Part 5 Systems and Equipment

Leaflet 5-1 Fire – General Precautions

1 Introduction

This Leaflet deals with fire precautions during maintenance and engine running and indicates some of the maintenance and inspection procedures concerned with fire prevention. Some general information on the causes of aircraft fires is also included. The Leaflet should be read in conjunction with the relevant manuals for the aircraft concerned, the Factories Act and any local regulations concerning the prevention of fire. CAP 748[1] gives guidance on the fire prevention measures which should be taken when fuelling and de-fuelling aircraft.

2 Prevention of Fire on the Ground

2.1 Personnel engaged in the maintenance, overhaul and repair of aircraft, should be fully conversant with the operation of fire protection equipment provided and the action to be taken in the event of discovering a fire. Supervisors should satisfy themselves that all reasonable safety precautions are taken and that all apparatus is completely serviceable. Personnel should not wear footwear with exposed iron or steel studs, nails or tips in hangars, fuelling and de-fuelling areas and aircraft movement areas and it is recommended that matches or other means of ignition should not be carried.

2.2 **Fuelling Operations**

2.2.1 Personnel concerned with fuelling should be fully conversant with the guidance material in CAP 748, with local aerodrome instructions and with the safety precautions detailed in the relevant aircraft Maintenance Manual. Fuelling should only be carried out at a site approved by the aerodrome authority and the precautions outlined in paragraphs 2.2.2 to 2.2.8 should be observed.

2.2.2 **Fuelling Zones**

Fuelling zones should be established before fuelling commences. These zones should be regarded as extending at least 6 m (20 ft) radially from the filling and venting points on the aircraft and fuelling equipment. Within this zone, smoking, the use of naked lights and the operation of switches which are not of an approved pattern should be forbidden:

a) Unless fuelling takes place in a designated no smoking area, 'No Smoking' signs should be displayed not less than 15 m (50 ft) from the fuelling equipment and aircraft tank vents.

b) Auxiliary Power Units (APUs) which have an exhaust discharging into the zone should, if required to be in operation during fuelling, be started before filler caps are removed or fuelling connections made. If an APU is stopped for any reason during a fuelling operation it should not be started again until fuelling has ceased and there is no danger of igniting fuel vapours.

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1. CAP 748 is available on the CAA web site at www.caa.co.uk under the Publications section. Paper copies are available from the CAA's printers whose details are given on the inside cover of this publication.

c) Ground Power Units (GPUs) should be located as far as practical from aircraft fuelling points and vents and should not be connected or disconnected while fuelling is in progress.

d) Fire extinguishers should be located so as to be readily accessible.

2.2.3 **Precautions Prior to Fuelling**

Before the transfer of fuel commences, the following procedure should be carried out:

a) The aircraft should be connected to an effective earthing point and to the fuelling equipment.

b) When overwing fuelling, the nozzle of the hose should be bonded to the aircraft structure before removing the tank filler cap. When fuelling from hand-operated equipment, including pumping from cans or drums, similar precautions should be taken to bond the pumping equipment, hose nozzle and containers. If funnels are used they too should be bonded to the nozzle or can and to the aircraft. If a chamois leather filter is used, the funnel and all metal parts securing the leather, should be included in the bonding circuit.

c) When pressure fuelling, the fuel tank pressure relief valves should, if possible, be checked for correct operation and the bonding lead on the fuelling hose should be connected to the receptacle, located adjacent to the fuelling point, before connecting the nozzle.

2.2.4 **Precautions During Fuel Transfer**

a) When overwing fuelling, the amount of fuel required should be determined and the quantity of fuel delivered should be regulated so that no overflow occurs. Fuel should not be splashed nor allowed to run into the aircraft structure.

b) When pressure fuelling, any fuel levelling devices between tanks should be operated as necessary. The correct sequence of operations is essential to avoid damage to tanks and subsequent leakage of fuel or vapour.

2.2.5 **Precautions After Fuelling**

When the transfer of fuel is completed, the bonding wires should not be removed until the filler caps have been refitted or the pressure fuelling hose disconnected, as appropriate.

NOTE: Any cables, clips and plugs used for bonding or earthing, should be maintained in good condition and should be regularly tested for continuity.

2.2.6 **Work on Aircraft During Fuelling**

Whilst fuelling is in progress, servicing, maintenance, test and repair activities within the fuelling zone should be closely controlled.

a) All ground equipment such as trestles, jacks, steps, etc., should be moved clear of the aircraft, to prevent damage to the aircraft as it settles because of the weight of fuel being uplifted.

b) The main aircraft engines should not be operated.

c) Only those electrical circuits essential to the fuelling operation should be switched on, except that some operators may permit certain specified maintenance work to be carried out during kerosene fuelling. The maintenance permitted is usually restricted to the replacement of complete unit assemblies. Testing and functioning of defined systems and equipment may be continued unless fuel spillage occurs or fuelling equipment becomes defective. No maintenance work may be permitted on aircraft using fuels which present a higher degree of fire hazard.

d) Strobe lighting should not be operated.

e) The engines of vehicles normally employed for servicing aircraft, including those on electrically powered vehicles, should not be run within the fuelling zone unless they have been designed for the purpose. All vehicles, their engines and equipment, should be subjected to regular inspection and maintenance to preserve their safety characteristics.

f) All connections between ground equipment and an aircraft should be made before fuelling equipment is connected and should not be broken until fuelling has been completed.

g) Battery trolleys may be used within the fuelling zone provided that connection is made to the aircraft before fuelling equipment is connected. The circuit should remain unbroken until fuelling has ceased.

h) Vehicles operating in the fuelling zone should not pass under or park beneath an aircraft unless specifically required to do so for maintenance or fuelling purposes. A clear exit path should be maintained.

i) Aircraft combustion heaters should not be used.

j) Maintenance work which may create a source of ignition should not be carried out in the vicinity of tanks or fuelling equipment.

k) All hand torches and inspection lamps and their cable connections, used within the fuelling zone, should be of certified 'flameproof' or 'intrinsically safe' type.

l) Only authorised persons and vehicles should be permitted within the fuelling zone and the numbers should be kept to a minimum.

2.2.7 **Special Hazards**

a) Aircraft should not be fuelled within 30 m (100 ft) of radar equipment under test, or in use in aircraft or ground installations.

b) When any part of an aircraft landing gear, i.e. the wheels, tyres and brakes, appears overheated, the Aerodrome Fire Service should be called and fuelling should not take place until the heat has dissipated (see also Leaflet 5–8).

c) Extreme caution should be exercised when fuelling during electrical storms. Fuelling should be suspended during severe electrical disturbances in the vicinity of the aerodrome.

d) The use of photographic flash bulbs and electronic flash equipment within 6 m (20 ft) of the filling or venting points or aircraft or fuelling equipment, should not be permitted.

2.2.8 **Spillage of Fuel**

The actions to be taken in the event of a spillage of fuel will depend on the size and location of the spillage, the type of fuel involved and prevailing weather conditions.

a) If, despite care, fuel is inadvertently spilled in the aircraft structure, it should be cleared before the main aircraft engines are started. Lowering the flaps may accelerate drainage in some cases. Flight should be delayed to permit the evaporation of spillage and air blowers should be utilised as necessary.

b) In the case of a minor spillage of fuel on the ground, all liquid should be mopped up and the area allowed to dry out before starting any aircraft or vehicle engines in the vicinity.

c) In the case of a major spillage of fuel (i.e. covering an area greater than 5 m^2 (55 ft^2)), action should immediately be taken to stop the flow of fuel, to evacuate all persons from the area and to notify the Aerodrome Fire Services.

d) Fuel should not be washed into drains or culverts, but if such contamination does occur, large-scale water flushing should be carried out and the local water authority notified. Absorbent cleaning agents or emulsion compounds should be used to absorb spilled fuel, the contaminated absorbents being placed in suitable containers and removed to a safe location for disposal. The selection of tools and equipment to be used in removing spilled fuel and disposing of contaminated materials should have regard to minimising the risk of ignition.

2.3 **Work in Hangars**

2.3.1 Before commencing any inspection, overhaul or repair work involving the use of possible ignition sources in the vicinity of the fuel tanks, all tanks should be drained. De-fuelling should be carried out in the open air, by means of a fuel tanker utilising the pressure fuelling/de-fuelling connections on the aircraft, or by draining the tanks into suitable containers. In either case, adequate bonding precautions should be taken, the tanker or containers being bonded to the aircraft and the ground before draining commences. Care should be taken to avoid spilling fuel on to the ground and containers should be sealed immediately after filling. To avoid danger from sparking between containers and ground contacts, the aircraft should normally be moved from the site first.

NOTE: If fuel tests (e.g. calibrations, flows, etc.) or draining become necessary inside hangars, then additional precautions are required. Adequate notices should be displayed and fire-fighting personnel should be in attendance. It should be noted that for calibration checks aircraft are usually on jacks to maintain a known datum and could not, therefore, be towed away in the event of a fire.

2.3.2 The draining of fuel tanks does not render them free from fire risk, as they will contain fuel vapour. It is therefore necessary to purge tanks of vapour before subjecting them to inspection or repair involving the use of heat, electrical equipment or other sources of ignition.

2.3.3 Special care is necessary during fuel flow testing and foam or CO_2 type extinguishers should always be available whilst this work is in progress. The use of an enclosed flow test rig is recommended (see paragraph 2.3.1 NOTE).

2.3.4 Electrical equipment used during maintenance work, e.g. portable lighting equipment, electric drills, soldering irons, etc., should be maintained in good condition to avoid generating sparks and should not be used when flammable vapours are present in the atmosphere. For work in areas where heavy fumes are present, e.g. inside fuel tanks, flameproof torches must be used. Care should be taken that no flammable fluid is splashed on naked bulbs or other hot surfaces as spontaneous ignition may follow. Low voltage electrical supplies for inspection lamps, etc., are advantageous.

2.3.5 As far as possible, only non-flammable cleaning fluids and paint strippers should be used, but if the use of solvents giving off flammable vapours is unavoidable, they should be handled with care and if spilt, should be wiped up immediately. During the use of such fluids the aircraft electrical system should be made inoperative with, for preference, the aircraft batteries removed.

2.3.6 In certain aircraft, special battery lead stowages are embodied. These should be utilised in accordance with the appropriate instructions contained in the Maintenance Manual.

2.3.7 The spraying of large surfaces with dope or paint should be carried out in a properly manufactured and equipped spray shop. When touching up small areas, all electrical apparatus worked from a mains supply should be switched off or removed from the vicinity.

2.3.8 Open containers of dirty oil, fuel, dope or solvents should not be stored in aircraft hangars and should be removed from the vicinity of aircraft as soon as possible, otherwise accumulations of flammable vapour may result.

2.3.9 Magnesium and titanium swarf should be completely removed after drilling or machining operations. Special dry powder extinguishants, which are usually known by a trade name, should be used on fires of these combustible metals; water must not be used. The extinguishants form a crust or skin over the burning metal and thus exclude air.

2.3.10 Before permitting the refitting of floor panels or inspection covers, inspectors should ensure that the bays are clean and free from all foreign matter, that all drains are unobstructed and all applications of primers, sealing compounds, etc., in the boxed up area are dry. In addition, all electrical connections, fuse box covers, etc., should be checked and the systems functioned and if the bay houses part of the flying control system duplicate inspection of the flying controls should be carried out before fitting the covers or panels.

NOTE: Fire precautions specified in the Factories Act and in other governmental or local regulations for industrial premises, should always be strictly observed.

