within a cable will mean its replacement.

Broken strands on a cable at a location not adjacent to a pulley or fairlead could be an indication that the breakage was due to corrosion.

Inspection for broken wires is carried out by bending the cable (**Fig. 13-5**) if possible, or by running the full length of cable through the protected hand, if necessary in short stages. The broken wires snag the cloth.

Figure 13-5. Inspection for broken wires

The inspection of a cable for internal corrosion should be done off aircraft, and will involve rejection of the cable if corrosion is found.

The maintenance carried out on cable runs usually involves both regular inspections and preservative measures. With the majority of cables being steel-based, it is vital that cables, passing through high

7.14.1 MATERIAL HANDLING - *SHEET METAL*

The majority of metals can be rolled into sheet form but working with sheets of the light alloys, which are encountered on aircraft and, in particular, those formed from aluminum alloy ingots is most important.

Aluminum Alloy Sheets

Sheets of aluminium alloy are comparatively thin in cross-section and, as such, they not only pose a health hazard, through cuts, when being handled but they are, also, prone to buckling and creasing if handled carelessly.

Large sheets of aluminium alloys are, usually stored upright, on their longest edge and supported, clear of the floor, in a wooden framework so they are protected from damage and corrosion. Care must be taken when removing a large sheet from its storage rack - a task which normally involves at least two persons - and good communication between the carriers is important so that the task is completed in a safe manner and no damage is done to the sheet metal.

Some sheets are covered, on one or both surfaces, with a thin protective plastic membrane and, if possible, it may be beneficial to leave at least the underneath protection in place while the marking out is done, to minimise the possibility of the surface sustaining undesirable scratch marks. If no protective membrane is applied to the sheet, then care must be taken over the condition of the surface of the table, or workbench, upon which the sheet is to be laid for the marking out procedures.

Other factors, which should be considered (as with all work), concern the requirements to ensure that:

- Material wastage is kept to a minimum;
- The task is done correctly, first time, so that valuable time, also, is not wasted.

The first point is usually obvious, due to the cost of the materials involved, but the second point quite often gets forgotten, when work is being done, but the actual labour costs far outweigh the material costs on a high percentage of tasks.

Repair or modification drawings must be studied very carefully, to ensure there is no doubt about the data and dimensions provided, so that the marking out is correctly done and the approved metal is shaped in exactly the manner that the designer of the drawing intended.

Marking Out

After analyzing the data and dimensions on the relevant drawing and confirming that the correct metal (according information presented in Conformity Statement or Certificate) is being used, the marking out of the pattern for the part which is being formed can proceed.

Firstly the overall dimensions of the part must be calculated and, where necessary, a bare outline drawn on the large sheet, so that the metal can be cut and, thus, allow an easier, smaller piece upon which to work.

Bending of aluminium alloys is achieved either by the use of:

- Specially-shaped bending bars: used for small pieces and larger angles and between which, the sheet is clamped, in a vice, while the metal is bent, by hitting with a hide-faced or similarly soft-headed hammer;
- A large, free standing, bending machine (or bending brake): in which the metal sheet is clamped and the bend made, in one movement, by means of a hinged bending leaf.

Caution must also be exercised when forming a bend, using the bending bars and soft-headed hammer method, because too many blows with the hammer will cause work-hardening of the metal, or the metal, in the bend, will become too thin and stretched. Subsequent cracking of the metal will result from these faults

For this reason the bending brake is preferred but, in a similar manner to the squaring shears, only the approved thicknesses of metals should be bent in these machines, as any distortion will destroy the accuracy of the bends.

Square (or sharp) angles, in aluminium alloys, are only formed by adhesive, casting, extrusion or welding methods. Whether it is the bending bars or the bending brake method, which is used to bend aluminium alloy sheet, the bend will always be formed around a radius, as it is not possible to create square angles by bending without cracking the metal.

Bend Allowance and Setback

When making a bend or fold in a sheet of metal, the bend allowance must be calculated. Bend allowance is the length of material required for the bend. This amount of metal must be added to the overall length of the layout pattern to assure adequate metal for the bend.

Bend Allowance Terms

Familiarity with the following terms is necessary for an understanding of bend allowance and its application to an actual bending job. **Fig. 14-1** illustrates most of these terms.

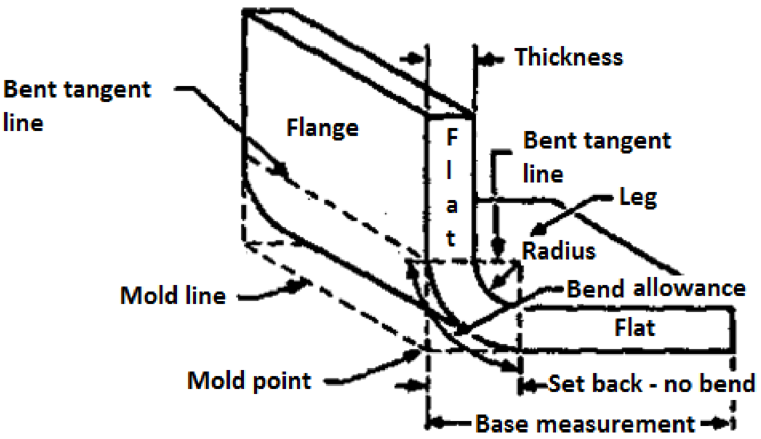


Figure14-1. Bend allowance terms

To calculate the setback for a 90-degree bend (**Fig. 14-4**), merely add the inside radius of the bend to the thickness of the sheet stock:

$$Setback = R + T$$

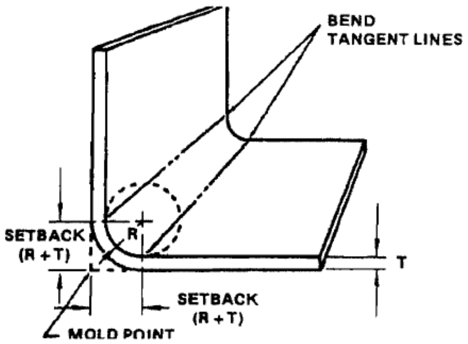


Figure 14-4. Setback, 90° bend

To calculate setback for angles larger or smaller than 90 degrees, consult standard setback charts or K chart for a value called K (**Fig. 14-6**), and then substitute this value in the formula,

$$Setback = K \times (R + T).$$

The value for K varies with the number of degrees in the bend.

Example: Calculate the setback for a 120-degree bend with a radius of bend of 0.125" for a sheet 0.032" thick:

$$Setback = K \times (R + T) = 1.7320 \times (0.125 + 0.032) = 0.272\ inches$$

Brake or Sight Line

The brake or sight line is the mark on a flat sheet (**Fig. 14-5**) which is set even with the nose of the radius bar of the cornice brake and serves as a guide in bending.

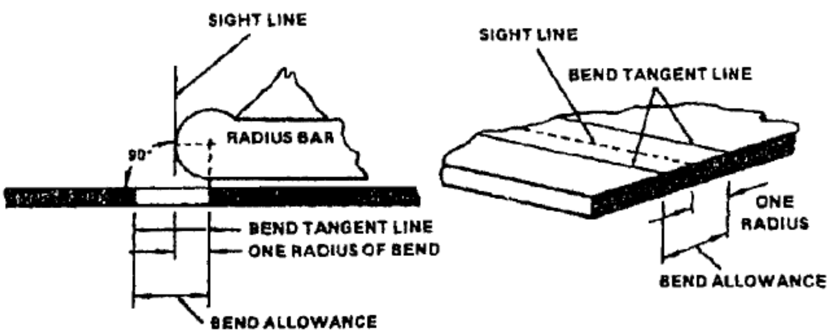


Figure 14-5. Setback, 90° bend and setback locating bend line in brake

The brake line can be located by measuring out one radius from the bend tangent line closest to the end which is to be inserted under the nose of the brake or against the radius form block. The nose of the brake or radius bar should fall directly over the brake or sight line as shown in **Fig. 14-5**.

7.14.2 MATERIAL HANDLING – COMPOSITE AND NON-METALLIC

Composite and other non-metallic materials are attached to the major structure or joined together in the ways mainly different of that for metals.

Bonding Practices

The major function of adhesives is for mechanical fastening. Because an adhesive can transmit loads from one member of a joint to another, it allows a more uniform stress distribution than is obtained using a mechanical fastener. Thus, adhesives often permit the fabrication of structures that are mechanically equivalent or superior to conventional assemblies and, furthermore, have cost and weight benefits. For example, adhesives can join thin metal sections to thick sections so that the full strength of the thin section is utilized. Conventional mechanical fastening or spot welding produces a structure whose strength is limited to that of the areas of the thin section that contact the fasteners or the welds. In addition, adhesives can produce joints with high strength, rigidity, and dimensional precision in the light metals, such as aluminum and magnesium, which may be weakened or distorted by welding.

Surface preparation of the adherents (materials to be joined) is necessary prior to the application of an adhesive. The treatment may range from a simple solvent wipe that is completed in seconds to a multistage cleaning and chemical treatment requiring 30 min or more. The purpose of pre-bond treatments is to remove existing adventitious surface layers from the parts to be joined and to replace them with sound surface layers known to be suitable for the application.

If a layer of grease or oil on an adherent is not removed, or if it is not absorbed and dispersed by the adhesive, it will affect the performance of the joint. Similarly, a thick or weak oxide layer on a metal adherent lowers joint strength and durability. It may be desirable to treat the surface, replacing an existing layer with a thinner and/or stronger oxide layer and/or one with different micro-roughness characteristics.

For metals a solvent wipe or vapours degrease is a minimum pre-bond treatment. This treatment is also a prerequisite to more extensive surface preparation. The minimum treatment is usually satisfactory only for noncritical assemblies or those that will not be subjected to high stress or adverse environments.

Initial joint strength is not a sufficient indicator of the durability of a joint in service. Joints made from minimally prepared metal adherents may have the same initial breaking strengths as those made from similar adherents prepared with the most elaborate chemical treatments. Joints made with minimally prepared adherents, however, are markedly inferior in durability when exposed to adverse environments.

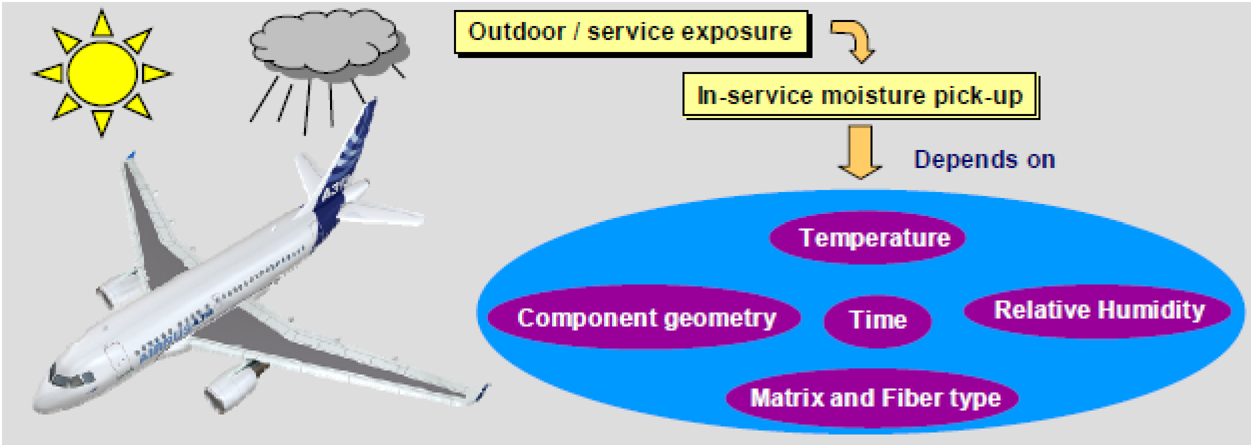


Figure 14-13. Outdoor factors

The results of outdoor conditions on composite properties are summarized in **Fig. 14-14**.

Resins absorb moisture until equilibrium (or saturation) is attained at 70°C/85% r.F.

Moisture lowers glass transition temperature (Tg)

- Thermosets absorb 1 – 2% of moisture
- Thermoplastics absorb 0.1 – 0.3% of moisture
- The laminates thicker than 8mm never experience a total saturation and therefore experience a lower degradation because of moisture.
- Hot / wet conditions cause the resin to become more plastic
- Cold / dry conditions cause the resin to become more brittle

The effect of moisture ingress can be nearly reversed by drying.

Figure 14-14. Outdor conditions effect on composites

Tensile Properties in the Fibre Direction of the UD Laminate

In order to establish the strength of the UD carbon fibre reinforcement, tensile testing is carried out, the test is totally fibre dominated with the fibres running parallel to the direction of the load.

The effect of the elevated temperature and moisture on the UD carbon fibre tensile specimens is very slight. There is no reduction in strength & modulus at 90ºC, and only a slight reduction in strength after the hot / wet conditioning of the specimen is changed.

Compressive Properties in a Direction Perpendicular to the Fibre

The stiffness of the carbon fibre has no influence during this type of test, as it can be seen; the strength decreases when the specimens are tested at 90ºC and decreases still further (30%) when the hot / wet conditioned specimens are tested. The compressive modulus of the carbon fibre remains constant throughout the different test conditions. The strength decrease during this test is resultant up on both fibre & resin matrices. Matrix softening & micro-buckling occur.

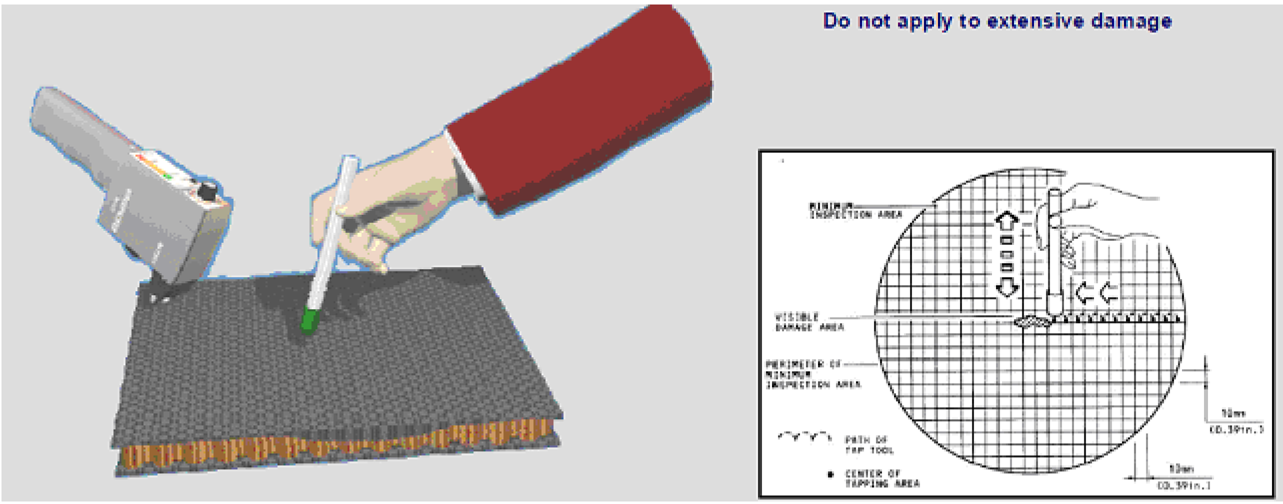


Figure 14-18. Tap Test using Woodpecker comparing to manual taping

The principal elements of Woodpecker are presented on **Fig. 14-19**. The rebound rate change is measured automatically through the sensor (accelerometer) and electronically processed so that the degree of change in a structures condition will be indicated visually (DATA lights) and by audio means (buzzer).

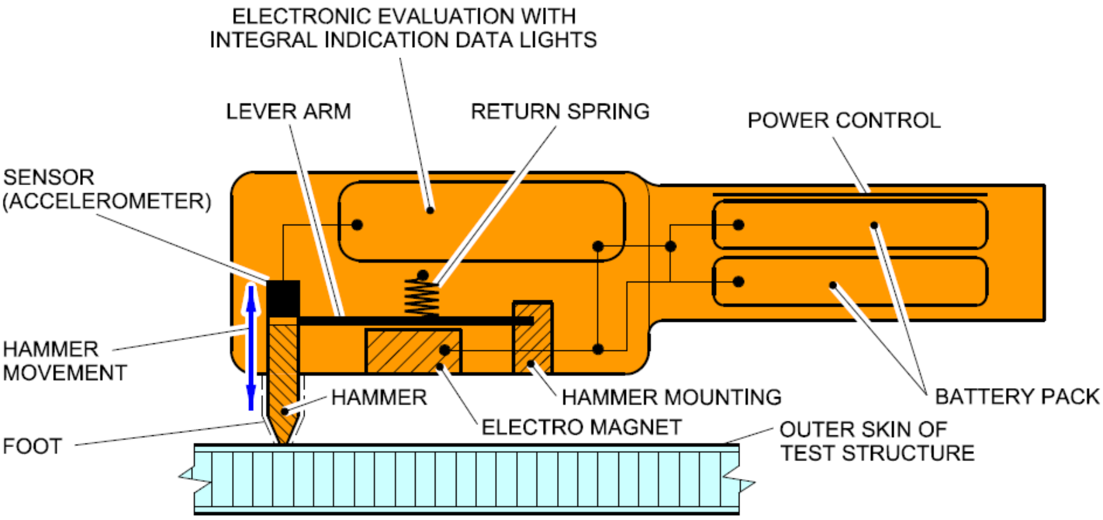


Figure 14-19. The Woodpecker

Ultrasonic Methods

The ultrasonic method uses the property of high frequency sound waves to propagate in materials and to be reflected by an interface with an air boundary (discontinuity). It has such applications as delamination/debonding in monolithic structures and thickness measurements.

This method is based on a principle of transmitting a high frequency ultrasonic signal into the material (**Fig. 14-20**). A defect in the material reflects or disturbs the ultrasonic signal. The interpretation of the signal can identify the depth, shape and size of the defect.

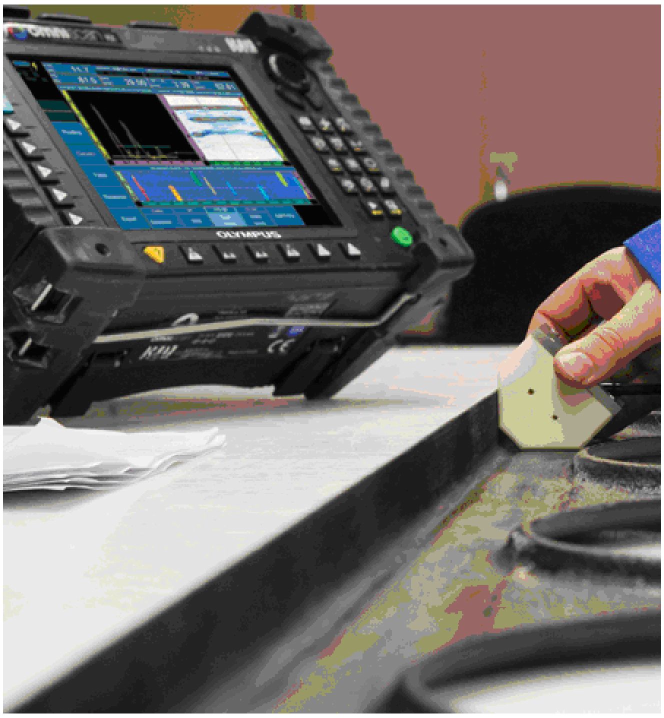


Figure 14-20. Ultrasonic inspection method

Various techniques of ultrasonic inspection may be used:

- Through Transmission Ultrasonic (TTU); this inspection needs two transducers, one on each side of the part;
- Pulse Echo process, requires one transducer only.

This method has its own limitations:

- The defect orientation must be parallel to the surface of inspection;
- Couplant is required between the search unit and the test part.

When performing an ultrasonic inspection, it is essential to know the structure configuration by reference to the illustration of the component in the Structural Repair Manual (SRM). Ultrasonic inspection can be carried out on almost every type of material used in the construction of aircraft. It is an extremely sensitive method of detecting surface and subsurface flaws, and has few limitations. Then direct coupling with the test part can be established, its resolving capability is excellent. The method uses the principle of reflected energy (sound wave echos).

There are three basic methods of ultrasonic testing (**Fig. 14-21**):

(1) Pulse-echo;

(2) Resonance, and

(3) Through transmission.

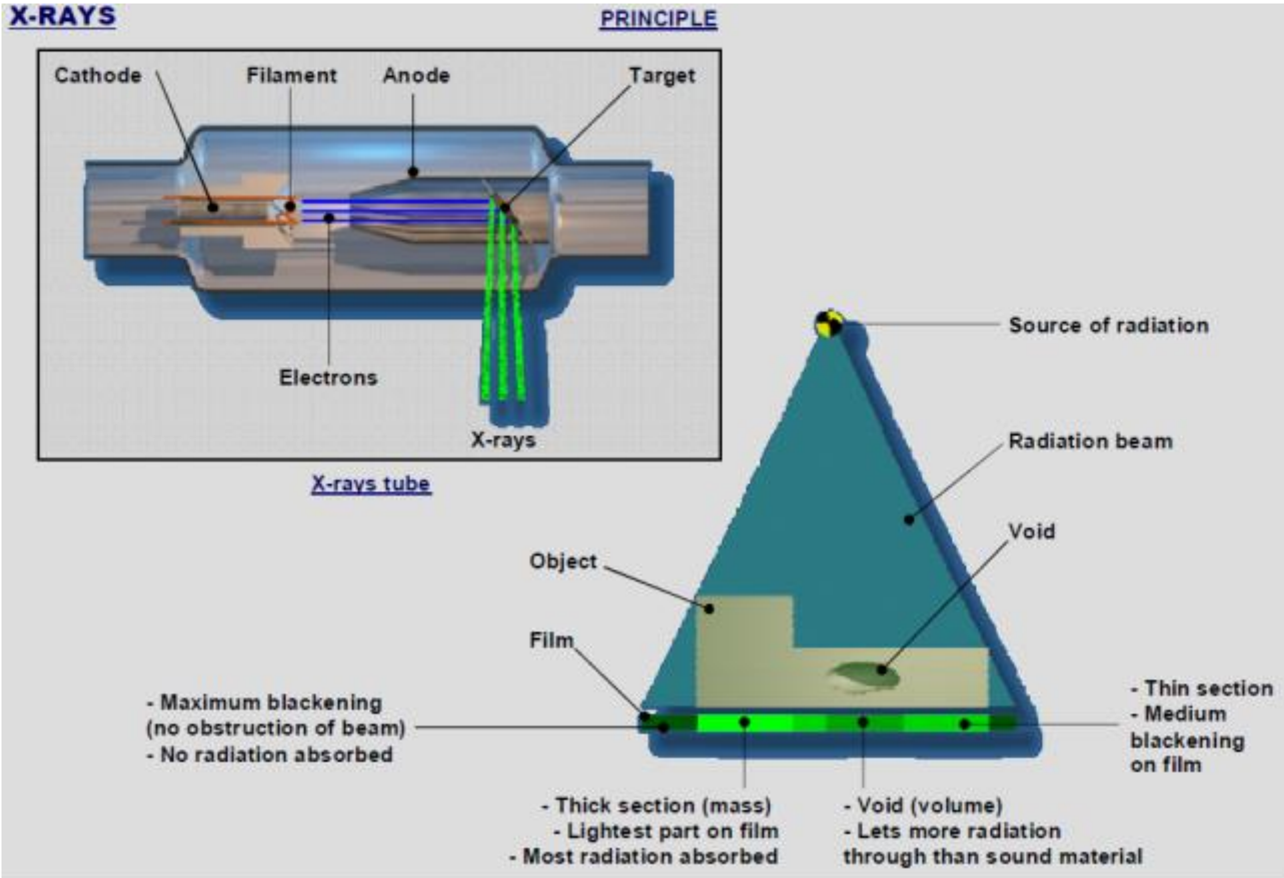


Figure 14-26. X-ray principle and application

X-rays are used to expose a radiographic film. When X-rays pass through the material, the intensity of the X-rays beam will be affected in relation with the material density and thickness of the part. The intensity of the X-Rays, that reach the film, is decreased in proportion to the thickness and density of material they have passed through. This decrease in intensity is caused by absorption and scattering of the rays. The greater the density, the greater the reduction is (**Fig. 14-26**). So, the radiographic film will be exposed differently and will show a white area for high density and a black area for low density.

The latest instruments are computerized and analysis of X-ray density is displayed in real time.

X-Rays Properties in Analysis

The intensity of the X-Rays, that reach the film, is decreased in proportion to the thickness and density of material they have passed through. This decrease in intensity is caused by absorption and scattering of the rays. Absorption is proportional to the:

- Thickness of the part being X-rayed;
- Density of the material

The very typical application of thermographic inspection may be the investigation of water ingress in sandwich panels (**Fig. 14-32**).

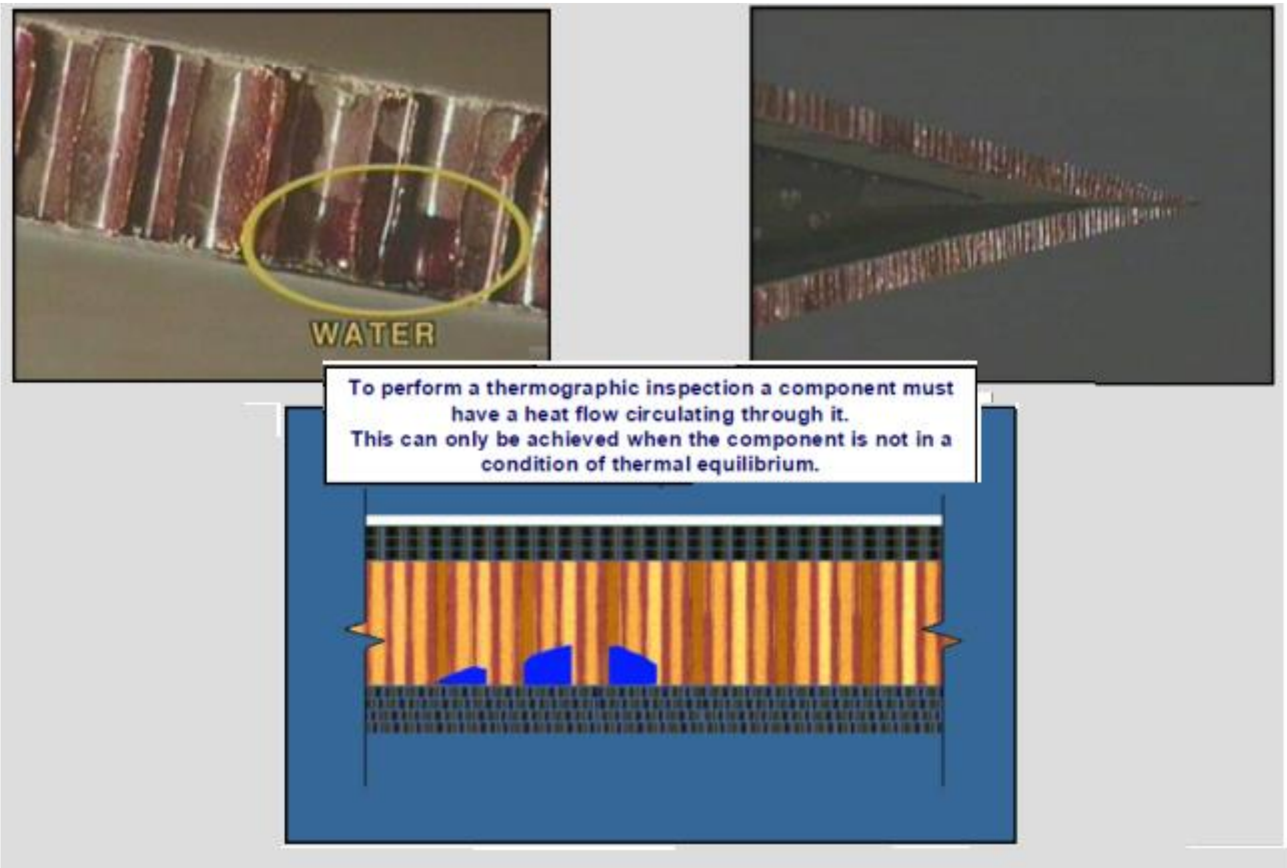


Figure 14-32. A thermographic inspection of water ingress in sandwich panel

The summary of all the inspection methods is given in **Fig. 14-33**.