3 Maintenance and Fire Prevention

3.1 The following recommendations provide guidance on maintenance practices which will reduce the risk of fires occurring in flight or when ground running engines.

3.2 Powerplant

3.2.1 Faulty assembly or mechanical failure of engines or powerplant components can cause fire and careful inspection is therefore essential to ensure that fractures, cracks or leaks are detected and rectified.

3.2.2 Attention should be given to main engine and APU starter systems and in particular, to ignition harnesses and to high energy igniter plugs and leads in turbine engines. Maintenance instructions must be carefully carried out in accordance with the engine Maintenance Manual.

3.2.3 Pipes carrying flammable fluids are routed by design as far from exhaust systems and electrical apparatus as the installation permits and if disturbed, should be re-installed so that the original distances from such sources of ignition are not reduced. Great care must always be exercised to ensure that pipes are in good condition, are appropriately colour coded and are adequately clipped and bonded and that unions are correctly secured so that leaks cannot occur and that drains are clear. Guidance on the inspection of flexible and rigid pipes is given in Leaflets 5–5 and 5–6 respectively (see also paragraph 3.2.13).

3.2.4 It is most important to trace the source of any flammable fluid leakage and to rectify it immediately. Kerosene, lubricating oil, gasolene and most hydraulic fluids will ignite spontaneously if in contact with hot surfaces, such as exhaust pipes, combustion chambers, jet pipes and overheated brakes. Gasolene at ambient temperatures and kerosene at elevated temperatures will vapourise and form a combustible mixture with air, which may be ignited by sparks from electrical equipment or accumulations of static electricity. Fuel and oil drains should be checked for blockage and the routeing of the pipes must be clear of cowlings and brake systems. Cowlings should be kept clean to obviate accumulations of flammable fluids, greases and dirt.

3.2.5 The flame traps or shutters of air intake systems must always be in good condition. Flame traps will burn if combustible sludge is allowed to accumulate on the gauze.

3.2.6 Grommets or flash plates used to seal openings in firewalls must always be refitted carefully and renewed if damaged. Gaps through or around a firewall are not permitted. Seals must be securely fixed in position, approved sealants should be renewed as necessary and distorted or damaged cowlings must be repaired or renewed.

3.2.7 The powerplant bonding system is an important safeguard against fire and all bonding connections should be inspected frequently according to the recommendations of Leaflet 9–1.

3.2.8 A major failure, such as the fracture of a cylinder or induction manifold on a piston engine (particularly a supercharged engine) is a serious matter, as air/fuel vapour mixture may be discharged and contact a hot surface in the powerplant area, where ignition could occur. Careful visual examination may reveal minor defects before the danger of a complete breakdown arises.

3.2.9 Shortage of coolant in liquid-cooled piston engines will result in overheating with a grave risk of mechanical failure of the engine causing a fire. It follows that careful maintenance of cooling systems is an aid to fire prevention.

3.2.10 Cracked exhaust manifolds, pipes, ejectors, or turbine-engine combustion chambers may allow hot gases or torching flame to impinge on vulnerable parts of the powerplant installation, either causing fire directly or giving rise to mechanical failure which may start a fire. Exhaust systems and combustion chambers should therefore receive very careful examination.

3.2.11 Engine vibration is generally an indication of a serious defect and can also result in the cracking of pipes or leaking of high pressure hoses and loosening of pipe connections.

3.2.12 It is most important that all the appropriate fire precautions are taken during the operation of auxiliary power units whilst the aircraft is on the ground. Intakes and exhausts must be free from obstruction. Temperature and warning indicators should be observed and action taken accordingly.

3.2.13 A contributory cause of fires in engine bays is the saturation of flexible-pipe lagging by flammable liquids. This can occur when the outer covering (e.g. sleeving of neoprene or rubber) has been damaged or has deteriorated, allowing seepage into the lagging. This condition can be detected by blistering or a soggy feel, as distinct from the hard feel of unsaturated pipes. If pipes are in a saturated condition they should be renewed.

3.3 Airframes

3.3.1 Leakage of fuel, hydraulic, de-icing or lubricating fluids, can be a source of fire in aircraft and this should be noted when inspecting aircraft systems. Minute pressure leaks of these fluids may be dangerous, as they could quickly produce an ignitable mixture.

3.3.2 Fuel tank installations should always be carefully examined for signs of external leaks. With integral fuel tanks, the external evidence of a leak may occur at some distance from where the fuel is actually escaping, particularly with kerosene which has particular penetrating properties.

3.3.3 Hydraulic fluids are generally flammable and should not be allowed to accumulate in the structure. Lagging and sound-proofing materials may be rendered highly flammable if soaked with oil of any kind and should be renewed.

3.3.4 All oxygen system equipment must be kept absolutely free from traces of oil, grease or flux, as these substances will ignite spontaneously in contact with pressurised oxygen. Oxygen servicing cylinders should be clearly marked so that they cannot be mistaken for cylinders containing Air, CO_2 or Nitrogen, as explosions and fatal accidents have resulted from these errors during maintenance operations.

NOTE: When a form of lubricant is necessary (e.g. because of a binding thread) the approved or recommended lubricant must be used. Lubricant should be used sparingly to ensure that it does not enter the oxygen system.

3.3.5 Any spillage or leakage of flammable fluid in the vicinity of combustion heaters is a serious fire risk, particularly if any vapour is drawn into the heater and passed over the hot combustion chamber. All safety devices, such as NO-HEAT or OVER-HEAT switches should be inspected at the intervals prescribed in the relevant Maintenance Schedule.

3.3.6 Hot air de-icing and other heating systems should be carefully inspected, particularly on turbine-engined aircraft, where high initial air temperatures exist, to ensure that the ducting and lagging are free from defects.

3.3.7 Pyrotechnical equipment such as signal cartridges, should be renewed if defective in any way. Stowages should not be located in high temperature zones.

3.4 Passenger Smoking Compartments

In these compartments, furnishing materials must be flame-resisting and approved by the CAA. It is important that any gaps or crevices in the flooring and at the free edges of panelling should be sealed and this should be checked at regular intervals. Furnishing materials should also be inspected for grease or oil stains which may tend to propagate a fire and loose covers which have been laundered or dry-cleaned should be re-proofed as necessary. Ash trays must be fitted and a hand-held fire extinguisher of an approved type must be installed.

NOTE: The use of highly toxic extinguishants such as methyl bromide or carbon tetrachloride is prohibited in either crew or passenger compartments. However, in the case of a fire occurring during servicing or maintenance, the toxicity of the extinguishant may be less important, particularly if it is possible to direct the extinguisher through an open door or window into the fuselage.

3.5 Electrical Equipment

3.5.1 As faulty electrical equipment can provide a source of ignition by generating sparks or becoming overheated, attention should be given to the following points:

a) Overheating and eventual destruction of cables can be caused by overloading a circuit. To prevent this, particular care should be taken when installing new fuses or cables to ensure that the design standards as shown on the relevant drawings or manuals are maintained.

b) Overheating of equipment can be caused by poor ventilation. Gauzes may become choked and cooling ducts damaged or disconnected.

c) Electrical sparks from bad commutation in generators or motors and arcing at relays and loose connections, are particularly dangerous. Terminal ends and cover bands must be torque loaded in accordance with the Maintenance Manual and securely locked.

NOTE: There have been cases of short-circuits at terminal positions and special care is necessary to prevent inter-action between circuits at these positions, particularly after any re-orientation of cables and looms. Care is also necessary to prevent arcing and tracking across terminal blocks through the ingress of moisture.

3.5.2 Deterioration of cable insulation can be caused by exposure to fluids such as fuel, hydraulic fluid, oil, etc., or their vapours. Heat and sunlight also have deleterious effects and if exposure is severe or continuous the insulation may eventually break down. Faulty insulation on cables may be the cause of arcing, particularly on heavy duty cables which are attached to movable components or parts, e.g. adjustable lamps, portable apparatus and leads to control columns. Particular care should be taken to ensure that these cables are correctly installed and tested for insulation resistance and freedom from chafing at the prescribed intervals, in accordance with the relevant Maintenance Manual.

3.5.3 Bearing failure in engine-driven rotating equipment may result in friction that could generate sufficient heat to destroy the component and create a serious fire risk.

4 Engine Running Precautions

4.1 General

Fires during engine starting and running can be avoided by observing the correct drill given in the relevant Manuals for the aircraft and engine concerned. General guidance on some important points is given in the following paragraphs:

a) Whilst engines are being started and ground run, fire extinguishing apparatus, preferably of the CO_2 trolley type with extending applicator and under the control of trained and experienced personnel, should be positioned near the aircraft. Additionally, a good communication system should be arranged between the cockpit and ground.

b) Persons in control of engine ground running should be familiar with the approved ground running instructions in the appropriate Manuals and with the correct fire drill procedure.

4.2 Piston Engines

4.2.1 Care should be exercised when priming piston engines preparatory to starting, particularly when an electrical priming pump is used or when priming is carried out by pumping the throttle (to operate the carburettor accelerator pump). Overpriming can cause an excess of fuel in the engine and could result in an intake fire.

4.2.2 When excess-fuel conditions exist and an engine fails to start (a common occurrence when engines are hot), the fuel cock should be turned OFF (or the fuel cut-out closed) and the throttle should be fully opened. After ensuring that all ignition switches including booster coil switches are OFF, the engine should be turned. Most types of engines can be turned in the running direction by the propeller or starter. When this has been done, precautions should be taken to dispel any accumulations of fuel in the exhaust system. On some small engines the propeller can be used to turn the engine in the reverse direction of rotation to expel the over-rich fuel-air mixture through the air intake.

4.2.3 If an air intake fire occurs before the engine picks up, a previously agreed signal should be made to the person at the controls, who should immediately turn off the appropriate engine fuel cock; it is often recommended to continue to motor the engine on the starter so that the burning fuel is drawn into the engine. If the engine picks up and runs, an air intake fire will probably cease without further action, in which case the fuel may be turned on again. Consideration should then be given to any damage which may have been caused to the intake filters by the intake fire.

4.2.4 If an intake fire persists or appears to be serious, a ground CO_2 type fire extinguisher should be discharged into the air intake. Outside action will also be necessary if burning fuel runs from the intake or exhaust on to the ground.

NOTES: 1) The ideal fire extinguishants to use are CO_2 or BCF which will cause no harm to the engine. If CO_2 or BCF have been drawn into an engine no harm should result provided the engine is run or turned over adequately within the next few hours. However, if an extinguishant such as methyl bromide is allowed to remain in the engine, particularly at temperatures below 4°C when it is in a liquid state, it will be necessary to strip the engine to ensure that corrosion has not occurred. If foam has been drawn into an engine the danger of corrosion can be greater. Mechanical foams can leave deposits which may be cleared by hot engine running. Chemical foams can leave deposits which require engine stripping.

2) Mechanical foam is an extinguishant formed by mixing air, water and foam-making liquid.

4.2.5 Should an engine fire occur whilst ground running, the drill given in the appropriate Manual should be followed. To help the person in charge of the ground fire-fighting equipment, any other operating engines should be shut down.

4.2.6 Any practice which promotes accumulation of flammable fluid or vapour inside engine cowlings should be avoided. Exhaust systems must give complete sealing; flanges, gaskets and air intake sealing must be regularly examined and maintained. In shutting-down, engines should first be cooled by running at low power for a short period and fuel cut-outs (if fitted) should be used strictly in accordance with the engine manufacturer’s operating instructions.