Inspection technique	Limit for use
Visual	For all open surface damage detection
Tap test / woodpecker	Disbond delamination[9]
X-Ray	Water ingress
US	Delamination / Disbond[10]
Thermography	Water ingress

Figure 14-33. The summary of inspection methods

[9] For sandwich structures
[10] Disbond detection for TTU or Bond master

7.15.1A WELDING, BRAZING, SOLDERING AND BONDING

During maintenance procedures maintenance technicians may be called to do some procedures. Some of them as soldering are outdated for commercial aviation but still used in small and amateur one.

Soldering is done at considerably low temperatures so that the parent metals do not melt and fuse together.

A fusible non-ferrous alloy (with a low melting point) is applied between the heated metals of the joint, such that the fusible alloy forms a metallic bond with the parent metals and, on cooling, creates a solid joint.

Methods of Soldering

Soldering can be divided into two basic methods, one of which uses higher temperature ranges than the other. Both methods are conducted at temperatures below the melting points of the parent metals of the intended joint.

The two basic methods of soldering are:

Hard Soldering*[11]*: done at temperatures in excess of 500°C and which include the processes of brazing and silver soldering;

Soft Soldering: done at temperatures within the range of 180°C to 330°C, which, consequently, create joints of lower strength (but less expense) than those achieved by the hard soldering methods.

Hard Soldering (Brazing and Silver Soldering)

Brazing, as the name implies, uses a Copper/Zinc (Brass) alloy, as the filler metal (spelter) between the parent metals of the joint. The degree of alloying will dictate the temperature at which the process is done but the melting point of the brazing alloys can be as high as 880°C.

Brazing is a process of joining in which, during, or after heating, the molten filler metal is drawn into, or retained in, the space between closely adjacent surfaces of the parts to be joined, by capillary attraction.

In general applications, workshops and small factories, a flame, directed onto the joint area, is the source of heat.

The flux mostly used for brazing processes is borax, which is based on Sodium Borate powder, mixed with water, to a thin paste before being applied, by brush or swab, to the site of the joint. Other fluxes are also available where required.

[11] The hard soldering processes are, normally, not used in aircraft servicing

placed together and the hot iron is applied to an outer surface of the joint. The heat is transmitted through the metal and melts the solder interfaces so that they fuse together and a typical soldered lap joint[13] of the metals is completed (**Fig. 15-2**).

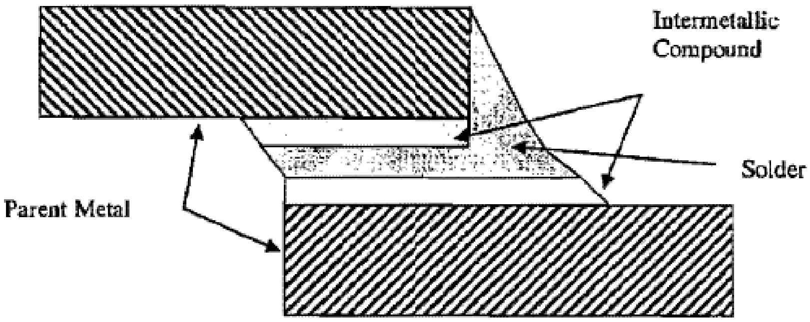


Figure 15-2. A typical soldered lap joint

Active and Passive Fluxes

Metal surfaces become more reactive to oxygen when they are heated and, to prevent this oxidation, during the soldering process a suitable flux is applied to the surfaces being joined.

The flux should possess certain characteristics in that it:

- Forms a liquid film over the joint and excludes the gases in the atmosphere;
- Prevents any further oxidation during the heating cycle;
- Assists in dissolving the oxide film on the metal surface and the solder;
- Is displaced from the joint by liquid filler metal.

Fluxes for soft soldering are often classified into two groups, which are the:

- Active group: which are corrosive or acid fluxes, and
- Passive group: which are non-corrosive fluxes.

The flux can be applied separately, or as a constituent within the solder. Fluxes may take the form of a liquid, paste or solid, and the application, for which they are being used, will govern the type selected.

Active (corrosive) fluxes are used where conditions require a rapidly working and highly active flux.

Active FLUXES CAN CAUSE BURNS TO FLESH AND CLOTHING
PROTECT THE EYES WITH GOGGLES AND WEAR RUBBER GLOVES AND APRON
WHEN USING A CORROSIVE FLUX

The common active fluxes[14] are:

[13] When making electrical connections, using soft solder, a type of lap joint must be made, since an end-to-end joint in wire would be impracticable

[14] Flux residues of acid fluxes remain active after soldering and will cause corrosion unless removed by thorough

7.15.2B WELDING, BRAZING, SOLDERING AND BONDING

Within the aircraft industry welding is considered to be a specialist skill and only suitably approved and authorised personnel can undertake welding procedures.

Approved welders must satisfy the CAA of their competency, by submitting several „test pieces“' of their typical work for testing and they are subjected to similar re-tests every 12 months in order to retain their approvals.

Welding may be defined as the permanent joining, by fusion, of two pieces of material (usually metals), by the progressive melting and subsequent solidification of the materials at the site of the joint.

The basic principle of fusion welding of metals is the same for all processes. The surfaces, or edges, of the metal to be joined are brought to a molten state and allowed, or caused, to intermix (with or without the addition of a filler metal), so that the parent metal and filler metal (if used) form a homogeneous molten pool which, when cooled, forms the complete weld.

Methods of Welding

Welds require the application of sufficient heat energy to melt the metals involved in the joint and the high temperatures are achieved by various methods.

Oxy-Acetylene Welding

The cutting of steel sections and plate material may be done by means of a flame torch, using a mixture of oxygen, with one of the appropriate fuel gases (acetylene, hydrogen, natural gas or propane).

For welding, however, only an oxygen and acetylene mixture will provide a sufficiently, high heat input, needed for the welding process (**Fig. 15-3**). The temperature of the oxy-acetylene flame is approximately 3150°C.

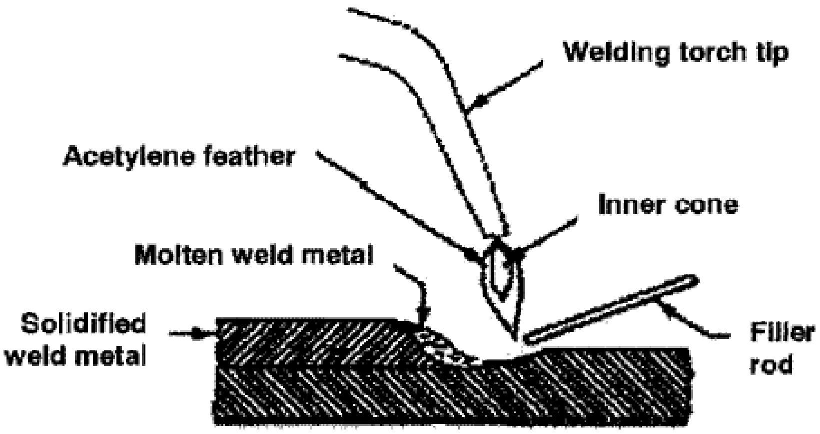


Figure 15-3. Oxy-acetylene welding schematic

Metal Inert Gas Welding

In metal inert gas welding semi-automatic welding process[15] (**Fig. 15-5**) two types of this process exists:

- Metal Inert Gas (MIG) welding where the shielding is provided by a shroud of inert gas;
- Metal Active Gas (MAG) welding where shroud of active, or non-inert, gas or mixture of gases provide the shielding.

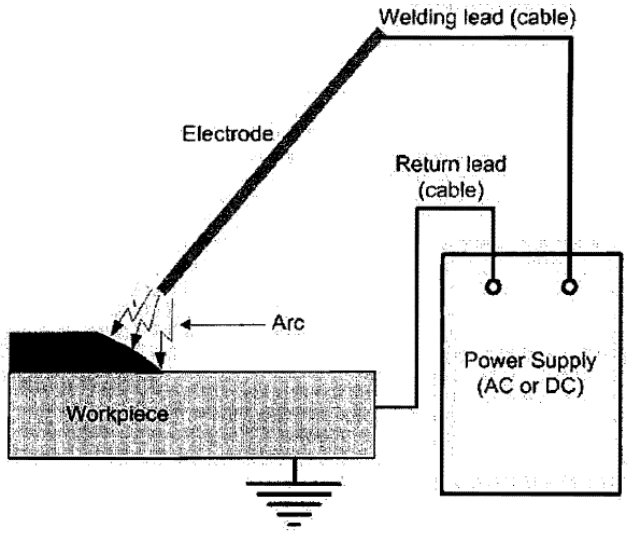


Figure 15-5. Metal inert gas welding schematic

In this process the heat source is also an electric arc, but the electrode is a bare wire, which is consumable and is supplied, from a reel, to the welding gun, by a wire feed unit (**Fig. 15-6A**).

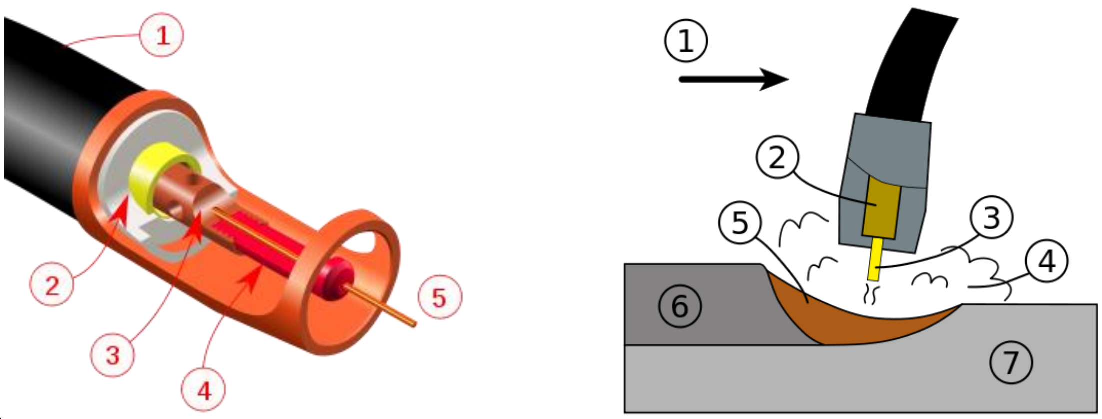


Figure 15-6. Gas metal arc welding torch nozzle (A) and welding cutaway image (B)

[15] This process may also be referred to according to the type of shielding gas (or mixture of gases) which is being used and whether those gases are inert or active.

It may, however, be possible that, after suitable training, some technicians can be granted approval to conduct limited Dye Penetrant inspection procedures on certain welds, which will be specified in the appropriate servicing manual.
For successful visual inspection and its reporting aircraft maintenance mechanic needs to know some conceptions from weld vocabulary (**Fig. 15-11**) and possible welding defects (**Fig. 15-12**).

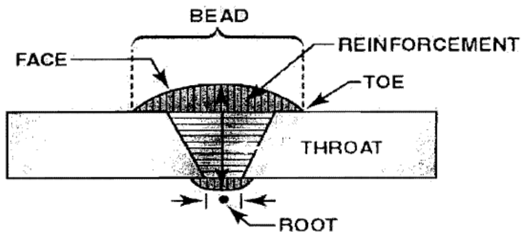


Figure 15-11. Weld terminology

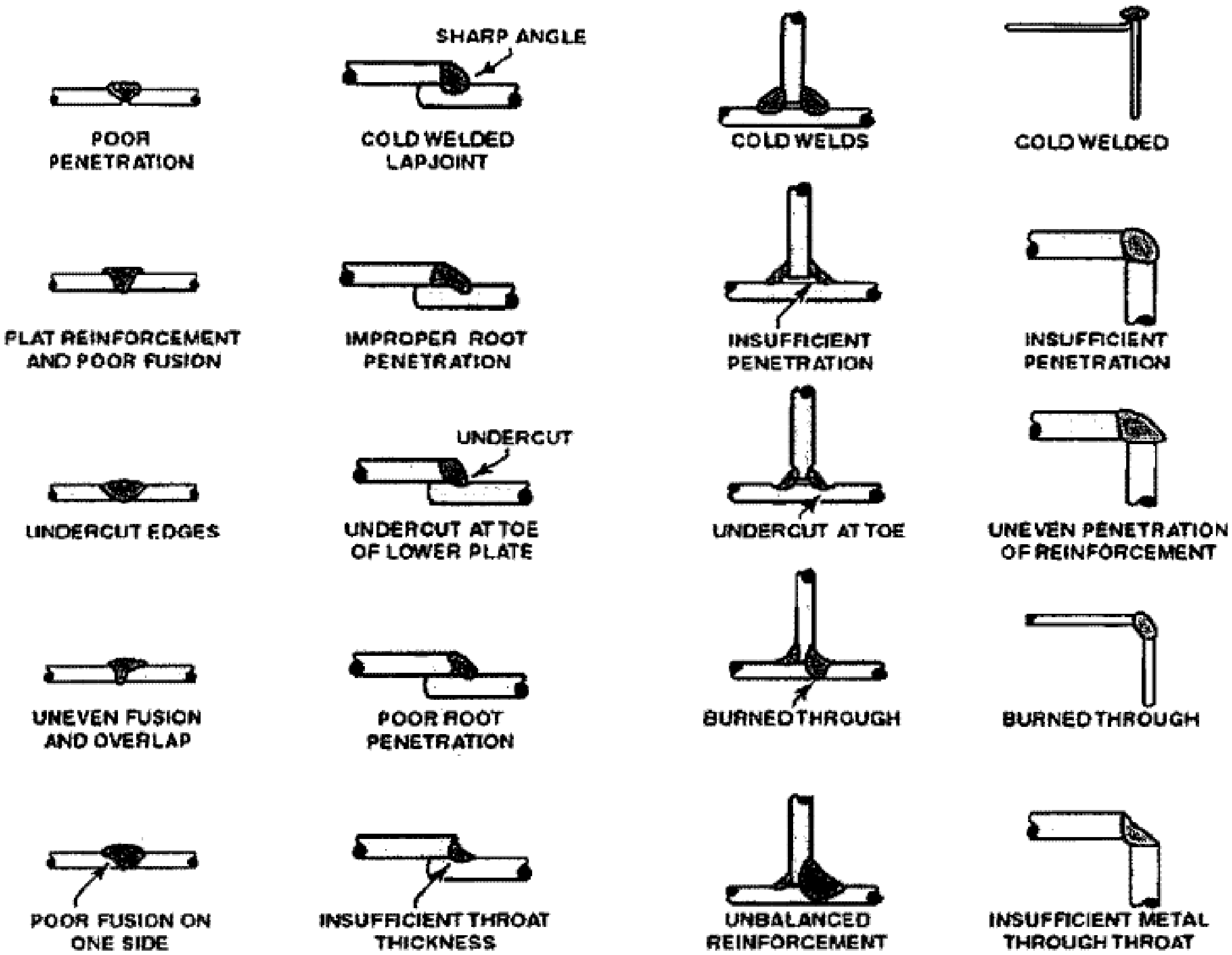


Figure 15-12. Weld defects

7.16.1A. AIRCRAFT WEIGHT AND BALANCE

The primary purpose of aircraft weight and balance control is safety. A secondary purpose is to achieve the utmost in efficiency during flight.

Improper loading reduces the efficiency of an aircraft from the standpoint of ceiling, manoeuvrability, rate of climb, speed, and fuel consumption. It can be the cause of failure to complete a flight, or even to start it. Possible loss of life and destruction of valuable equipment may result from overstressed structures or from a sudden shift in cargo and consequent change in flight characteristics.

The empty weight and the corresponding e.g. (centre of gravity) of all civil aircraft must be determined at the time of certification. The manufacturer can weigh the aircraft, or he can compute the weight and balance report. A manufacturer is permitted to weigh one aircraft out of each 10 produced. The remaining nine aircraft are issued a computed weight and balance report based on the averaged figures of aircraft that are actually weighed. The condition of the aircraft at the time of determining empty weight must be one that is well defined and can be easily repeated.

Need for Re-weighting

Aircraft have a tendency to gain weight because of the accumulation of dirt, greases, etc., in areas not readily accessible for washing and cleaning. The weight gained in any given period of time will depend on the function of the aircraft, its hours in flight, atmospheric conditions, and the type landing field from which it is operating. For this reason, periodic aircraft weightings are desirable and, in the case of air carrier and air taxi aircraft, are required by Aviation Regulations.

Airline aircraft (scheduled and non-scheduled) carrying passengers or cargo are subject to certain rules that require owners to show that the aircraft is properly loaded and will not exceed the authorized weight and balance limitations during operation.

Weight and balance control consists of mathematical proof of the correct weight, balance, and loading within specified limits. These limits are set forth in the specifications for a particular aircraft. The removal or addition of equipment changes the aircraft empty weight and the e.g. the useful load is affected accordingly. The effects these changes produce on the balance of an aircraft must be investigated to determine the effect on the flight characteristics of the aircraft.

Weight and Balance Data

Weight and balance data can be obtained from the following sources:

1. The aircraft specifications;
2. The aircraft operating limitations;
3. The aircraft flight manual, and
4. The aircraft weight and balance report.

Centre of Gravity

The CG of an aircraft is a point about which the nose-heavy and tail-heavy moments are exactly equal in magnitude. An aircraft suspended from this point would have no tendency to rotate in either a nose up or nose down attitude. It is the point about which the weight of an airplane or any object is concentrated.

The Arm

The arm is the horizontal distance that an item of equipment is located from the datum. The arm's distance is always given or measured in inches, and, except for a location which might be exactly on the datum (0), it is preceded by the algebraic sign for plus (+) or minus (-).

The plus (+) sign indicates a distance aft of the datum and the minus (-) sign indicates a distance forward of the datum. If the manufacturer chooses a datum that is at the most forward location on an aircraft (or some distance forward of the aircraft), all the arms will be plus (+) arms.

Location of the datum at any other point on the aircraft will result in some arms being plus (+), or aft of the datum, and some arms minus (-), or forward of the datum.

The arm of each item is usually included in parentheses immediately after the item's name or weight in the specifications for the aircraft, e.g., seat (+23). When such information is not given, it must be obtained by actual measurement. Datum, arm, CG (Center of Gravity), and the forward and aft CG limits are illustrated in **Fig. 16-2**.

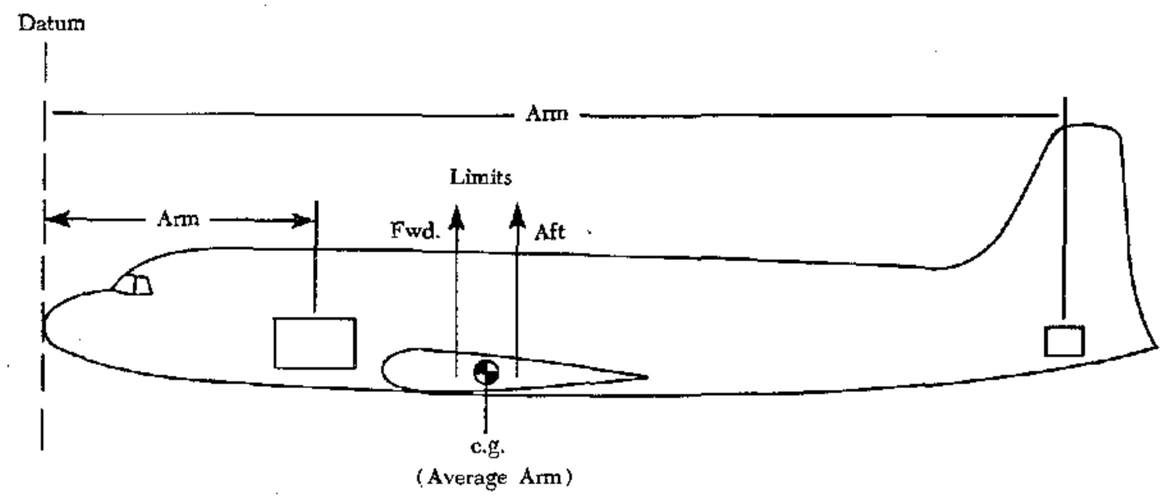


Figure 16-2. Datum, arm, CG, and CG limits

The Moment

A moment is the product of a weight multiplied by its arm. The moment of an item about the datum is obtained by multiplying the weight of the item by its horizontal distance from the datum. Likewise, the moment of an item about the CG can be computed by multiplying its weight by the horizontal distance from the CG.

7.16.1B. AIRCRAFT WEIGHT AND BALANCE

Weighing an Aircraft

Weighing an aircraft is a very important and exacting phase of aircraft maintenance and must be carried out with accuracy and good workmanship. Thoughtful preparation saves time and prevents mistakes.

To begin, assemble all the necessary equipment, such as:

1. Scales, hoisting equipment, jacks, and levelling equipment;
2. Blocks, chocks, or sandbags for holding the airplane on the scales;
3. Straightedge, spirit level, plumb bobs, chalk line, and a measuring tape;
4. Applicable Aircraft Specifications and weight and balance computation forms.

If possible, aircraft should be weighed in a closed building where there are no air currents to cause incorrect scale readings. An outside weighing is permissible if wind and moisture are negligible.

Preparation of Aircraft for Weighing

Drain the fuel system until the quantity indication reads zero, or empty, with the aircraft in a level attitude. If any fuel is left in the tanks, the aircraft will weigh more, and all later calculations for useful load and balance will be affected. Only trapped or unusable fuel (residual fuel) is considered part of the aircraft empty weight. Fuel tank caps should be on the tanks or placed as close as possible to their correct locations, so that the weight distribution will be correct.

In special cases, the aircraft may be weighed with the fuel tanks full, provided a means of determining the exact weight of the fuel is available. Consult the aircraft manufacturer's instructions to determine whether a particular model aircraft should be weighed with full fuel or with the fuel drained.

If possible, drain all engine oil from the oil tanks. The system should be drained with all drain valves open. Under these conditions, the amount of oil remaining in the oil tank, lines, and engine is termed residual oil and is included in the empty weight. If impractical to drain, the oil tanks should be completely filled.

The position of such items as spoilers, slats, flaps is an important factor when weighing an aircraft. Always refer to the manufacturer's instructions for the proper position of these items.

Unless otherwise noted in the Aircraft Specifications or manufacturer's instructions, hydraulic reservoirs and systems should be filled; drinking and washing water reservoirs and lavatory tanks should be drained; and constant-speed-drive oil tanks should be filled.

Inspect the aircraft to see that all items included in the certificated empty weight are installed in the proper location. Remove items that are not regularly carried in flight. Also look in the baggage compartments to make sure they are empty.

7.17 AIRCRAFT HANDLING AND STORAGE

Aircraft maintenance engineers devote a portion of their aviation career working with ground support equipment and ground handling of aircraft. The complexity of support equipment and the hazards involved in ground handling of expensive aircraft require that maintenance engineers possess a detailed knowledge of safe procedures used in aircraft servicing, taxiing, run-up, and in the use of ground support equipment.

Movement of Aircraft

Movement of large aircraft on an airport and about the flight line and hangar is usually accomplished by towing with a tow tractor (sometimes called a "mule or tug"). In the case of small aircraft, most moving is accomplished by hand, by pushing on certain areas of the aircraft surface. Aircraft may also be taxied about the flight line, but usually only by certain qualified persons.

Towing of Aircraft

Towing aircraft can be a hazardous operation, causing damage to the aircraft and injury to personnel, if done recklessly or carelessly. A general procedure for towing aircraft is described further however; specific instructions for each model of aircraft are detailed in the manufacturer's maintenance instructions and should be followed in all instances.

Before the aircraft to be towed is moved, a qualified man must be in the cockpit to operate the brakes in case the tow bar should fail or become unhooked. The aircraft can then be stopped, preventing possible damage.

Some types of tow bars available for use in general aviation (**Fig. 17-1**) can be used for many types of towing operations.

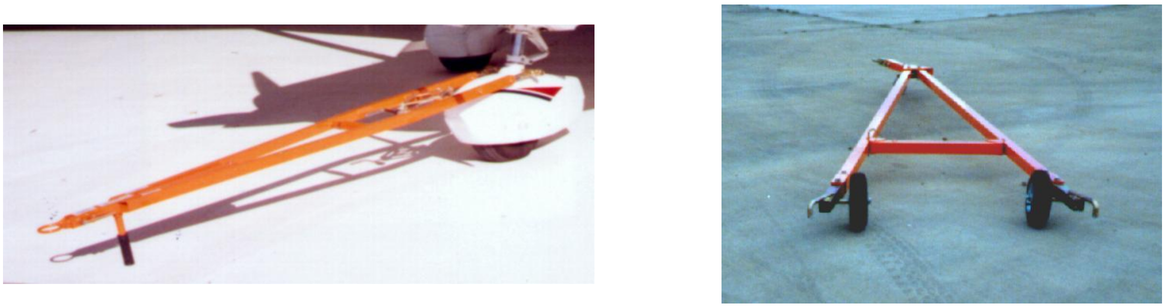


Figure 17-1. A general aviation tow bar

These bars are designed with sufficient tensile strength to pull most aircraft, but are not intended to be subjected to torsional or twisting loads. Although many have small wheels that permit them to be drawn behind the towing vehicle going to or from an aircraft, they will suffer less damage and wear if they are loaded aboard the vehicle and hauled to the aircraft. When the bar is attached to the aircraft, all the engaging devices should be inspected for damage or malfunction before moving the aircraft.

Care should be taken to identify the aviation fuel and lubricating oil dispensed from each refuelling unit before beginning the actual servicing.

A check should also be made to see that all radio equipment and electrical switches not needed for the fuelling operation are turned off, and nonessential outside electrical sources are not connected to the aircraft. A member of the crew then makes sure that both the aircraft and the truck are properly grounded to prevent sparks from static electricity.