4.3 Gas Turbine Engines

4.3.1 The most frequent cause of fire during starting is the accumulation of fuel in the engine and jet pipe following an earlier 'wet start' (i.e. an unsuccessful attempt to start in which the fuel has failed to ignite and has been distributed throughout the engine and jet pipe and drained into the lower combustion chambers and drain system). It is necessary to ensure that the drain system operates correctly and to drain the vent tank (which has a limited capacity), as advised by the manufacturer. It is normal practice to carry out a 'dry run' (i.e. motor the engine through the starting cycle with the fuel and ignition turned off) after a wet start, before making another attempt to start an engine.

4.3.2 As kerosene spreads readily and does not evaporate quickly, a very slight leak is significant and must be remedied. Fuel which may have collected in cavities, cowlings, etc., should be wiped up after maintenance operations before any attempt is made to start the engines.

4.3.3 If there is any indication of an internal engine fire when an engine is not running, the fuel cocks should immediately be turned OFF and every attempt made to localise the fire. An outside assistant should discharge a CO_2 or BCF extinguisher into the intake or jet pipe if necessary.

4.3.4 When starting and running gas turbines, particular note should be taken of the jet pipe temperature. If this exceeds the manufacturer's limitations, a serious risk of mechanical failure followed by fire may result.

4.3.5 The recommendations of paragraph 4.2.5 apply equally to gas turbine engines.

4.4 Engine Nacelle Fire Extinguisher Doors

These engine nacelle doors (British Standard C.6), when fitted, should be maintained strictly in accordance with the aircraft Maintenance Manual. It is important that the doors operate freely inwards and that the beads or lips on the doors will not restrict the removal of the extinguisher nozzle.

Leaflet 5-2 Lifejackets

1 Introduction

This Leaflet provides guidance and advice on the inspection and maintenance of lifejackets, which are required to be carried in certain aircraft operating under conditions specified in the Air Navigation Order (ANO). Owing to the wide variety of lifejackets, the information is of a general nature and does not apply to any particular make or type of lifejacket. The maintenance and servicing of the less common types of survival equipment are very similar to the single inflation chamber type covered by this Leaflet.

2 General

2.1 Lifejackets are designed as lightweight items of equipment and as such should be treated with care. Lifejackets are normally packed in specially made valises or containers for ease of handling and these also protect the lifejacket; they also help to keep the lifejacket correctly folded, to facilitate donning. However, care should be taken not to drop a packed lifejacket or to place loads upon it. Manufacturers often recommend that a lifejacket which has been subjected to such abuse or has been immersed in sea water, should be rejected for further operational use.

2.2 The necessary instructions for fitting lifejackets are displayed in the aircraft and, in many instances, these instructions are repeated in safety pamphlets for distribution to individual passengers. Similar information may also be given on the lifejacket by means of special adhesive labels or stencilling on the surface of the jacket.

2.3 Passenger lifejackets are usually stowed either under seats or armrests. Crew life jackets are stowed in easily accessible positions. Stowages should be kept clean and dry and the stowage retaining device should be checked periodically for security and ease of release.

2.4 Lifejackets which have been used for demonstration by crew members should be returned for inspection as if they were time expired. To ensure that this is always done, the demonstration lifejackets should be kept out of the normal stowage and a suitable warning label should be attached.

3 Lifejackets – General Description

3.1 There are several types of lifejackets in use and all are basically similar. Buoyancy is obtained by inflating the jacket with carbon dioxide (CO_2) gas, which is stored under pressure in a small cylinder and released by means of a manually operated mechanism. A standby mouth inflation valve is also provided in case the CO_2 system is inoperative, or if it is necessary to 'top-up' the pressure after a long period of immersion. To assist rescue operations, lifejackets are equipped with an identification light, battery and a whistle is also provided. Certain types of lifejackets may also carry additional equipment such as fluorescent sea marker dye, shark repellent products and special signalling devices.

NOTE: Care should be taken to avoid unintentional operation of the inflation mechanism. The mechanism cannot be used to stop the gas flow, which will inflate the lifejacket in a few seconds. However, if the lifejacket is inadvertently inflated, means are provided for deflation. This can be effected on some lifejackets by depressing the non-return valve in the mouthpiece, by means of a deflation key stowed next to the mouth inflation valve and secured to the lifejacket by an attachment cord, or by inserting the extension piece moulded on to the side of the valve protection cap.

3.2 Most lifejackets are of the single inflation chamber type as illustrated in Figure 1, but there are others which have more than one inflation chamber, gas cylinder and mouth inflation facility; some aircraft may also carry baby flotation survival cots.

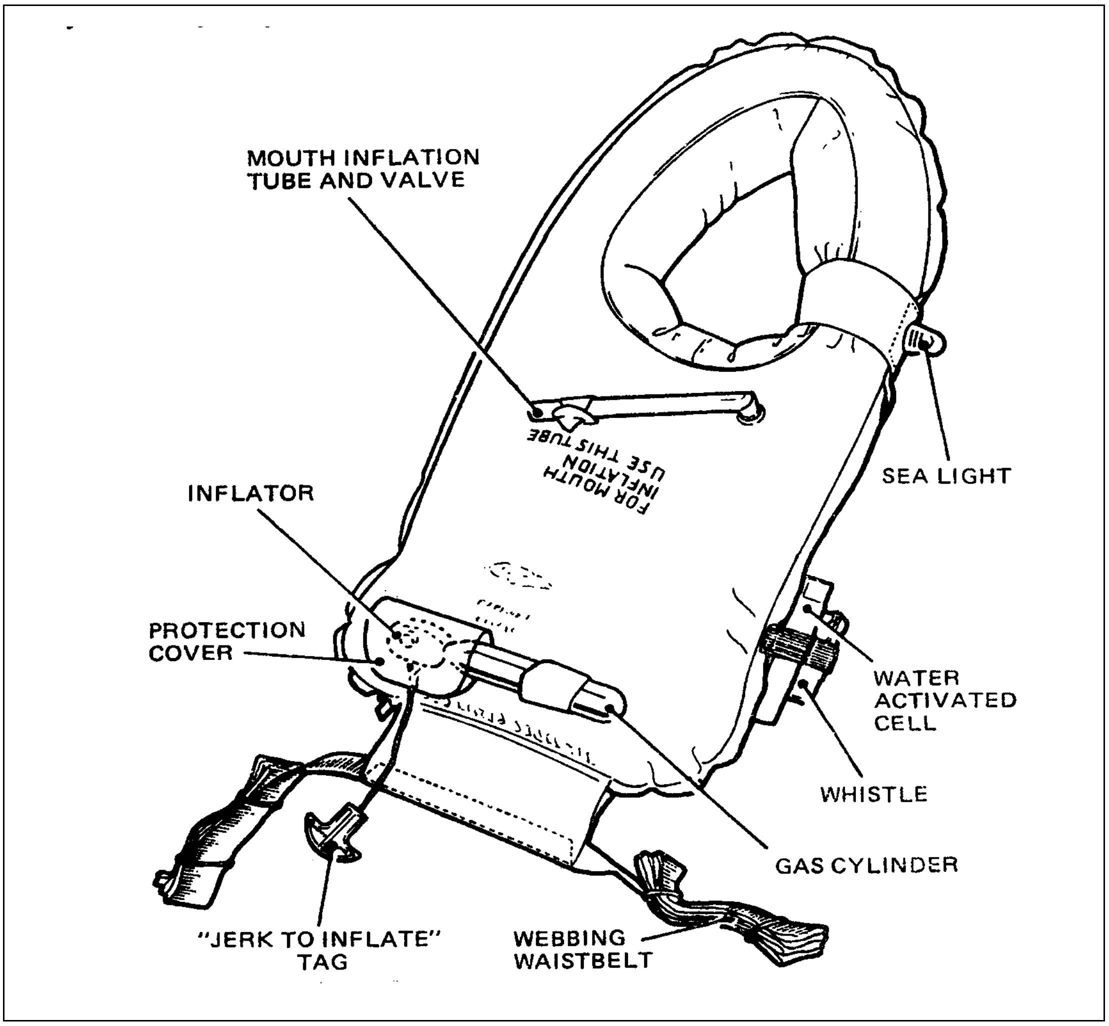

Figure 1 Typical Lifejacket

3.3 The material used for fabricating lifejackets is generally either rubberised cotton or polyurethane coated nylon (coated on either one or both sides), the panels being joined by the use of an adhesive or by welding.

3.4 A light unit is attached to a lifejacket in such a way as to ensure that, when the lifejacket is in use, the lamp assembly will be in a prominent position. The bulb is connected by means of a plastic covered lead to a battery, which is usually water activated and located below the water line. Operation of the battery is achieved by the ingress of water into the cell.

3.5 The operating mechanism into which the CO_2 cylinder is fitted consists of a housing containing a piercing pin which, when pushed forward by a cam-type operating lever, pierces a sealing disc in the neck of the cylinder, allowing gas to flow past a non-return valve into the lifejacket. The piercing pin is actuated by pulling a red knob or tag, which is attached by a cord or chain to the operating lever.

4 Maintenance Requirements

4.1 The appropriate manufacturer's publication will stipulate the periods at which inspections and related tests are required and will also give full details of the inspection and test operations involved. It may stipulate inspection after every 6 months of service life, with a more comprehensive inspection after every 18 months, or it may stipulate a yearly inspection only. Similar information will also be given regarding accessories, such as CO_2 mechanisms, identification lights, inflation valves, etc. The lifejacket and some of the accessories (e.g. CO_2 cylinder), will also have a maximum service or storage life, stipulated in years, which must not be exceeded. All work should be carried out in accordance with the relevant publications and the lifejacket and inflation equipment manufacturers' Service Bulletins, etc. All details of a particular lifejacket, including modifications and inspections and the Inspector's stamp or signature, should be recorded on an Inspection Record kept at the maintenance base.

4.2 **Inspection Facility**

4.2.1 Inspections and tests should be carried out in clean premises kept at stable room temperature. To avoid damage through puncture or abrasion, the inspection tables should have smooth, well finished surfaces free from any wood splinters or sharp corners and the working surfaces should be kept thoroughly clean. Precautions should be taken to avoid any contact with oil, grease or acid.

4.2.2 A rack should be provided from which lifejackets under inflation test can be suspended and a method of referencing should be adopted to relate each lifejacket with the time of inflation and the duration of the test period. The rack should be kept away from direct sunlight or radiated heat.

NOTE: All inflation tests must be carried out under stable temperature conditions.

4.2.3 To trace leaks in lifejackets which have failed to maintain the required test pressure, an immersion tank containing clean water is often used. In other instances, the suspected area is smeared with an acid-free soap solution, all traces of which should be thoroughly removed by rinsing with lukewarm water immediately after test.

4.2.4 Laboratory type scales having an accuracy of 0·1 gramme should be available for cylinder gas-charge checks.

5 Inspections and Tests

5.1 **Lifejacket**

5.1.1 The lifejacket should be withdrawn from its valise, unfolded and equipment such as the CO_2 cylinder, identification light assembly and whistle removed. A check of the serial number marked on the lifejacket and that on the related Inspection Record should be made. All instructions stencilled or labelled on the lifejacket should be examined for legibility. Such information as date of manufacture, modifications embodied, etc., must agree with the Inspection Record.

NOTE: In some instances it may be necessary to clean the lifejacket before inspection. This should be done with lukewarm water and the cleaning agent recommended by the manufacturer.

5.1.2 **Inspection**

The proofed fabric should be inspected for slits, tears, holes, adhesion of seams and general deterioration. Deterioration is seldom immediately apparent and can easily be overlooked. It is vitally important therefore, that a careful inspection for any of the following signs should be made:

a) Discoloured areas (not due to surface dirt which can be washed off).

b) Sticky areas.

c) Hard or stiff areas.

d) Shiny areas.