Before starting overwing refuelling:

1. Bond the refuelling vehicle or cabinet to aircraft bonding point;
2. Bond the refuelling nozzle clip to the aircraft bonding point;
3. Remove the fuel tank cap (if there is a handle on the cap, turn it in anti-clockwise direction or to OPEN);
4. Insert nozzle and fill the desired quantity;
5. Tanks are filled to maximum capacity when the fuel level reaches the bottom pf the filer port skirt. No additional fuel must be added above this level;
6. Remove the nozzle and the bonding clip.
7. Replace the refuel cap with the arrow pointing forward;
8. Rotate the cap handle to CLOSED position;
9. Lock the filler cap by pushing the handle down to the flat in it's access;
10. Ensure that the fuel load is correct;
11. Disconnect the bonding cable from the refuelling vehicle.

Pressure Fuelling

Figure 17-17. Pressure fuelling (single-point or underwing)

Pressure fuelling is used on most modern and commercial aviation aircrafts. This fuelling process sometimes referred to as single-point or underwing fuelling (**Fig. 17-17**) greatly reduces the time required to service large aircraft.

the lighter executive twin-engine aircraft. Much higher load capacity is required for the heavier transport-type aircraft.

Do not depend on the weight of the multiengine aircraft to protect it from damage by windstorms. It is possible for a sudden, severe windstorm to move, damage, or even overturn such aircraft.

Multiengine aircraft should, therefore, always be tied down and chocked when left unattended for any length of time. Gust locks should be used to protect control surfaces. If the landing gear uses down lock safety pins, these pins should be inserted at the time the aircraft is being secured.

Cold Weather Suggestions

When an aircraft is to be exposed to extreme cold for any length of time, extra care should be taken to see that the aircraft is prepared for winter. All covers for engines, air-conditioning system intakes, pitot and static system openings, and ram air inlets should be installed to prevent snow and ice accumulations. Small covers should be conspicuously marked or tagged so that they are not likely to be overlooked before flight.

If the aircraft is to be parked in snow or ice conditions, it sometimes saves time and man-hours to paint around doors and frequently opened access panels with one of the inhibited glycol antifreeze compounds. The glycol may be painted on surfaces under snow covers to prevent the cover freezing to the surface. It can also be used full strength on wing or tail surfaces themselves to prevent frost. However, if snow is expected, painting exposed surfaces is rarely useful, since the slush that forms will be more troublesome than dry snow.

Another timesaver can be parking the wheels on planking rather than on ice or packed snow, or when sleet or slush may be expected to freeze tires to the ground. Sand can be used for such a purpose but should be confined to wheel areas and not distributed where it may be drawn into the engines on starting.

Flaps and spoilers should be retracted. Aircraft with movable horizontal stabilizers should have them set at approximately zero. All water and waste systems should be drained or serviced with an antifreeze solution when applicable.

If an aircraft is to be parked for a long period of time, leaving a window partially open will permit circulation of the air inside and help prevent frosting of the windows. The best way to remove snow is to sweep off as much as possible. One method is to throw a line over the fuselage and drag the snow off. A brush or broom can be used on wing and tail surfaces. Do not damage vortex generators on aircraft that have them.

A certain amount of snow may freeze to the aircraft surfaces which cannot be brushed off. It is important that all surfaces are entirely free of ice, snow, or frost before takeoff.

Most commercial facilities have spray equipment for applying de-icing fluids, which are usually diluted with water and sometimes heated. Glycol antifreeze compounds, often identified by military specification numbers, have been materially improved. The compound recommended for commercial use is MIL-A-8243A. This is ethylene glycol and propylene glycol in approximately 3:1 ratio, with added corrosion inhibitor and a wetting agent. It has low toxicity, causes no damage to aircraft metals, and has no effect on most plastics, paint, or rubber.

If hot air is used for de-icing, particularly from a ground starter unit, skin areas should not be overheated. A large flow of warm air is more effective than a blast of hot air. Any temperature under the boiling point of water is safe.

Should the last layer of ice or snow be melted from the fuselage, or from the leading edges of the wing, by internal heating from ground sources, the water will probably run down and refreeze in unheated areas, and must be removed. Whatever the de-icing method, inspect the trailing edge mechanism areas of the wing and tail to be sure that water or slush has not run down inside to refreeze.

When conditions warrant, preheating is used on the following sections or parts of the aircraft: accessory section, nose section, Y-drain valve, all oil lines, oil tank sump, starters, instruments, tires, cockpits, and elevator trim tabs.

Check all drain valves, oil tank sumps, oil drains, fuel strainers, vent lines, and all main and auxiliary control hinges and surfaces, for the existence of ice or hard snow. Thoroughly check all de-icing equipment to ensure proper operation. Alcohol tanks must be checked for proper level of de-icing alcohol.

The use of an external heater is permissible at temperatures below 0° C. for heating oil and engine(s). If a heater is not available for heating the oil, the oil can be drained, heated, and put back into the system.

When starting a reciprocating engine in cold weather, try to catch the engine on the first starting attempt to prevent ice forming on the spark plugs. If ice should form, remove the spark plugs, bake, and reinstall.

In freezing weather, ice may form on the propellers while the engine is warming up. Using the propeller de-icer (if available) during warm-up eliminates this condition. The turbine engine should be easier to start in very bad weather than the average piston engine. Turbine engines do not require oil dilution, priming, or lengthy warm-up.

Turbine engine compressor rotors should be checked to see that ice has not formed inside. This is particularly necessary when an engine has shut down in driving rain or snow. Be very careful when running engines if icy conditions exist. With icy pavement, chocks slide very easily, and once the aircraft is in motion it is difficult to stop.

7.18A DISASSEMBLY, INSPECTION, REPAIR AND ASSEMBLY TECHNIQUES

Aircraft structural members are designed to perform a specific function or to serve a definite purpose. The prime objective of aircraft repair is to restore damaged parts to their original condition. The function of any damaged part must be carefully determined so that the repair will meet the requirements.

Definition of Defects

Types of damage and defects, which may be observed on parts of assembly, 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 no displacement nor 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 bore or 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 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 will usually be slightly upset
Erosion	Loss of metal from the surface by mechanical action of foreign objects, such as grit or fine sand. The eroded area will be 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. Usually no loss of metal or cracking of surface but generally showing similar appearance

Damage Necessitating Replacement of Parts

Replacement of an entire part is considered when one or more of the following conditions exist:

1. When a complicated part has been extensively damaged;
2. When surrounding structure or inaccessibility makes repair impractical;
3. When damaged part is relatively easy to replace;
4. When forged or cast fittings are damaged beyond the negligible limits.

Visual Inspections

Dimensions

There are a number of places where checking the measurement of a component can establish its serviceability. Landing gear oleo shock struts can be checked for correct inflation, by measuring their extension. If the dimension is less than quoted in the manual, then it may be low on pressure and further checks will be required. These checks are usually only done during line maintenance, with checking of the pressure being required for trouble shooting or hangar maintenance.

Combined hydraulic and spring dampers, fitted to some landing gears, often have one or more engraved lines on the sliding portion of the unit. This can indicate whether the hydraulic precharge is correct or requires replenishment.

Tyres

Tyres have their serviceability indicated by the depth of the groove in the tyre tread. The AMM gives information of what constitutes a worn or damaged tyre. Apart from normal wear, other defects, that can affect a tyre, are cuts, blisters, creep and low pressure. Most tyres can be re-treaded a number of times after they have reached their wear limits, but the re-tread can only be completed if the complete tyre has not been damaged badly.

Creep is the movement of a cover around the rim, in very small movements, due to heavy braking action. This movement is dangerous if the tyre is fitted with a tube, as the movement can tear the charging valve out of the tube, causing a rapid loss of pressure.

To provide an indicator, small white marks are painted across the wheel rim and the tyre side wall cover so, if creep takes place, the marks will split in half and indicate clearly that the tyre cover has moved in relation to the wheel rim.

The installation of tubeless covers has reduced the problem of creep, as the valve is permanently fitted to the wheel. It is still possible for tyres to creep a small amount, but the air remains in the tyre as the seal remains secure. Tyre-inflation devices usually consist of high-pressure bottles fitted with a pressure-reducing valve or a simple air compressor. The pressure a tyre should be inflated to depends on various factors such as the weight of the aircraft.

The correct pressure for a specific aircraft is given in the relevant AMM for the aircraft in question. It is possible for a tyre to lose a small amount of pressure overnight. A pressure drop of less than 10% of the recommended pressure is not unusual, but the exact figures are given in the AMM.

If a tyre is completely deflated with the weight of the aircraft on it, or is one of a pair on a single landing gear leg, which has run without pressure, all the tyres concerned must be replaced due to the possible, unseen damage within the cover. Again the AMM will dictate the conditions.

Various aircraft tyre defects are presented on **Fig. 18-1** and **Fig. 18-2**.

Figure 18-1. Aircraft tyres defects

Defects to aircraft wheels (**Fig. 18-3**) are usually due to impact damage from heavy landings or from items on the runway hitting the wheel rim. Other problems can arise from corrosion starting as a result of the impact damage and the shearing of wheel bolts, which hold the two halves of a split wheel together. Wheels are usually inspected thoroughly during tyre replacement and it is very unusual for serious defects to be found during normal inspections of a wheel.

Brakes

Brake units are normally attached onto the axle of an undercarriage leg, and located inside the well of the main wheels. During braking operation, they absorb large amounts of energy as heat. This results in the brake rotors (**Fig. 18-4**) and stators wearing away and, if become too hot, the stator (**Fig. 18-5**) material may break up.

Figure 18-4. Overheated brake rotor

Figure 18-5. Brake stator plate. Cracks from holes

Inspection of brake units between flights is essential, to check for signs of excessive heating and to ensure that they have not worn beyond their limits. Wear results in the total thickness of the brake

Emergency System Indication

Some systems use protective covers, to prevent inadvertent operation of a switch. These covers are usually held closed by some form of frangible device that will indicate the system has been operated when it is broken. Thin copper wire is, sometimes, used to hold the protective cover closed on fire extinguisher switches (**Fig. 18-9**).

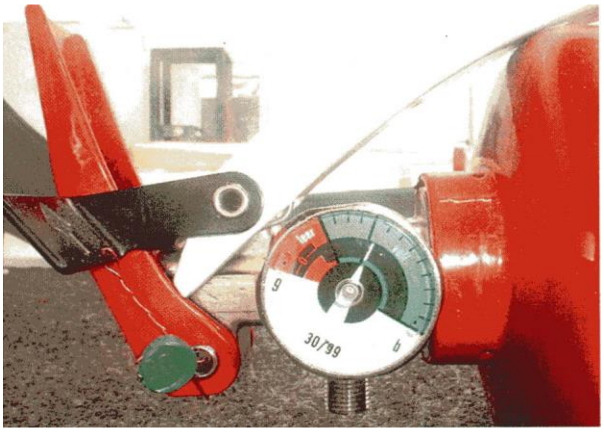


Figure 18-9. Copper „tell-tail“ wire on a hand-held fire extinguisher

A broken wire will indicate that the cover has been lifted and the system may have been operated. Any indication like this must be thoroughly investigated.

Corrosion Removal, Assessment and Re-protection

Locations of Corrosion in Aircraft

Certain locations in aircraft are more prone to corrosion than others. The rate of deterioration varies widely with aircraft design, build, operational use and environment. External surfaces are open to inspection and are usually protected by paint. Magnesium and aluminium alloy surfaces are particularly susceptible to corrosion along rivet lines, lap joints, fasteners, faying surfaces and where protective coatings have been damaged or neglected.

Exhaust Areas **-** Fairings, located in the path of the exhaust gases of gas turbine and piston engines, are subject to highly corrosive influences. This is particularly so where exhaust deposits may be trapped in fissures, crevices, seams or hinges. Such deposits are difficult to remove by ordinary cleaning methods.

During maintenance, the fairings in critical areas should be removed for cleaning and examination. All fairings, in other exhaust areas, should also be thoroughly cleaned and inspected. In some situations, a chemical barrier can be applied to critical areas, to facilitate easier removal of deposits at a later date, and to reduce the corrosive effects of these deposits.

Aluminium alloys form a smooth surface oxidation, which provides a hard shell, that, in turn, may form a barrier to corrosive elements. This must not be confused with the more serious forms of corrosion (**Fig. 18-10**).

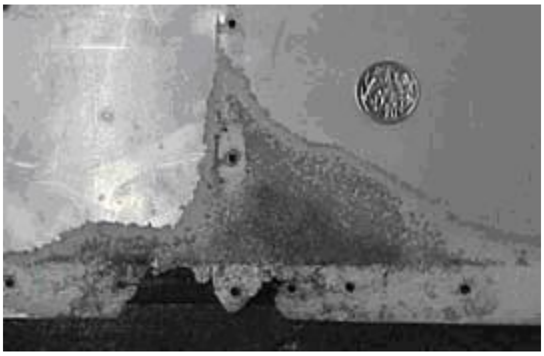


Figure 18-10. Aluminum corrosion

General surface attack penetrates slowly, but is speeded up in the presence of dissolved salts. Considerable attack can take place before serious loss of strength occurs. Three forms of attack, which are particularly serious, are:

- Penetrating pit-type corrosion through the walls of tubing;
- Stress corrosion cracking under sustained stress;
- Inter-granular attack characteristic of certain improperly heat treated alloys.

Treatment involves mechanical or chemical removal of as much of the corrosion products as possible and the inhibition of residual materials by chemical means. This, again, should be followed by restoration of permanent surface coatings.

Alclad

Obviously great care must be taken, not to remove too much of the protective aluminium layer by mechanical methods, as the core alloy metal may be exposed, therefore, where heavy corrosion is found, on clad aluminium alloys (**Fig. 18-11**), it must be removed by chemical methods wherever possible.

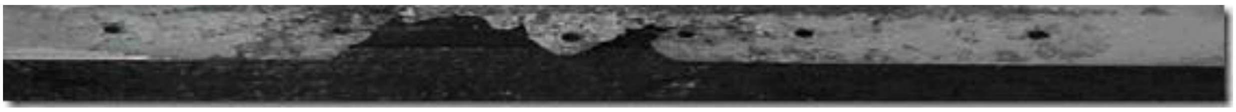


Figure 18-11. Alclad corrosion

Corrosion-free areas must be masked off and the appropriate remover (usually a phosphoric-acid based fluid) applied, normally with the use of a stiff bristled brush, to the corroded surface, until all corrosion products have been removed.

7.18B DISASSEMBLY, INSPECTION, REPAIR AND ASSEMBLY TECHNIQUES

Owing to the difficulty of formulating repair instructions for members or parts of similar size designed to take different loads, the airframe structure has been divided into three classifications:

(a) Primary Structure. These parts of the airframe are highly stressed and, if damaged, may cause failure of the aircraft and loss of life of the aircrew, e.g. spars, longerons, engine mounting, stressed skin, etc. They are sometimes shown in RED (or white in non-colored drawings – **Fig. 18-14**) in repair manuals and drawings.

(b) Secondary Structure. These parts of the airframe are highly stressed but, if damaged, will not cause failure of the aircraft or loss of life of the aircrew, e.g. flooring, which is normally stronger than is necessary and if damaged locally would not collapse. This classification also includes ancillary frames designed to support components such as oxygen bottles, cameras, etc. They are sometimes shown as YELLOW (or hatched in non-colored drawings – **Fig. 18-14**) in repair manuals and drawings.

(c) Tertiary Structure. These are lightly stressed parts such as fairing, wheel shields, minor component brackets, etc. They are often shown in GREEN (or stippled in non-colored drawings – **Fig. 18-14**) in repair manuals or drawings.

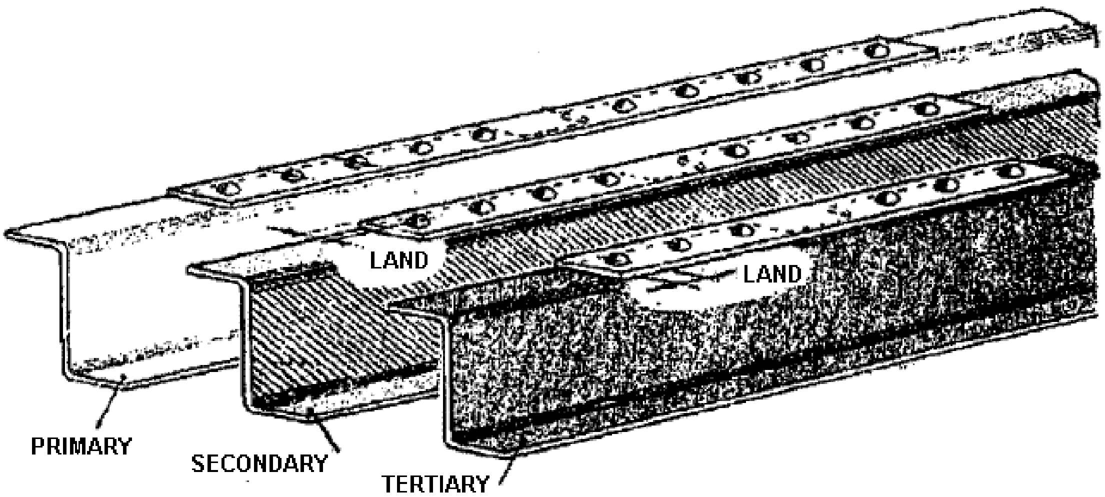


Figure 18-14. Primary, secondary and tertiary structure symbols in black and white

Concerning the whole aircraft (**Fig. 18-15**) the primary structure (shown in white) consists of highly stressed parts of aircraft construction and, if damaged, may cause failure of the aircraft and loss of life of the aircrew, e.g. spars, longerons, engine mounting, stressed skin, etc.
The secondary of the airframe are highly stressed but, if damaged, will not cause failure of the aircraft or loss of life of the aircrew, e.g. flooring, which is normally stronger than is necessary and if damaged locally would not collapse. This classification also includes ancillary frames designed to support

The successfulness of CPCP is determined by the "level" of corrosion found on Principal Structural Elements (PSEs).

<u>Level 1 Corrosion</u>

Corrosion damage occurring ***between successive inspections***, that is local and can be re-worked/blended-out ***within allowable limits*** as defined by the manufacturer (e.g. SRM; SB; etc.); or

Corrosion damage occurring ***between successive inspections***, that is widespread and can be reworked/blended-out ***well below allowable limits*** as defined by the manufacturer; or

Corrosion damage that ***exceeds allowable limits*** and can be attributed to an event not typical of the operator's usage of other airplanes in the same fleet (e.g. Mercury spill); or

Operator experience over several years has demonstrated only light corrosion between successive inspections but latest inspection and cumulative blendout now exceed allowable limit.

<u>Level 2 Corrosion</u>

Corrosion occurring ***between successive inspections*** that requires a single re-work/blend-out which ***exceeds allowable limits***, requiring a repair/reinforcement or complete or partial replacement of a structural component, element or detail listed in the Baseline Program; or

Corrosion occurring ***between successive inspections*** that is ***widespread*** and requires a single blend-out ***approaching allowable re-work limits***.

<u>Level 3 Corrosion</u> [21]

Corrosion found during the ***first or subsequent inspections***, which is determined (normally by the operator) to be an ***urgent airworthiness concern*** requiring expeditious action.

AN EFFECTIVE PROGRAM IS ONE THAT CONTROLS CORROSION OF ALL STRUCTURE LISTED IN THE BASELINE PROGRAM TO LEVEL 1 OR BETTER

Program Application

Maintenance programs for affected airplanes must include a corrosion prevention and control procedures that limit corrosion findings, on all PSEs and other defined structural areas, to LEVEL 1 or better. When an operator does not have a CPCP or an existing CPCP is shown inadequate, the appropriate tasks from the BASELINE PROGRAM must be applied.

In some cases, the Baseline Program may prove inadequate for several reasons such as continuous exposure to adverse operating conditions, leakage of corrosive cargo or an earlier history of

[21] When LEVEL 3 corrosion is found, consideration should be given to action required on other airplanes in the operator's fleet. Details of the corrosion findings and planned action(s) should be expeditiously reported to the appropriate regulatory authority.

Baseline Program Implementation

The Baseline Program is subdivided into specific airplane task areas and locations, each having an Implementation Age (**I**) and Repeat Interval (**R**) for application of the Basic Task. The task areas and locations, which are ***applicable*** to a given airplane, are those where the given airplane age (years since initial delivery) is equal to or greater than (**I**).

Implement each Baseline Program task (***first*** application of the CPCP Task) on all ***affected*** airplanes (airplane age equal to or greater than (**I**)) during any convenient maintenance visit, but prior to the airplane exceeding an age corresponding to (**I**) + (**R**) for each respective task.

*Early implementation of each task is **highly recommended***

For structural items which have been ***completely*** replaced or overhauled, such as a flap track, (**I**) may be calculated from the time the new or overhauled part is installed on the airplane.

Components removed from a currently airworthy airplane, then installed on a different airplane, can be transferred to that airplane's CPCP, provided they are inspected and signed-off by quality control before they are installed on the new airplane. Such components are to be visually inspected from a distance considered necessary to detect early stages of corrosion or indications of other discrepancies such as cracking (e.g., surveillance inspection). If there are indications of hidden corrosion, such as bulging skins, corrosion running into splices or under fittings, etc., additional inspections or partial disassembly is required.

For airplanes that are approaching or have already exceeded (**I**) + (**R**), implement the applicable tasks with a schedule approved by the appropriate regulatory authority.

Fig. 18-23. and **Fig. 18-24.** show associated maintenance planning data used in Corrosion Prevention Program.

Extent of Corrosion

The physical extent of a corrosion is a problem relative to the airplane structure. The common descriptions of corrosion as ***local*** and ***widespread*** corrosion are for general use in areas where no specific description is given.

Local Corrosion

It is a corrosion of a skin or web (Wing, Fuselage, Empennage or Strut) not exceeding one frame, stringer or stiffener bay or, corrosion of a single frame, chord, stringer or stiffener; or, corrosion of more than one frame, chord, stringer or stiffener but, no corrosion on two adjacent members on each side of the corroded member (**Fig. 18-25**).

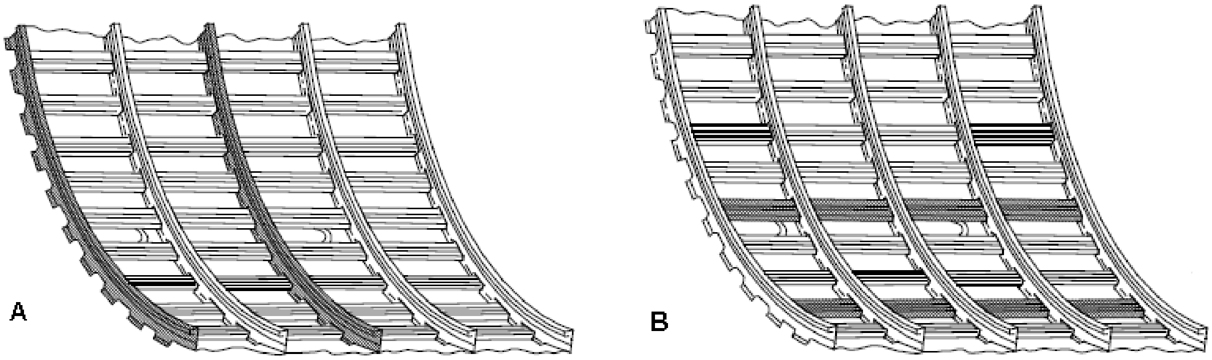


Figure 18-25. Local corrosion occurring in non-adjacent frames (A) and stringers/longerons (B)

Widespread Corrosion

It is a corrosion of two or more adjacent skin or web bays defined by frame, stringer or stiffener spacing; or, corrosion of two or more adjacent frames, chords, stringers or stiffeners; or, corrosion of a frame, chord, stringer or stiffener and an adjacent skin/web bay (**Fig. 18-26**).

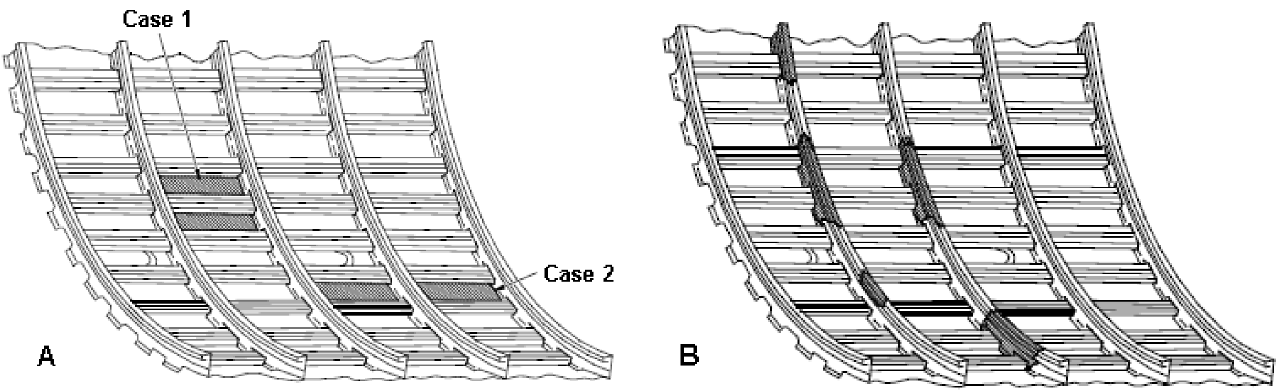


Figure 18-26. Widespread corrosion in adjacent skin panels (A) and frames (B)

7.18C DISASSEMBLY, INSPECTION, REPAIR AND ASSEMBLY TECHNIQUES

There are many defects that cannot be seen by naked eye. Special inspection methods named as non-destructive testing are used to identify such "non-visible" defects.

Non-destructive Testing in the Aerospace Industry

In the aerospace industry, as with other transportation industries, NDT can make the difference between life and death. Aircraft components are inspected before they are assembled into the aircraft and then they are periodically inspected throughout their useful life. Aircraft parts are designed to be as light as possible while still performing their intended function. This generally means that components carry very high loads relative to their material strength and small flaws can cause a component to fail. Since aircraft are cycled (loaded and unloaded) as they fly, land, taxi, and pressurize the cabin, many components are prone to fatigue cracking after some length of time. If you are unfamiliar with the term "fatigue cracking" think about what happens when you bend a paper clip or piece of wire back and forth ...eventually it will break. Even parts that are loaded well below the level that causes them to deform can develop fatigue cracks after being cycled for a long time. This is what happens in aircraft. After they are used for a while, fatigue cracks start growing in some of their parts. Cracking can also occur due to other things like a lightning strike. Aircraft have some protection against lightning strikes but occasionally they occur and can results in cracks forming at the strike location (**Fig. 18-27**).