5.1.3 Webbings, elastics and cordages should be inspected for discoloration, deterioration and security of attachment (e.g. condition of stitching and security of knots).

5.1.4 Metal and plastics components should be inspected for cleanliness, damage or deterioration and security (e.g. adhesion of components to fabric where applicable).

5.1.5 **Inflation Tests**

Inflation tests are required to check a lifejacket for leaks and may be carried out after repairs have been made, to check the buoyancy chamber, or after the gas cylinder has been inspected and reassembled, to check the complete jacket. The lifejacket is inflated using a test rig, which may be connected either to the mouth inflation valve or to the operating head (with the gas cylinder removed), depending on the reason for the test.

NOTE: Before tests are commenced the test equipment should be checked for leaks, especially at the connections.

5.1.6 The initial test consists of inflating the lifejacket to a given pressure and allowing the pressure to stabilise with the air supply disconnected. After a given time, the pressure is checked to ensure that it has not dropped below a specified figure.

NOTE: The lifejacket should not be touched whilst on test as the pressure reading may be affected.

5.1.7 If the initial test is satisfactory, the lifejacket is re-inflated and allowed to stand for a longer test period, after which the pressure should not have dropped below a second stipulated figure.

5.1.8 Whilst the lifejacket is inflated a visual examination should be made for any signs of distortion or damage not revealed before inflation.

5.1.9 If any stage of the test proves unsatisfactory, leakage may be traced by either of the methods outlined in paragraph 4.2.3, when air bubbles will indicate the position of the leaks. Local repairs may often be carried out, but where damage exceeds limits specified in the relevant manual, the lifejacket should be returned to the manufacturer (see paragraph 6).

5.1.10 The mouth inflation valve will also require pressure testing for leaks, either by placing a small amount of water in the mouthpiece or by immersing the valve unit in water and checking for the presence of bubbles. A valve functioning test may be specified; this is done by applying air pressure to the mouthpiece and ensuring that the valve opens at a specified pressure below the working pressure of the lifejacket. If the valve should leak, or if it fails to open at the functioning pressure specified, the following actions should be taken depending on the type of valve:

a) With the type of valve which can be disassembled, this should be done and the valve should be cleaned and its seat checked for deterioration or dirt and then lubricated with a silicone grease specified by the manufacturer. After re-test, if the valve still leaks it should be replaced by a new assembly and again tested.

b) With the type of valve which cannot be disassembled, it should be renewed in accordance with the instructions contained in the relevant Overhaul Manual.

5.2 **Light Unit**

5.2.1 **General**

The life of the light unit is often indefinite, provided that periodic inspections and tests prove satisfactory.

5.2.2 **Inspection**

The battery should be inspected for any signs of damage or deterioration, or for signs of chemical reaction indicated by the presence of a white powdery deposit or bulging of the battery case.

5.2.3 It is also important to ensure that no activation has taken place due to the ingress of moisture. Depending on the design of the battery it is often possible to check for activation visually. With some types this may be done by holding a source of light at the base of the battery case and looking through the water holes at the top. It should be possible to see clearly through the holes but if any activation has taken place the holes will be obstructed.

5.2.4 When fitting water-activated batteries into stowages on the lifejackets, care is necessary to ensure that the instructions regarding the removal of the water sealing plugs or other sealing devices are carefully followed, as they will vary with the type of battery used.

5.2.5 **Electrical Tests**

Electrical tests for the water-activated type of battery are usually prescribed. They often consist of testing with a standard aircraft insulation resistance tester connected across the battery terminals to obtain a specified reading in megohms (e.g. 1 megohm minimum). A milli-voltmeter test is also often acceptable; with the milli-voltmeter across the battery terminals, no voltage should be registered.

NOTE: When testing with a milli-voltmeter, an initial test should be made at a higher scale reading to obviate damage to the meter should the battery be active.

5.2.6 The electrical circuit and the bulb should be checked for electrical continuity and functioning using a slave battery of the correct voltage.

5.3 **Gas Cylinders**

5.3.1 The CO_2 cylinders should be carefully inspected for any signs of damage such as dents, scores or corrosion, which would weaken the cylinder and render it unserviceable and possibly dangerous. The cylinder threads should also be checked for obvious signs of damage.

5.3.2 With the operating mechanism removed, the CO_2 cylinder should be checked for correct gas charge by weighing. Some cylinders are marked with the empty weight and the weight of the gas charge is given in the appropriate publication; later cylinders are marked with the total (charged) weight, e.g. TW. 146. Should the cylinder be found to be outside the weight limitations it should be replaced by a fully charged one.

5.3.3 All CO_2 cylinders are 'lifed' and should be returned to the manufacturer for inspection and test when their life has expired. A code representing the date of manufacture, or the actual date of manufacture of a cylinder, is stamped on its base and this should be checked during inspection.

5.4 **Operating Mechanism**

5.4.1 With the CO_2 cylinder removed, the inspection instructions usually stipulate a functioning check to ensure the correct travel of the piercing pin and in some cases the mechanism is disassembled and all parts cleaned and inspected at specified intervals. Damaged or corroded metal parts and seals or rubber washers showing any signs of deterioration should be renewed if permitted by the manufacturer.

5.4.2 On some lifejackets the operating mechanism is mounted on a rubber base and the unit is bonded to the lifejacket; no attempt should be made to separate this bond. Care is therefore necessary to avoid damage to the attached lifejacket when work is carried out on the operating mechanism.

5.4.3 After reassembly of the operating mechanism a final check should be made to ensure that the operating lever is in the correct position (i.e. cocked) and that the safety retaining device (e.g. break thread or spring clip) has been properly fitted.

5.4.4 In the event of the mechanism having been immersed in sea water, it should be disassembled, checked for corrosion and then thoroughly cleaned to remove all traces of salt deposit.

6 Repairs

6.1 **General**

The parts of a lifejacket which are made from proofed fabric are liable to suffer from damage or deterioration and repair schemes and instructions are often contained in the relevant Overhaul Manual. In the case of lifejackets which are joined by an adhesive, extensive repairs are often permissible within limits specified by the manufacturer, but in the case of lifejackets which are joined by welding, only minor patch repairs are usually permitted. This is because the machine settings have to be predetermined for each tool and type of weld and it is unlikely that a lifejacket servicing facility other than the manufacturer could carry out satisfactory welded repairs.

6.2 **Repair Limitations**

6.2.1 Repairs are carried out by patching with a material identical to or compatible with that used in the original lifejacket, using a self-vulcanising solution as the adhesive. Repairs are to be carried out within the limitations contained in the relevant Overhaul Manual.

6.2.2 Patches should be circular, or rectangular with rounded corners and should overlap any damage by at least 25 mm (1 in). Reinforcing strip should overlap the existing strip by at least 25 mm (1 in) and exterior tape should overlap by 50 mm (2 in).

6.2.3 The repair solution is supplied as a kit and contains a number of ingredients which must be mixed strictly in accordance with the manufacturer’s instructions. Once mixed the solution must be used within a few hours, as it soon becomes unstable.

6.2.4 All tools and utensils used when carrying out repairs, e.g. roller, brushes and spatula, should be kept scrupulously clean and free from abrasions.

6.2.5 In some cases it may be recommended that a test piece should be prepared using the fabric and adhesive used for the repair, in order to check the progress of vulcanisation. At the end of the vulcanising period (2 to 4 days) a portion of the test piece should be peeled apart and a few drops of an appropriate solvent applied to the surface. If vulcanisation is complete the liquid will spread quickly and be absorbed, but if not it will be absorbed slowly and the surface will be tacky.

6.3 Repair Procedure

6.3.1 Because of the different methods of manufacture of lifejackets, damage could be caused by using inappropriate repair procedures. As an example, some fabrics are proofed on the outside only, whilst others are proofed on the inside only; abrading the former is an essential part of the repair procedure, whereas abrading the latter would weaken the fabric and cause further damage. It is essential, therefore, that the manufacturer's instructions concerning the repair of a particular lifejacket are carefully followed and any related safety precautions are observed.

6.3.2 After repairs have been carried out the lifejacket should be tested as outlined in the Overhaul Manual.

7 Final Assembly

7.1 General

After all the inspections, repairs and tests have been satisfactorily completed and before the lifejacket is folded, a careful check should be made to ensure that all the related equipment has been correctly assembled and fitted to the lifejacket in accordance with the instructions for the type concerned.

7.2 Folding

7.2.1 The folding instructions will vary in detail with different types of lifejacket, or in some instances with similar types fitted with different equipment. Care is necessary to ensure that all air has been expelled from the lifejacket before folding.

NOTE: On some lifejackets a deflation key is fitted to the mouth inflation valve to ensure that all air is expelled; this key must be removed before the lifejacket is folded.

7.2.2 After inspecting the valise or container for cleanliness and damage, the lifejacket should be inserted and the closure secured.

7.2.3 A tie-on label giving the serial number of the lifejacket and the date of the next inspection due should be attached, or when a pocket is provided in the valise, a card giving similar information should be inserted.

NOTE: When a tie-on label is used, the quality of the label and the attaching cord should be such that they cannot be damaged or become detached whilst the lifejacket is in service. Some instances have arisen where lifejackets have been transferred from one aircraft to another and the label(s) have become detached. This has necessitated unpacking and checking against the base Inspection Record to ensure that the inspection date had not expired.

8 Storage

Leaflet 1–8, Storage Conditions for Aeronautical Supplies, gives guidance on acceptable conditions for the storage of lifejackets.

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Leaflet 5-3 Carbon Monoxide Contamination

1 Introduction

1.1 This Leaflet describes the nature and effects of carbon monoxide (CO) and outlines the main causes of this type of contamination. It gives only general guidance on the inspections, tests and repairs which should be carried out in order to minimise the dangers of such contamination to crew and passengers and must, therefore, be read in conjunction with the relevant aircraft Maintenance Manuals.

1.2 The harmful effects of contaminants in the air breathed by crew and passengers are recognised in British Civil Airworthiness Requirements (BCAR). It is stipulated in the Requirements that CO should not be present in occupied compartments in quantities exceeding 50 parts/million by volume, for any period exceeding five minutes: maximum allowable concentrations are also prescribed for other noxious substances such as fuel, oil, de-icing and hydraulic fluids, fire extinguishing agents and the fumes given off by other materials when they are heated. CAAIP Leaflet 11-2 and CAP 747 Mandatory Requirements for Airworthiness Generic Requirement (GR) No. 11 deal specifically with CO contamination.

2 The Nature and Effects of Carbon Monoxide

2.1 Carbon monoxide is a gas which is colourless, odourless and tasteless and is therefore impossible to detect by the senses. It is a product of the incomplete combustion of carbonaceous materials and is found in varying amounts in the smoke and fumes emanating from the exhaust systems of aircraft engines and combustion heaters.

2.2 If a person breathes air contaminated by CO, the CO will combine with the haemoglobin in the blood and cause oxygen starvation in the body and brain, thus reducing the person’s normal ability to reason and make decisions. Exposure to even small amounts of CO over a period of several hours can be as dangerous as a short exposure to much larger amounts. At altitude, with a smaller quantity of oxygen in the atmosphere, the susceptibility to CO poisoning is correspondingly increased.

2.3 The presence of CO in the air may often be assumed from the smell of exhaust fumes and from the onset of symptoms such as mild tiredness, a feeling of warmth and tightness across the forehead. These symptoms cannot, however, be relied upon to give adequate warning of CO contamination and a person’s judgement may become impaired by levels of CO in the blood lower than that at which the symptoms normally appear.