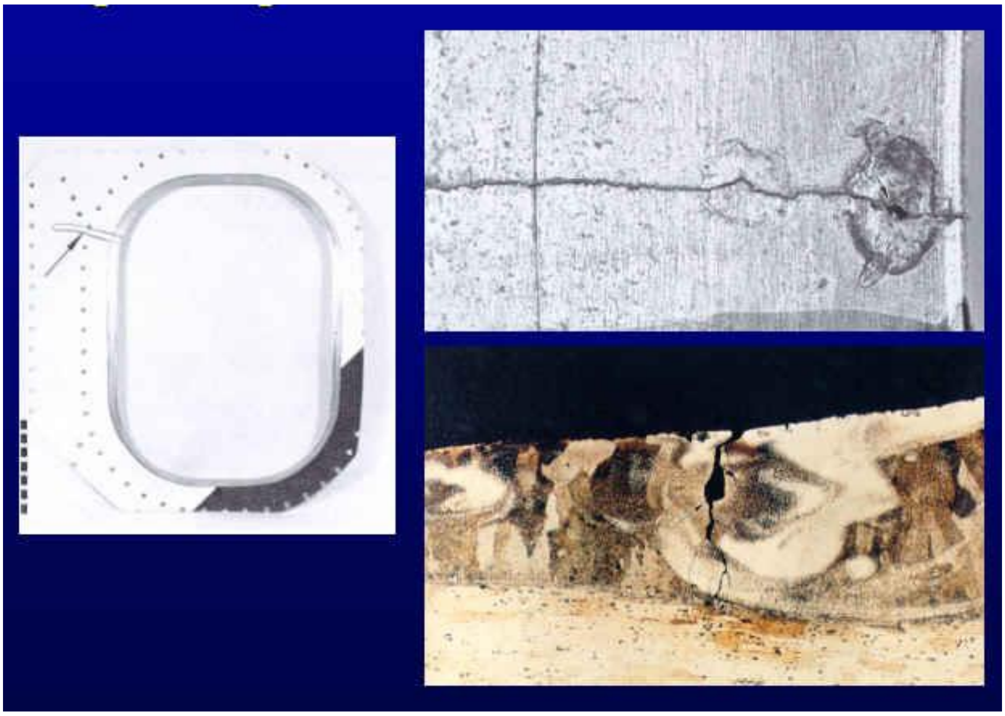


Figure 18-27. Lightning strike effect on aircraft structure

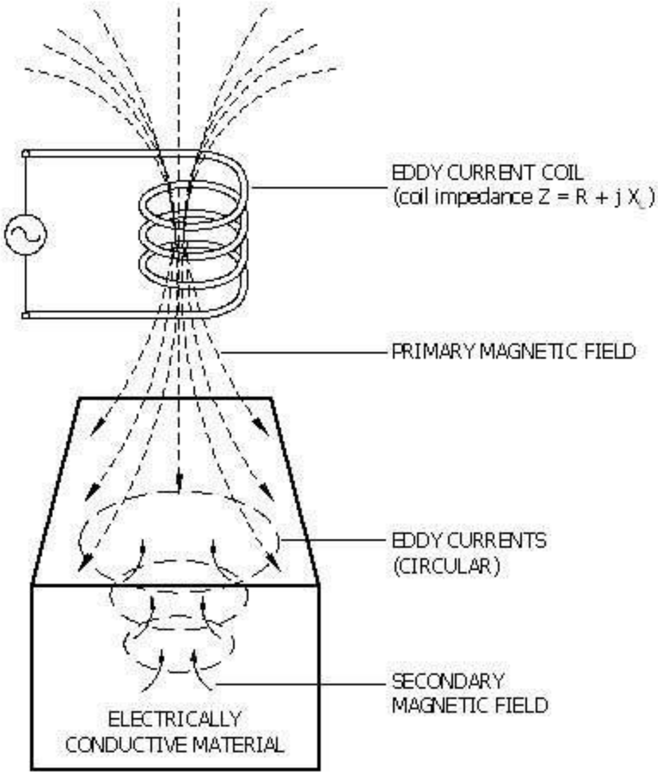


Figure 18.-34. Eddy current inspection

The magnitude and phase of this counter field is dependent primarily upon the resistivity and permeability of the specimen under consideration, and it is the fact that enables us to make a qualitative determination of various physical properties of the test material. The interaction of the eddy current field with the original field results is a power change that can be measured by utilizing electronic circuitry similar to a Wheatstone bridge.

The specimen is either placed in or passed through the field of an electromagnetic induction coil (a probe), and its effect on the impedance of the coil or on the voltage output of one or more test coils is observed. The process-whereby electric fields are made to explore a test piece for various conditions - involves the transmission of energy through the specimen depending of probe construction (**Fig. 18-35**).

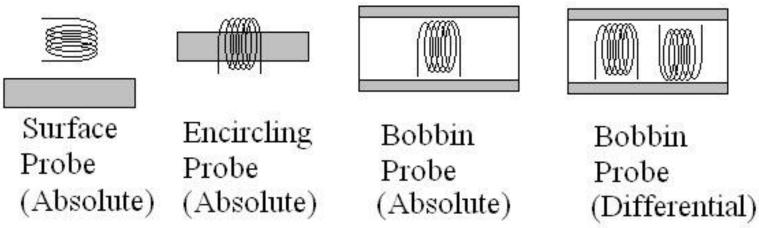


Figure 18-35. Eddy current probes

of precision optical lenses and mirrors, surrounded by a bundle of very fine glass fibre filaments, which guide light to the viewing end of the tube (**Fig. 18-40**).

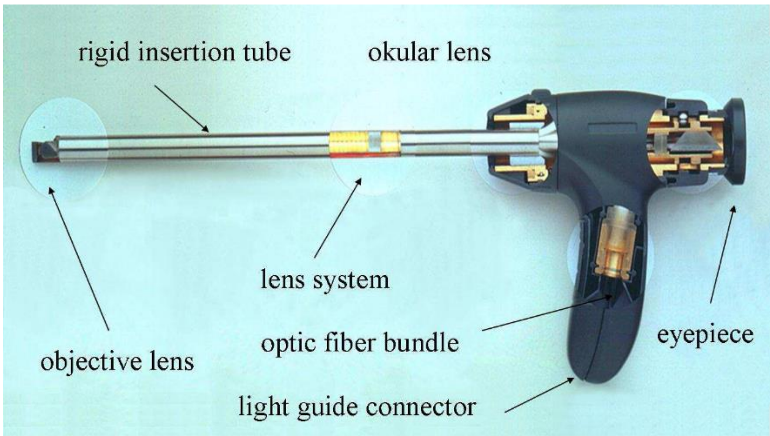


Figure 18-40. Borescope design (rigid tube)

The light is provided by a box, containing an electrical transformer, a high-intensity, light bulb of quartz-iodine, Xenon or something similar (which is mounted in front of a reflector), and a cooling fan. The light source box is usually connected to a mains outlet and the powerful light is transmitted to the borescope by means of a connecting flexible cable which also contains a guide bundle of glass fibres.

In this way „cold“ yet brilliant light is provided at the viewing area, to give the necessary high quality illumination without the hazards associated with heat and any flammable fluids which may be present in the viewing area.

Rigid borescopes are provided with several versions of viewing ends, which allow either a forward view, a lateral view (normal to the longitudinal axis of the tube), a forward oblique or a retrograde (reverse) view of the inspection area (**Fig. 18-41**).

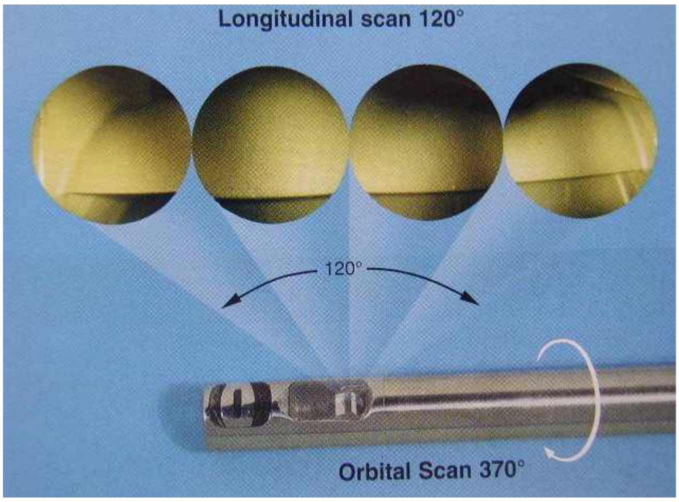


Figure 18-41. Scanning possibility of borescope

7.18D DISASSEMBLY, INSPECTION, REPAIR AND ASSEMBLY TECHNIQUES

Disassembly and re-assembly, in the terms of aircraft, can cover a range of activities from complete airframes down to component maintenance, with several steps in between. The reasons for dismantling and re-assembly may include:

- Complete airframe disassembly for road/air shipment;
- Replacement of major components/modules;
- Replacement of minor components/modules;
- Disassembly & re-assembly of major components;
- Disassembly & re-assembly of minor components.

Complete Airframes

It may be necessary to dismantle a complete aircraft for the purpose of transportation by road or by air. This could be for recovery from an accident site, remote from the airfield or for movement of the aircraft when it is totally non-airworthy, due perhaps to severe corrosion or an unknown maintenance history.

Because many larger, modem aircraft are manufactured at several different locations, the completed modules are assembled in the final build hall of the primary manufacturer. The joining points are often known as „transportation joints", and, in extreme instances, can be the points where the aircraft may be dismantled again to allow transportation.

The instructions for the dismantling operation will be found either in the aircraft's Maintenance Manual or in a special dismantling procedure, issued by the manufacturer. During the dismantling operation, precautions must be taken to prevent injury and damage. General precautions would include such items as:

- The aircraft should, if at all possible, be dismantled within a hangar. If this is not possible, then level and firm ground will suffice;
- Sufficient clearance in the hangar must be available, both to clear the airframe when on jacks, and to allow heavy lifting cranes enough room to manoeuvre over the aircraft;
- All precautions, in accordance with the manufacturer's instructions, must be taken prior to the aircraft entering the hangar; such as de-fuelling and the removal of devices such as emergency oxygen canisters;
- When the aircraft is jacked-up, all trestles must also be placed in position. This allows the aircraft to be climbed upon and, later, ensures that it will not overbalance when a major part (such as a wing), is removed.

The removal of nuts from bolts is normally accomplished using a socket and wrench set and these sockets can be of the twelve-point or six-point type. When spanners need to be used, preference should be given to a ring spanner rather than an open-ended spanner.

Adjustable spanners or „mole grips“ should never be used on aircraft!!!

The manufacturer of the aircraft often specifies special tools, when standard tools are unable to complete the task. Unless approved to do so, the technician should never substitute conventional tools for the special tools that are called for in the manual. Damage to the part being worked upon will almost always result from the use of incorrect tools.

"Murphy's Law"

This "law" states that:

If a part or component can be installed incorrectly, someone, somewhere will install it that way

There are numerous solutions in the fight against this problem. For example, when a pair of pipes or hoses are to be joined, there is the risk of the two pairs of couplings being „cross connected“. This could result in serious damage if the pipes carried fuel and hydraulic oil.

To prevent this happening, pipes and couplings usually have different diameters. Alternatively, the two sets of couplings would be located at different places, so the pipes could not be wrongly connected under any circumstances.

The same logic is applied to control cables that, of course, must also never be cross-connected. In this instance, the turnbuckles are located at slightly different locations at each cable break, again making it impossible to connect the wrong pair of cables together.

7.18E DISASSEMBLY, INSPECTION, REPAIR AND ASSEMBLY TECHNIQUES

Many manuals have troubleshooting sections, or there is a separate Troubleshooting Manual (TSM), which take you through the logical and best fault finding diagnosis to ascertain what is wrong. If no troubleshooting process is available then a logical approach must be adopted, a typical thought process to arrive at best means of finding the defect in the minimum of time and with the minimum of cost, is as follows:

- Gather all the information available, the more information you have the quicker a solution will be forthcoming. The sources of information could be the aircraft technical log book, results of carrying out a test such as a ground run, fully understanding how the item/system works is also essential. So time gathering this information is time well spent
- Having analysed this information a strategy can be evolved. This information will give a starting point and quite often point to the most likely cause of the problem.

For example you have an aircraft that is suffering from nose-wheel shimmy. Now you could start by changing the nose leg and this would probably solve the problem, but hardly the most cost effective in time and money.

A more practical way of solving the problem is a follows:

- Read the aircraft technical logbook and if possible speak to the pilot, he should be able to tell you when this problem occurs and under what conditions;
- Check the manual for any troubleshooting charts, and if there is one apply the information you have gathered, to discover a possible cause;
- If there is not a troubleshooting chart apply a logical approach and inspect the nose-leg gear for an obvious cause, such as badly worn wheel (especially on twin nose-wheel configuration), are there signs of it recently being lubricated, wear in the torque links, is the shimmy damper secure or damaged and so on.

If nothing obvious is found, you will have to start with what you believe to be the most obvious or likely cause of the defect in this scenario the tire being worn or out of shape is the most common cause of this defect.

Jack the nose up in accordance with the AMM. Spin the wheel and watch it go round to see if it is out of shape, also take this opportunity to check for wear in the bearings of the torque links, shimmy damper, steering collar etc.

If again there is nothing obvious, replace the wheel(s) or perhaps lubricated the leg and ask for further report from the pilot as there is no way you can prove you have fixed the problem.

If the aircraft returns and there is no wheel shimmy then the problem is resolved. If not you have eliminated the most likely cause and further investigation is required.

7.19A ABNORMAL EVENTS

Lightning is an atmospheric electrostatic discharge. From this discharge of atmospheric electricity, a leader of a bolt of lightning can travel at speeds of 220 000 km/h (140 000 mph), and can reach temperatures approaching 30 000°C (54 000°F). There are some 16 million lightning storms in the world every year.

That means the flying aircraft could meet with a thunderstorm and be subjected by lightning with damage to aircraft structure or electronic components.

During the service life of an aircraft, occasions may arise when landings are made in an overweight condition or part of a flight must be made through severe turbulence. Bough landings are also experienced for a number of reasons.

When these situations are encountered, special inspection procedures should be followed to determine if any damage to the aircraft structure has occurred.

Types of Abnormal Occurrences

The aircraft maintenance manual will normally list the types of abnormal occurrences needing special inspection. The list may vary depending on the aircraft.

The following items are a selection from a typical aircraft:

- Lightning strikes;
- High-intensity radiated fields penetration;
- Heavy or overweight landing;
- Flight through severe turbulence;
- Burst tyre;
- Flap or slat over-speed;
- Flight through volcanic ash;
- Tail strike;
- Mercury spillage;
- Dragged engine or engine seizure.

Inspections Following Lightning and High Intensity Radiated Fields (HIRF)

Lightning Strike

Lightning strikes may have two effects on an aircraft:

- Strike damage where the discharge enters the aircraft and
- Static discharge damage subsequent to the strike.

Strike damage is generally found at the wing tips, leading edges of wings and tail unit and at the fuselage nose. Static discharge damage will usually be found at wing tips, tailing edges and antennae.

In composite (non-metallic) structures (**Fig. 19-3**), solid laminate or honeycomb damage shows as discoloured paint. It also shows as burned, punctured, or de-laminated skin plies. Hidden damage can also exist. This damage can extend around the visible area. Signs of arcing and burning can also occur around the attachments to the supporting structure.

A **B**

Figure 19-3. Lightning strike signs

Lightning has vaporized both resin and fibers in this carbon fiber-reinforced polymer composite (**Fig. 19-3A**) and (**Fig. 19-3B**). The damage zone exhibits micro-cracking and intra-ply delamination.

Aircraft components made of ferromagnetic material may become strongly magnetised when subjected to large currents during lightning strike.

External Components at Risk

A lightning strike usually attaches to the aircraft in Zone 1 and goes out a different Zone 1 area. It can enter the nose radome and go out of the aircraft at one of the horizontal stabiliser trailing edges. External components most likely to be hit are the:

- Nose radome;
- Nacelles;
- Wing tips;
- Horizontal stabiliser tips;
- Elevators;
- Vertical fin tips;
- Ends of the leading edge flaps;
- Trailing edge flap track fairings;
- Landing gear;
- Water waste drain masts;
- Pitot probes.

7.19B ABNORMAL EVENTS

Hard or Overweight Landing Inspection

The structural stress induced by a landing depends not only upon the gross weight at the time but also upon the severity of impact. However, because of the difficulty in estimating vertical velocity at the time of contact, it is hard to judge whether or not a landing has been sufficiently severe to cause structural damage. For this reason, a special inspection should be performed after a landing is made at a weight known to exceed the design landing weight or after a rough landing, even though the latter may have occurred when the aircraft did not exceed the design landing weight.

An aircraft landing gear is designed to withstand landing at a particular aircraft weight and rate of descent. If either of these parameters was exceeded during a landing, then it is probable that some damage has been caused to the landing gear, its supporting structure or elsewhere on the airframe. Overstressing may occur if the aircraft is not parallel to the runway when it lands or if the nose-or tail-wheel strikes the runway before the main wheels.

Some aircraft are provided with heavy landing indicators, which give a visual indication that specified „g“ forces have been exceeded. Long aircraft may have a tail scrape indicator fitted, as a scrape is more likely. In all instances of suspect heavy landings, the flight crew should be questioned for details of the aircraft's weight, fuel distribution, landing conditions and whether any unusual noises were heard during the incident.

The damages related to heavy or hard landing are classified as primary and secondary:

Primary damage	May be expected following a heavy landing, would normally be concentrated around the landing gear, its supporting structure in the wings or fuselage, the wing and tail plane attachments and the engine mountings
Secondary damage	May be found on the fuselage upper and lower skins and on the wing skin and structure

Different aircraft have their own heavy landing procedures. For example, some aircraft, which show no primary damage, need no further inspection, whilst others require that all inspections are made after every reported heavy landing. This is because some aircraft can have hidden damage in remote locations whilst the outside of the aircraft appears to be undamaged.

7.20 MAINTENANCE PROCEDURES

As an aircraft is being designed one of the major considerations that has to be taken into account is that the aircraft will need to be maintained over the course of its life. Many things need to be taken into consideration, but before the aircraft can be issued with a Type Certificate it has to have a maintenance program written which details the various inspections, life of components and the many other requirements necessary to make sure that the aircraft will continue to operate safely.

Maintenance Program and Maintenance Procedures

A maintenance program tells the operator and the maintenance organization what and when things have to be done to an aircraft. It does not tell you how to carry out a particular task that is the purpose of the maintenance manual describing procedures (tasks) required to fulfil the program's requirements.

Large Aircraft and Commercial Air Transport

The term "maintenance program" is intended to include scheduled maintenance tasks the associated procedures and standard maintenance practices.

The term "maintenance schedule" is intended to embrace the scheduled maintenance tasks alone. Every aircraft shall be maintained in accordance with a maintenance program approved by the competent authority, which shall be periodically reviewed and amended accordingly.

The maintenance program must establish compliance with:

- Instruction for continuing airworthiness issued by type certificate and supplementary type certificate holders and any other organization that publishes such data in accordance with EASA Part 21;
- Instructions issued by the competent authority, if they differ from the above, or in the absent of specific recommendations;
- Instructions defined by the owner or the operator and approved by the competent authority if they differ from the above.

The maintenance program shall contain details, including frequency, of all maintenance to be carried out, including specific tasks linked to specific operations. The program must include a reliability programme when the maintenance program is based:

- On maintenance steering group logic;
- Mainly on condition monitoring.

When the aircraft continuing airworthiness is managed by a Part M subpart G organization, the maintenance program and its amendments may be approved through a maintenance program procedure established by such an organization.

Stores that operate within an organisation that is approved by the CAA to operate, with little control or supervision from the CAA, is known as an „Approved Stores“.

An "Approved" Store will contain three main departments:

- A quarantine store, which accepts items from other companies and checks that they are satisfactory;
- A bonded store which takes items from the quarantine store, after approval, and, when requested, issues those components to the servicing technicians;
- An office or administration centre, which keeps adequate files and records, to enable crosschecking of any transaction through the store system.

To gain the necessary approvals to maintain and operate aircraft the company concerned must write an exposition, it is the exposition that will detail a particular company's procedures, in this case their stores procedures. These procedures will be slightly different from one another, but all must meet a minimum standard and have the required facilities to gain an authority's approval.

Storage Procedures, Tagging and Release of Aircraft Components and Materials to Aircraft Maintenance

All orders for aircraft components, materials or services must be authorised by the Chief Engineer or his Deputy, giving full details and costs. All orders must pass through the Head of Department and the Deputy Principal Administration Officer for processing prior to placement.

Order forms are normally issued in triplicate:

1st (top copy) - to Vendor;
2nd - to the department Admin files and
3rd - to Accounts Department.

The Admin file copy has provision for monitoring partial fulfilment, back order situations.

Good Receipt

All aircraft components/materials/services (here after referred to as Items) received are unpacked and laid out with their incoming authorised certificates and subjected to an incoming stores acceptance inspection in accordance with the procedures set out as follows:

- Aircraft components and material from outside contractors will be subjected to inspection of the documentation to ascertain they relate to the original order placed with the supplier/approved organisation for description, correctness of part number and modification status that are recorded on the accompanying authorised certificates before acceptance;

The Acceptance of New Aircraft Components

With regard to the acceptance of new aircraft components by persons issuing the Certificate of Release to Service for the installation of components, or organizations sourcing such components, for incorporation into parts or assemblies for release under a production organization approval, it is required that the responsibilities under the applicable EC Regulations.

This applies to:

- Aircraft which remain subject to national legislation as defined in Articles 1 (2) and 4(2) of EC Regulation No. 216/2008;
- Aircraft not defined as above are subject to EC Regulation No. 748/2012, incorporating Part 21, and EC Regulation No. 1321/2014, incorporating Part-145. The EASA is therefore responsible for guidance regarding these aircraft (EASA aircraft).

Definitions

For the purpose of this acceptance of new components, the following definitions apply:

Aircraft Component	Any new part of an aircraft including a complete powerplant and any operational or emergency equipment
Standard Parts	A part is considered as a standard part where it is designated as such by the Design Approval Holder (DAH) responsible for the product, part or appliance in which the part is intended to be used
Critical	A part for which the failure analysis shows that hazardous effects, or worse, are not to occur at a rate in excess of extremely remote. This can also include parts for which a replacement time, inspection interval, or related procedure is specified in the Airworthiness Limitations section of the manufacturer's maintenance manual or Instructions for Continued Airworthiness

In order to be considered a standard part[25], all design, manufacturing, inspection data and marking requirements necessary to demonstrate conformance of that part must be in the public domain and published as part of a national or international specification.

[25] Parts which are the subject of specific product or equipment approvals such as National Equipment Approvals, grandfathered in accordance with the provisions of paragraph 13 of Article 2 of EC Regulation No. 748/2012, Technical Standard Orders (TSO), Joint Technical Standard Orders (JTSO) or European Technical Standard Orders (ETSO) are not considered as standard parts.

New / Unused Aircraft Components

Any unused aircraft component in storage[28] without an EASA Form 1 up to the effective date(s) for Part-21 that was manufactured by an organisation acceptable to the competent authority at the time may be issued an EASA Form 1 by an appropriately rated maintenance organisation approved under Part-145.

The EASA Form 1 should be issued in accordance with the following subparagraphs which should be included in a procedure within the maintenance organisation manual:

- An acceptance test report or statement should be available for all used and unused aircraft components that are subjected to acceptance testing after manufacturing or maintenance as appropriate;
- The aircraft component should be inspected for compliance with the manufacturer's instructions and limitations for storage and condition including any requirement for limited storage life, inhibitors, controlled -climate and special storage containers. In addition or in the absence of specific storage instructions the aircraft component should be inspected for damage, corrosion and leakage to ensure good condition.
- The storage life used of any storage life limited parts should be established.

If it is not possible to establish satisfactory compliance with all applicable conditions specified the aircraft component should be disassembled by an appropriately rated organisation and subjected to a check for incorporated airworthiness directives, repairs and modifications and inspected/tested in accordance with the manufacturers maintenance instructions to establish satisfactory condition and, if relevant, all seals, lubricants and life limited parts replaced.

On satisfactory completion after reassembly an EASA Form 1 may be issued stating what was carried out and the reference of the manufacturers maintenance instructions included.

[28] It should be understood that the release of a stored but unused aircraft component in accordance with this paragraph represents a maintenance release under Part-145 and not a production release under Part-21. It is not intended to bypass the production release procedure agreed by the Member State for parts and subassemblies intended for fitment on the manufacturers own production line.

Used Aircraft Components Removed from a Serviceable Aircraft

Serviceable aircraft components removed from a Member State registered aircraft may be issued an EASA Form 1 by an appropriately rated organisation subject to compliance with:

- The organisation should ensure that the component was removed from the aircraft by an appropriately qualified person;
- The aircraft component may only be deemed serviceable if the last flight operation with the component fitted revealed no faults on that component/related system;
- The aircraft component should be inspected for satisfactory condition including in particular damage, corrosion or leakage and compliance with any additional manufacturer's maintenance instructions;
- The aircraft record should be researched for any unusual events that could affect the serviceability of the aircraft component such as involvement in accidents, incidents, heavy landings or lightning strikes. Under no circumstances may an EASA Form 1 be issued if it is suspected that the aircraft component has been subjected to extremes of stress, temperatures or immersion which could effect its operation;
- A maintenance history record should be available for all used serialised aircraft components;
- Compliance with known modifications and repairs should be established;
- The flight hours/cycles/landings as applicable of any service life limited parts including time since overhaul should be established;
- Compliance with known applicable airworthiness directives should be established;
- Subject to satisfactory compliance with these paragraphs, an EASA Form 1 may be issued and should contain the information as specified above including the aircraft from which the aircraft component was removed.

Serviceable aircraft components removed from a non Member State registered aircraft may only be issued an EASA Form 1 if the components are leased or loaned from the maintenance organisation approved under Part-145 who retains control of the airworthiness status of the components. An EASA Form 1 may be issued and should contain the information including the aircraft from which the aircraft component was removed.

Interface With Aircraft Operation

Regulation 965/2012

There are many links between aircraft maintenance and the flying done by both commercial and private operations. These links, or interfaces, include the legislation that dictates how the two operations are to work together. For the larger commercial companies, all the legislation is currently laid down under Regulation (EU) 965/2012.

This Regulation controls many facets of commercial flying. This can include how the company maintains its aircraft, (or how it sub-contracts the work elsewhere); how the documentation and publications record all the information needed for both the engineers and the flight crew and how the quality of the whole operation is kept to an acceptable standard.

Technical Log and Log Books

The communication of information between maintenance and flying personnel is nonnally via a number of different publications such as:

- The Technical Log Book (Tech. Log);
- The Log Books (Aircraft, Engine and Propeller);
- The Modification Records.

The Tech. Log contains all details of the sector by sector flight operations, such as flight times, defects, fuel (on arrival and uplifted), other ground maintenance and replenishments.

The Log Books are usually kept within the records department, but they are a long term record of not only the total flying hours, but of the life remaining on engines and propellers and the maintenance checks done on the aircraft.

The Modification Records allow all to see what changes (modifications), have been embodied to the aircraft. These changes might require different flight operations or maintenance actions than prior to their embodiment.

Other publications that can be used by both sections include:

- The Minimum Equipment List (MEL) and
- Configuration Deviation List (CDL).

These publications inform both the crews and the engineers which components and parts can be unserviceable, and yet allow the aircraft to be dispatched.