3 Causes of Carbon Monoxide Contamination

Carbon monoxide may enter the interior of an aircraft in a number of ways. Defective cabin heating systems of the type which use the engine exhaust pipe as the heat source and combustion heaters which are independent of the aircraft engines, may introduce CO directly into the fuselage through the cabin heater outlets, while the engine and heater exhaust gases may enter from the outside, either on the ground or during flight. Exhaust gas leaking from any part of the engine exhaust system through cracks, or faulty slip joints, gaskets or muffs, can find its way into the aircraft through ineffectively sealed bulkheads, access panels or skin joints and in some cases, particularly during starting, ground-running and taxiing, the gas discharged from the engine exhaust pipes may enter through open windows or cabin fresh-air intakes. During flight, any poorly sealed doors or windows can result in reduced cabin pressure, encouraging exhaust gas to be drawn into the cabin through the lower fuselage or wing roots.

4 Routine Inspections

4.1 The physical inspection of all exhaust system and cabin heating components, of bulkheads and of access panels in the fuselage, should be carried out at the intervals prescribed in the Maintenance Schedule.

4.2 All parts of the engine exhaust system should be inspected for security, warping, dents, cracks and evidence of gas leakage (i.e. overheating or smoke traces) particularly at clips, slip-joints, clamps, expansion joints and heater jackets. Repair or replacement should be carried out in accordance with the manufacturer's instructions.

4.3 Exhaust pipes under heater jackets should be inspected very carefully at the prescribed intervals and whenever CO contamination is suspected. In some cases the heater jacket is detachable and can be completely removed to enable a thorough visual inspection of the exhaust pipe for signs of gas leakage. In cases where the jacket is integral with the exhaust pipe, it is recommended that a pressure test should be carried out by blanking the outlet from the heater jacket and applying air pressure, via a suitable non-return valve, through the inlet; there should be no leakage when the air supply is turned off.

NOTE: The maximum test pressure prescribed in the appropriate Maintenance Manual should not be exceeded, since excessive pressure may damage the jacket and increase the likelihood of crack propagation.

4.4 The procedures for ensuring the serviceability of combustion heaters are outlined in CAP 747 GR No. 11 and detailed in the appropriate manufacturer's and aircraft manuals. The heater exhaust system should be inspected for the defects listed in paragraph 4.2 and the ducting carrying the heated fresh air from the combustion heater to the cabin should be examined for signs of exhaust contamination. Overhauls of heaters should normally be carried out at the prescribed intervals (normally not exceeding two years). In some instances the combustion chambers are required to be pressure-tested at half the overhaul life.

4.5 Engine bulkheads and the bulkheads isolating combustion heaters, are designed to prevent the transmission of flame, heat or gas to the airframe structure or cabin. Any joins or openings for controls, pipes, or fittings, are sealed with heat-resistant material. All bulkheads should be examined for cracks, damage, ineffective sealing and signs of smoke or overheating.

4.6 Access panels, particularly those fitted in the underside of the fuselage or giving direct access to the cabin, are generally sealed with a rubber or elastomeric gasket between the panel and the fuselage skin. These gaskets prevent the entry of exhaust gases into the fuselage and are thus important in preventing CO contamination. The fasteners and gaskets of access panels should be examined for security and effectiveness whenever the panels are removed.

4.7 Lap joints and butt joints in the exterior skin of an aircraft are often sealed by the use of a liquid sealant when the skins are riveted during manufacture. When modifications or skin repairs are carried out the same methods should be used to prevent the entry of exhaust gas and an inspection should be made to ensure that the sealing is effective.

4.8 Cabin windows and windscreens are usually secured to the metallic structure of the aircraft by means of rubber sealing channels or strips. Poor sealing of these glazed panels could allow exhaust gas into the fuselage and the seals should be examined for security, condition and fit.

4.9 On twin-engined aircraft, exhaust gas may enter the wheel wells or flap shrouds and flow along the leading and trailing edges of the wings into the fuselage. The sealing in these areas and the landing gear doors, should be checked for effectiveness.

5 Tests for CO Contamination

5.1 When doubt exists as to the extent of contamination of the air in the crew or passenger compartments, a test should be carried out to determine the CO concentration. This test is usually carried out by a sampling process, detection being based on the colour reaction of CO with iodine pentoxide, selenium dioxide and fuming sulphuric acid. A typical apparatus and test are described in paragraph 5.1.

5.2 **Test Apparatus**

5.2.1 The apparatus usually consists of a hand-operated bellows, which is used to draw a specified volume of air through a sampling tube, the presence of CO being indicated by the staining of crystals in the indicating portion of the tube.

5.2.2 The sampling tube is a sealed glass capsule containing crystals which are white on one side of a datum line and pigmented with the reagent on the other side of the datum line. The white (indicating) part of the tube has two scales marked on the outside of the glass, one graduated for small CO concentrations and the other graduated for large CO concentrations, the units used generally being parts per million (ppm).

5.2.3 When carrying out a test, the ends of a sampling tube should be broken to expose the chemicals and the indicating end of the tube should be inserted in the air intake opening of the bellows assembly. The bellows should then be fully compressed and when released will expand under internal spring pressure to draw a specified quantity of air through the sampling tube. The number of times the bellows is operated depends on which scale is being used and this information should be obtained from the manufacturer's published literature. The presence of CO in the air drawn through the sampling tube will result in a green-brown staining of the indicator crystals, the extent of staining depending on the quantity of CO in the sample. The CO concentration can then be read directly from the appropriate scale, at the dividing line between the white and stained crystals.

5.2.4 Tests should be carried out with the engine(s) running and the cabin heater turned on, both on the ground and during flight, to take account of varying conditions of airflow around the aircraft.

6 Repair or Replacement of Parts

6.1 The repair or replacement of parts may have to be carried out if it is discovered that CO is entering the crew or passenger compartments in quantities sufficient to cause concern. The procedures relevant to particular components are outlined in paragraphs 6.2 to 6.6.

6.2 **Exhaust Pipes and Heater Jackets**

Renewal of damaged parts is generally preferable to repair and new gaskets or seals should always be fitted when replacing a component. Damage may often be repaired by welding, but when making such repairs it is important to comply with any specific instructions which may be contained in the relevant Maintenance Manual. Extreme care should be taken to maintain the original contour, since any disruption to the smooth flow of exhaust gas will result in a hot spot and lead to early failure at that point. It is also important to ensure that the materials used in a repair are the same as, or compatible with, the original material. Pre-heating may be necessary in some cases to prevent cracking and it may be recommended that, after welding, parts are heat-treated in accordance with a prescribed procedure or normalised to reduce grain size in the weld area. Pressure tests are generally required after welding operations.

6.3 **Combustion Heaters**

Combustion heaters should be maintained in accordance with an approved Maintenance Schedule, using only those procedures detailed in the relevant manuals produced by the aircraft manufacturer or the equipment manufacturer; any repairs or replacements which become necessary should be carried out in accordance with these instructions. If burning or traces of smoke are found in the cabin heater ducting the cause should be ascertained and the defective parts repaired or renewed as necessary. Damage to the cabin heater ducting, which is generally made from glass-cloth, nylon or silicone rubber and supported by a steel coil, is generally not repairable and the affected parts should be renewed.

6.4 **Bulkheads**

Cracked or otherwise damaged bulkheads should be repaired in accordance with the procedures laid down in the relevant Repair Manual and using only those materials specified for the particular repair. At the same time that repairs are carried out, all sealing material applied to the bulkhead should be examined for condition and effectiveness and renewed as necessary.

6.5 **Access Panels**

Access panels may become distorted with use and allow contaminated air to enter the aircraft. If a panel is found to be in this condition it may sometimes be repaired by, for example, adding a stiffener, or by adjustment or replacement of the fasteners, but replacement with a new panel may often be necessary. Damaged or incorrectly fitted rubbing strips or seals in an access panel aperture may also result in air leakage and should be repaired or renewed in accordance with the relevant manuals.

6.6 **Doors and Windows**

Poorly fitting or ineffectively sealed cabin doors and windows on aircraft can allow the entry of contaminated air. Although hinges and locks are adjusted during installation to provide a good aerodynamic fit and to ensure the safety of the locking mechanisms, the effects of air loads and wear may result in the need for re-adjustment from time to time and this should be carried out strictly in accordance with the manufacturer's instructions. Door seals may be of the solid or inflatable type and are usually attached to the door surround with a suitable adhesive; if damaged or loose they may usually be repaired, but special procedures and materials are usually required. Information concerning the repair or replacement of door and window seals should be obtained from the relevant Maintenance Manual.

Leaflet 5-4 Control Chains, Chain Wheels and Pulleys

1 Introduction

1.1 The purpose of this Leaflet is to provide guidance and advice on the installation and maintenance of steel roller chains, chain wheels and pulleys used in aircraft control systems.

1.2 Chains provide strong, flexible and positive connections and are generally used wherever it becomes necessary to change the direction of control runs in systems where considerable force is exerted, e.g. aileron and elevator controls. The change of direction is achieved by the use of chain wheels or pulleys. Chains may be found in, control column installations, aileron controls and elevator controls and in trim control systems.

1.3 Chains may be used solely in control runs or in conjunction with cable assemblies. In either case, the incorrect assembly of the chains should be rendered impossible by the use of non-reversible chains in conjunction with the appropriate types of wheels, guards and connectors.

1.4 Subject headings are as follows:

2 Specifications

2.1 Chains used for aircraft purposes are generally of the simple roller type and comply with the requirements of British Standard BS 228: 1984, entitled Specification for Short Pitch Transmission Precision Roller Chains and Chain Wheels. A complete schedule of dimensions and breaking loads for chains is given in this Standard.

NOTE: BS 228 is equivalent to ISO 606 – 1982.

2.2 Chain assemblies are produced to standards prepared by the Society of British Aircraft Constructors (SBAC). These standards provide a range of chains built up in various combinations with standard fittings, e.g. end connectors with internal or external threads, bi-planer blocks for changing the plane of articulation of a chain through 90° (see Figure 4) and cable spools for connecting chains to cables having eye-splices. Such fittings are illustrated in Figures 1 and 4.

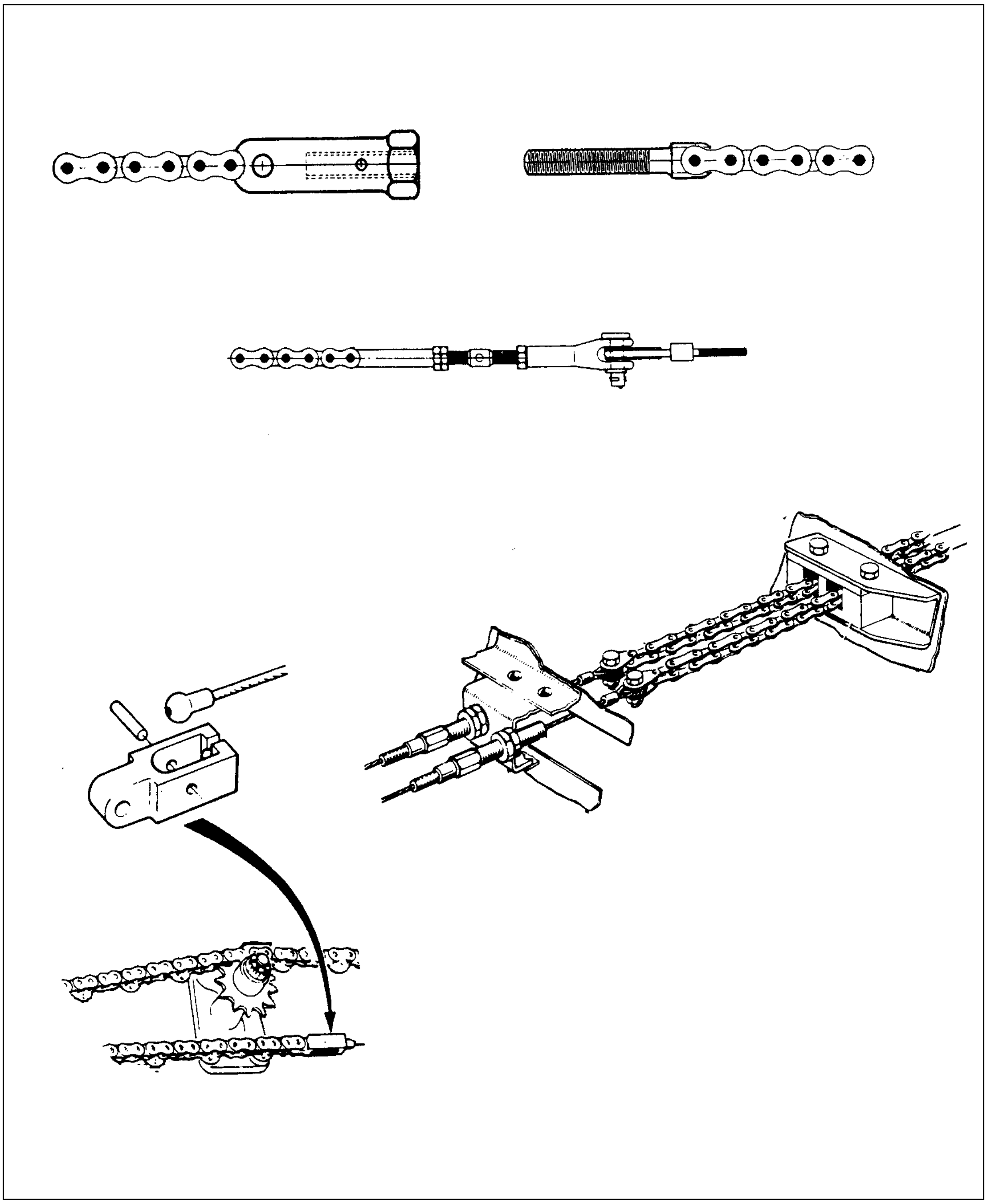

Figure 1 Standard Chain Fittings

3 Chain Assemblies

3.1 A simple roller chain consists of outer and inner plates, rollers, bearing pins and bushes; the component parts are shown in Figure 2(a). The chain has three principal dimensions (known as gearing dimensions since they are related to the size of the wheels on which the chains run), these being pitch, width between inner plates and roller diameter. The positions at which these dimensions are measured are shown in Figure 2(b).

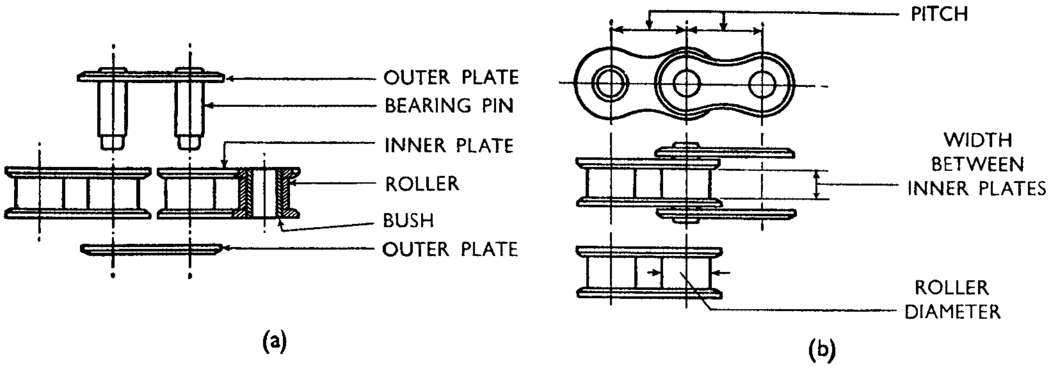

Figure 2 Chain Details

3.2 A typical assembly for 3/8 in and ½ in chains, using a standard end connector with an internal thread, is shown in Figure 3.

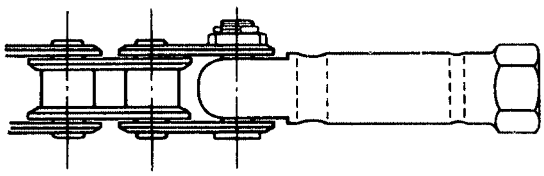

Figure 3 Typical Chain End Assembly

3.3 The pitch of the chain is the distance between the centres of the rollers and for aircraft purposes, four sizes of chain are standardised by the SBAC, as shown in Table 1. BS 228 prescribes that the proof-load (see paragraph 6.6) for a chain should be one-third of the minimum breaking load; the relevant figures for simple chains are also given in Table 1.

Table 1

Chain Pitch	BS No.	Minimum Breaking Load	Proof Load (lb)
8 mm	1	800 lb	267
0·375 in	2	1900 lb	634
0·50 in	4	1800 lb	600
0·50 in	6	3500 lb	1166

3.4 Chain assemblies for aircraft systems should be obtained as complete, proof-loaded units from approved chain assembly manufacturers and no attempt should be made to break and reassemble riveted links or riveted attachments. If it is necessary to disconnect the chain, this should be undertaken only at the bolted or screwed attachments. Split pins must not be re-used and this applies also to nuts and bolts which have been peened.

NOTE: The procedure specified by SBAC standards for securing nut and bolt joints for Class 1 application is to peen the bolt end for 8 mm pitch chain and to split pin the bolts of the remaining standard chains. In all cases the nut is actually a lock nut, since the hole in the loose outer plate is also tapped.

3.5 The use of cranked links for the attachment of the chain to end fittings, etc, is not permitted, thus, when a chain is required to terminate in a similar manner at each end, the length should be an odd number of pitches. For the same reason, an endless chain should have an even number of pitches.

3.6 The use of spring clip connecting links is prohibited and the attachment of chains to other parts of the system should be effected by positive methods such as pre-riveted or bolted joints.

4 Installation of Chain Assemblies

4.1 Figure 4 illustrates typical arrangements of chain assemblies. Figure 4(a) shows the simple transfer of straight-line to rotary motion, Figure 4(b) illustrates how a change of direction of straight-line motion is obtained, whilst Figure 4(c) shows a change of direction of motion in two planes by the use of a bi-planer block.

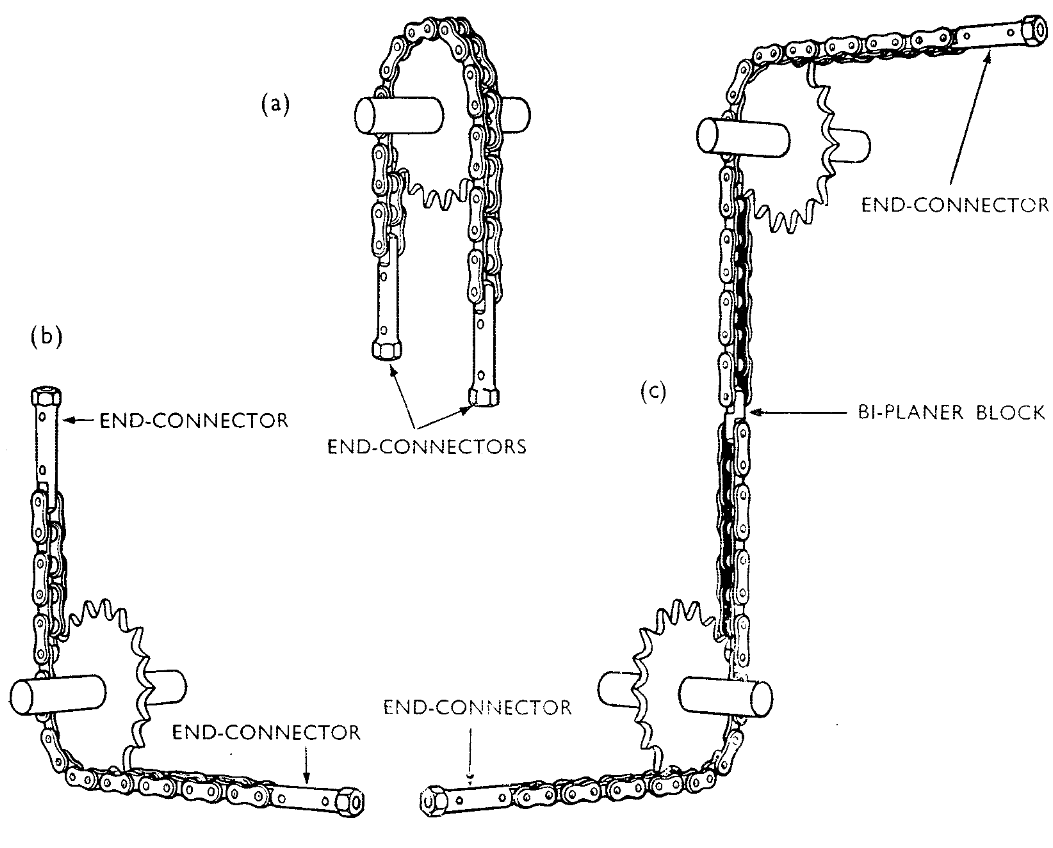

Figure 4 Typical Chain Assembly Arrangements

4.2 A range of non-interchangeable end fittings is available as a safeguard against the crossing of controls. However, these connectors do not always prevent the possibility of reversing the chain end to end on its wheel, neither do they prevent the possibility of the chain being assembled to gear on the wrong face where two wheels are operated by the same chain. Such contingencies can be overcome by the use of non-reversible chains.

4.3 **Non-reversible Chains**

4.3.1 Non-reversible chains are similar to standard chains except that every second outer plate is extended in one direction in order to break up the symmetry of the chain. The complete system of non-reversibility involves the use of five features, i.e. the non-reversible chain, the shroud on the wheel, correct positioning of the wheel on its shaft, the chain guard and non-interchangeable connectors. The shape of the special outer plates and the principle of non-reversible chains is shown in Figure 5.

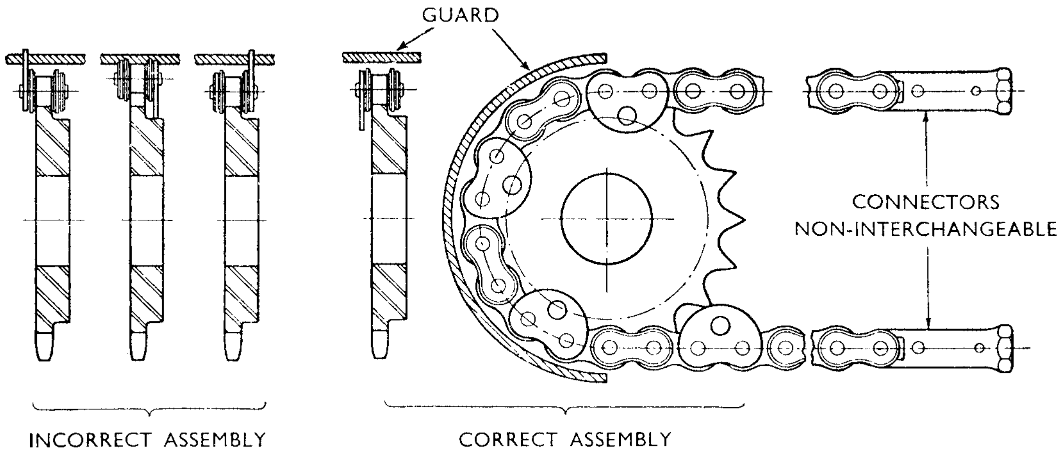

Figure 5 Non-reversible Chain Assembly

4.3.2 It will be seen from Figure 5 that by providing a shroud on one side of the wheel and by making use of the chain guard, the reversing of the chain end to end on its wheel is not possible. It should be borne in mind that in practice a special feature, such as an attachment collar, a key, or a flat on the shaft in conjunction with a specially shaped hole, is incorporated in the wheel mounting to ensure that it can be assembled on its shaft in one definite position only.

4.3.3 Figure 6 illustrates an instance where the use of jockeys is necessary or where contra-rotation of the wheels is required; it will be seen that the feature of non-reversibility does not affect the ability of the chain to gear on both sides.

4.4 **Inspection after Assembly**

4.4.1 After installation in the aircraft, the chain should be examined for freedom from twist, particularly in instances where the attachment is made to threaded rods by means of screwed end connectors, or where a twist may inadvertently be applied to the chain during the locking of the assembly. Care should be also taken to ensure that the chain is not pulled out of line by the chain wheel; the chain should engage smoothly and evenly with the wheel teeth and there should be no tendency for the chain to ride up the teeth.

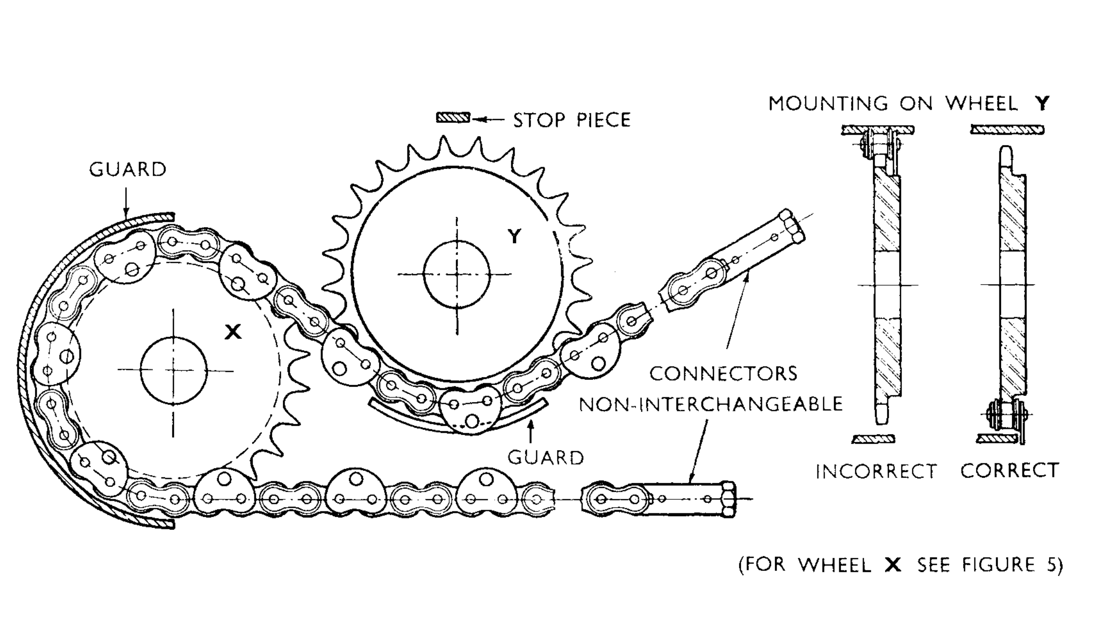

Figure 6 Non-reversible Chain With Jockey Pulley

4.4.2 The pre-tensioning of chains should not be excessive, as this will cause friction, but should be just sufficient to prevent any back-lash in the system.

4.4.3 The guarding should be checked to ensure that jamming could not occur and that the chain would not come off the wheel should it become slack.

4.4.4 The security of end connections should be checked, care being taken to ensure that the split pins in the chain connecting bolts are correctly locked.

4.4.5 The initial lubricant on new chains should not be removed and the chains should be further lubricated after assembly by brushing all over, particularly on link edges, with lubricant complying with specification DTD 417A, unless otherwise specified.

4.4.6 The wheel or pulley mountings should be examined to ensure that the wheels or pulleys are firmly secured to the shafts or spindles, that they are correctly located and are running freely.

5 Maintenance Inspection

5.1 Chain assemblies should be inspected for serviceability at the periods specified in the relevant Maintenance Schedule; guidance on the recommended methods of checking chains is given in the following paragraphs.

5.2 The continued smoothness of operation between the chain and the chain wheel or pulley should be checked. If the chain does not pass freely round the wheel or pulley, it should be removed and checked as detailed in paragraph 6.

5.3 The chain should be checked for wear; if it is worn so that the links are loose and can be lifted away from the wheel teeth, it should be removed and checked for excessive elongation as detailed in paragraph 6.3.

5.4 The chain should be checked for damage, cleanliness, adequacy of lubrication and freedom from corrosion. If the inspection shows the chain to be corroded or otherwise defective, it should be removed.

5.5 In instances where it becomes necessary to adjust the tension of the chain in systems incorporating turnbuckles or screwed end connectors, care should be taken to ensure that the chain itself is not twisted during the adjustment. The connectors should be held firmly while the locknuts are being slackened or tightened.

6 Inspection of Chain Assemblies

6.1 General

Chain assemblies should be removed from the aircraft for complete inspection at the periods specified in the appropriate Maintenance Schedule.

6.2 Removal

When it is necessary to disconnect the chains the assemblies must be removed at design breakdown points.

6.3 Checking Elongation

6.3.1 If elongation through wear is suspected, the following procedure should be adopted:

a) The chains should be cleaned by immersion in clean paraffin and brushing with a stiff brush; after cleaning, the chains should be dried immediately by hot air to ensure that no paraffin remains, otherwise the chains will corrode. The chains should be measured when clean but before any oil is applied.

b) The chains should be placed on a flat surface and stretched by the application of a tensile load. Table 2 indicates the load applicable to the various sizes of chains. The length should then be measured between the centres of the bearing pins, elongation being calculated by the formula given in sub-paragraph c).

Table 2

Chain Pitch	BS No.	Tensile Load (lb)
8 mm	1	12
0·375 in	2	16
0·50 in	4	28
0·50 in	6	28

c) The percentage extension over the nominal length should be calculated by the following 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.

6.3.2 If the extension is in excess of 2% on any section of the chain the whole run of chain should be replaced. Should localised wear be likely to occur in a chain run, additional checks should be made on such sections and the percentage extension ascertained from the formula given in paragraph 6.3.1 c). If the extension in such sections is in excess of 2%, the chain should be rejected.

6.3.3 The chain should be checked for kinks and twists by suspending it freely and sighting along the length; if kinks or twists exist the chain should be rejected.

6.4 Checking Articulation

The chain should be checked for tight joints by articulating each link through approximately 180°. The most suitable method being to draw the chain over a finger. Tight joints may be caused by foreign matter on the bearing pins or between the inner and outer plates; this may be remedied by cleaning as described in paragraph 6.3.1 a). If cleaning is not successful, the end of the bearing pin may be very gently tapped with a light hammer, but if this does not clear the joint, the chain should be rejected. Tightness may also be caused through lack of clearance between the inner and outer plates due to damage; if this is so, the chain should be rejected.

6.5 Checking for Deterioration

The chain should be examined for damage, cracks and wear to plates and rollers and for evidence of corrosion and pitting.

NOTE: It is not permissible to break down or attempt to tighten a riveted link in a run of chain.

6.6 Proof Loading

It is not necessary to proof load a chain after removal for routine examination. However, if it is desired to replace a portion only of the assembly, proof loading of the complete assembly is necessary. The proof load (Table 1) should be evenly applied and unless this can be assured, it is considered preferable to fit a complete new assembly.

6.7 Protection and Storage

After the chain has been cleaned, inspected and found to be acceptable, it should be thoroughly soaked in an appropriate oil, time being allowed for the lubricant to penetrate to the bearing surfaces. If not required for immediate use, the chain should be laid on a flat surface, carefully coiled and wrapped in greaseproof paper, care being taken to ensure the exclusion of dirt and the prevention of distortion, during storage.

7 Installation of Chain Wheels and Pulleys

7.1 During installation, chain wheels and pulleys should be checked to ensure that they are attached in the manner and method specified by the relevant drawings. The correct positioning of chain wheels is of particular importance when non-reversible chains are used (see paragraph 4.3). During maintenance, chain wheels should be checked for security and wear on the teeth. Pulleys should be checked for damage and excessive wear on the walls and on the chain guide section. The continued efficiency of ball races should also be ascertained.

Leaflet 5-5 Hose and Hose Assemblies

1 Introduction

1.1 This Leaflet provides guidance and advice on the installation and maintenance of hose and hose assemblies in aircraft and should be read in conjunction with the relevant manuals for the aircraft concerned.

NOTE: In this Leaflet the term 'hose' is used to describe a flexible tube which may be used on its own in some locations and the term 'hose assembly' is used to describe the hose complete with end fittings. Some manufacturers use the terms 'flexible pipe' and 'flexible pipe assembly' to describe the same parts.

1.2 Factors which affect the service life and reliability of hose and hose assemblies include the conditions prevailing in the area in which they are installed, the care with which they are installed and maintained and the pressures, temperatures and externally applied loads to which they are subjected in service. The need for scrupulous cleanliness at all stages during the lives of the hoses and hose assemblies cannot be over-emphasised.

1.3 Paragraphs 2 to 9 of this Leaflet deal with rubber and synthetic material hose assemblies. Metallic hose assemblies differ considerably with regard to manufacture, installation and maintenance and are dealt with separately in paragraph 10.

1.4 Guidance on the installation of rigid pipes is given in Leaflet 5–6.

2 General

2.1 Hose assemblies for use in high-pressure fluid systems are usually supplied by the manufacturers complete with end fittings which, in most cases, cannot be dismantled or altered in any way. However, there are some types of hose assemblies on which the end fittings may be changed, if necessary and these are dealt with in paragraph 9.

2.2 Hose Assemblies

2.2.1 Modern high-pressure, metal-reinforced rubber or synthetic material hose assemblies are designed for the widest possible application in aircraft and engine manufacture. The tube or lining of the hose is manufactured from material such as synthetic rubber, which is specially compounded to withstand the deleterious effects of high pressures, high temperatures, oils, solvents, fuels and other fluids. The hose is considerably strengthened by the incorporation of high tensile steel wire braiding or spiral lay, which provides maximum resistance to bursting, together with minimum dimensional alterations when the hose assembly is subjected to high internal pressure. Hose assemblies are generally designed either for specific functions or for a limited range of functions only and it is essential to ensure that only the hose specified on the appropriate drawing or in the approved parts catalogue is fitted in any particular system and location.

2.2.2 One material which is widely used for the manufacture of hose for engine and hydraulic systems is polytetrafluoroethylene (PTFE). This material is chemically inert, is unaffected by the synthetic oils and fluids used in aircraft systems, operates satisfactorily at high fluid and ambient temperatures and normally has an unlimited shelf life. PTFE hose is, however, more susceptible to damage from careless handling than rubber hose and great care is required during removal, installation and inspection.

2.2.3 The operating conditions under which a hose assembly may have to function vary considerably. Fluids may have to be conveyed at very high pressures at altitude where the ambient temperature may be in the region of –55°C; on the other hand high ambient temperatures in the region of jet engines may affect the same hose assembly. Hose assemblies required to function in designated fire zones or adjacent to fireproof bulkheads must possess fire-resistant properties and are usually fitted with a protective sleeve; these sleeves are usually made from woven asbestos, are covered with asbestos-impregnated synthetic or silicone rubber and may be secured to the hose assembly by clips.

2.2.4 In addition to the pressures and temperatures to which hose assemblies are subjected, vibration and in some cases appreciable angles of flexing, may have to be accommodated. It is, therefore, essential that the lives specified for these assemblies in the approved Maintenance Schedule should not be exceeded.

2.3 **Manufacture of High-pressure Hose Assemblies**

2.3.1 A typical high pressure hose assembly (Figure 1) consists of an inner tube or lining covered by one or two closely-woven wire braids, either moulded or sandwiched between the synthetic rubber of the tube, or woven on the surface of the tube. The whole may be enclosed by an outer cover, the purpose of which is to provide protection for the other parts of the hose, to resist abrasion and the effects of weather and environmental fluids and chemicals and in some cases, to provide a degree of fire resistance. In some cases cotton braid is introduced between the wire braids and the rubber inner and outer tubes and a thin rubber layer may be interposed between layers of wire braid.

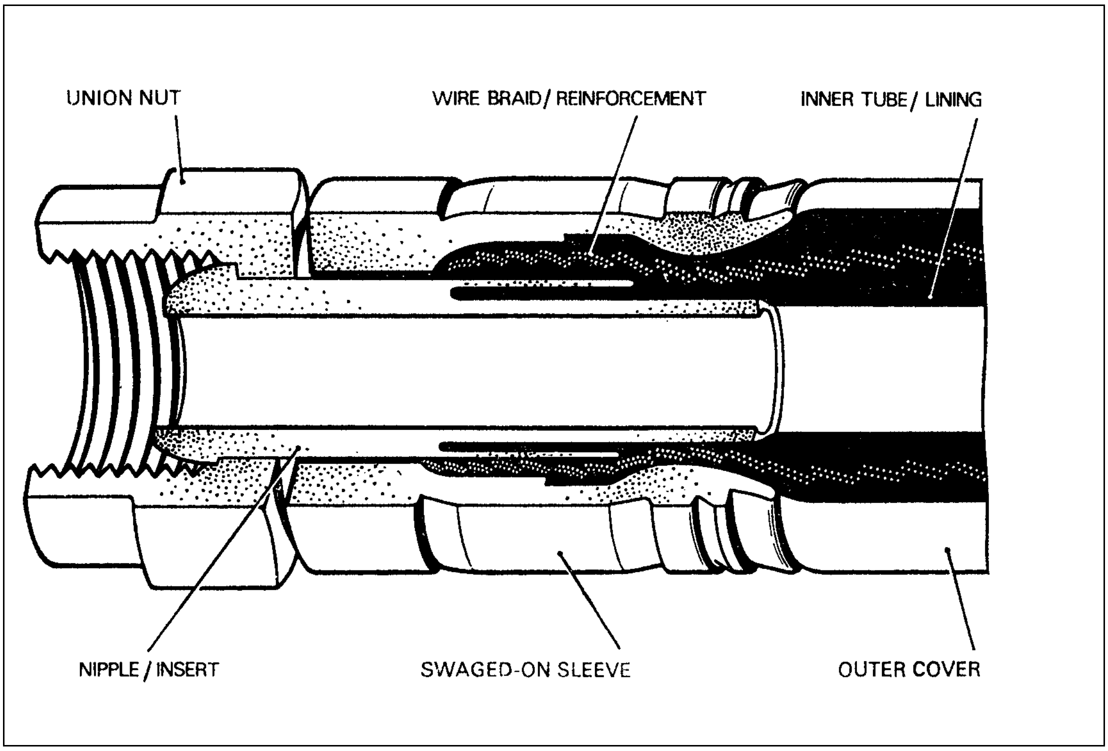

Figure 1 High Pressure Hose Assembly

2.3.2 The end fittings on a hose assembly are made of steel or light alloy, depending on the application and they are designed to exert a grip on both the tubes and wire braids so as to resist high pressure, twisting and vibrating loads and to provide an electrical bond throughout the assembly.

2.4 **Measurement of Length**

The length of hose assemblies with straight end fittings is taken as the distance between the extremities of the two nipples. In the case of elbowed end fittings the length is taken from the centre of the bore (see Figure 2).

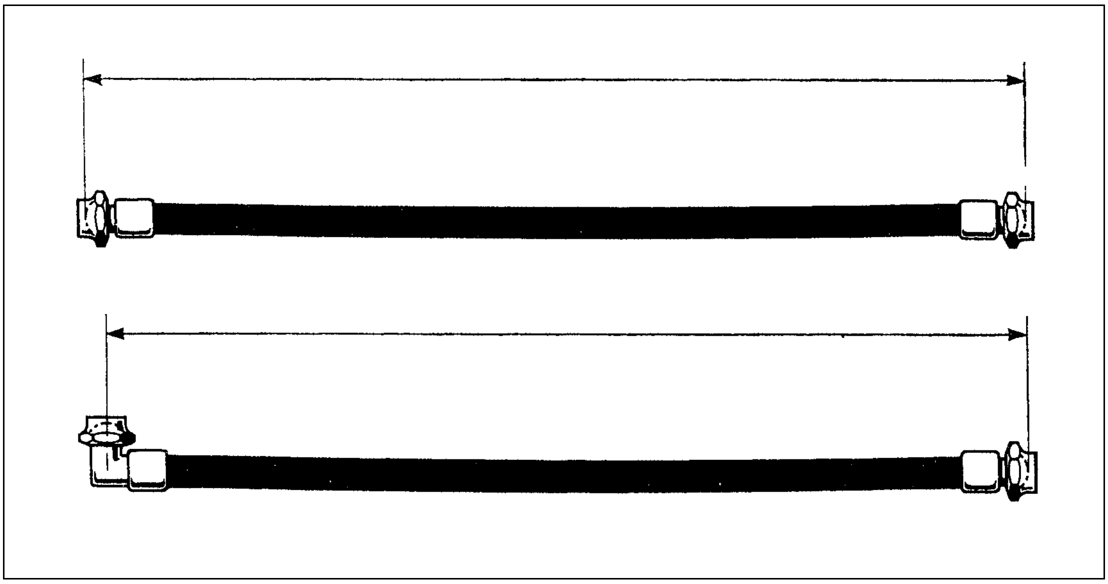

Figure 2 Measuring Hose Assemblies

2.5 **Low-pressure Hose**

2.5.1 There are many types of low-pressure hose used on aircraft, e.g. the thin-walled textile reinforced type used for instrument lines (especially for instruments mounted on panels equipped with vibration isolators) and the rubber or canvas spirally-corrugated hose having a spiral of spring steel embedded in the corrugations, which is often used for systems where there are negative pressures.

2.5.2 With low-pressure hose it is important to ensure that bends are not too acute, since this may result in kinking of the hose or flattening of the cross-sectional area at the bend. Where sharp bends cannot be avoided an internal support coil may be included in the design.

3 Storage of Hose and Hose Assemblies

3.1 PTFE hose does not normally have a specified storage life, but rubber or synthetic rubber hose normally has a storage life, depending on the formulation of the material, of between 3 and 5 years. The storage details relevant to a particular hose or hose assembly should be obtained from the appropriate Maintenance Manual or manufacturer's manual and any instructions relating to the inspection and testing of hose or hose assemblies while in storage or prior to installation should be carefully observed. The storage life of hose supplied in bulk is calculated from the cure date and the storage life of hose assemblies is calculated from the date of manufacture or assembly.

3.2 **Storage Conditions**

3.2.1 Bulk supplies of hose are generally stored in coils of large diameter, but hose assemblies should be stored flat and relieved of stress. Hose and hose assemblies should be stored away from strong light and running electric motors and air should be permitted to circulate freely about the parts unless they are contained in plastics envelopes. The temperature should be controlled between 10°C and 26°C.

3.2.2 Preformed hose assemblies and PTFE hose assemblies which are being stored after removal from an aircraft system must be stored in such a way that the required or assumed shape is maintained; no attempt should be made to straighten or bend these hoses. A length of locking wire may be attached between the end fittings to prevent the hose from straightening.

3.3 **Sealing Blanks**

During storage, the correct sealing blanks should be fitted. Plugs and caps conforming to appropriate AGS and AS Specifications are usually suitable, but in instances where the standard blanks cannot be used, blanks should be so designed that they cannot enter the end fitting or be left in position when the assembly is connected. It is also important to ensure that the material used for blanking will not 'pick-up' or otherwise tend to leave small particles inside the end fitting after long periods of storage. Tape or rag must not be used for blanking purposes.

3.4 **Rotation of Stock**

Strict rotation of issue from stores must be observed to ensure that older stock is issued first.

3.5 **Bore Protection**

In some special cases, to prevent deterioration of the bore or inner lining of the hose, it may have to be stored filled with the liquid which it is intended to contain in service; special instructions concerning such assemblies will normally be attached by the manufacturer. If a hose assembly is issued in an airtight plastics envelope, this should not be removed until the part is fitted. Should the envelope become damaged during handling, any desiccant contained within should be checked for condition and the envelope should be re-sealed or renewed.

4 Markings on Hose and Hose Assemblies

4.1 There are many ways in which the date of manufacture is marked on hoses and hose assemblies, varying according to the type and manufacture of the item. The date may be stencilled on the external surface, or impressed on a tab or band secured to the hose; in instances where the external surface is of cotton braid some of the 'strands' are woven in black and some are coloured to indicate the month and year of manufacture.

4.2 In addition to the date of manufacture, hose assemblies are marked with the drawing number or part number, inspection stamp, 'test' stamp and name of manufacturer.

4.3 Most hose assemblies are marked along their length with one or more continuous thin lines to indicate any twist which may occur on installation. Some manufacturers use these lines also for manufacture identification (see Figure 4), e.g. a hose having a single high-tensile wire braid would be indicated by a single line, while a hose having a double wire braid would be indicated by a double line.

5 Pre-installation Checks

5.1 Before a hose assembly is fitted to an aircraft it should be examined for damage and corrosion and for cleanliness. The part number, date of manufacture and date of last test should also be ascertained. Where specified by the manufacturer, hose assemblies should be pressure tested before installation (see paragraph 8).

5.2 Where possible, every hose assembly should be examined internally to ensure that the bore is free from obstruction or damage. Straight hose assemblies may be examined by looking through them with a light positioned at the opposite end, but preformed hose should be checked by means of a ball test (paragraph 9.5.3 a)).

5.3 If the end fittings have been welded, brazed or silver soldered, they should be examined for any corrosion which may have developed during manufacture. An Introscope or similar inspection instrument should be used in cases where direct viewing is impractical.

5.4 The hose bore should be examined for cleanliness, blown through with clean, dry compressed air as necessary and, when recommended by the manufacturer, flushed with clean fluid of the type used in the system to which the hose assembly is to be fitted.

6 Installation

6.1 When installing a hose assembly, it should be ensured that there is adequate clearance between the hose and other parts of the aircraft structure, so as to prevent chafing or electrolytic corrosion. It must be borne in mind that hose may flex when internal pressure is applied and considerable 'whip' may occur under surge conditions; the force exerted when a hose 'whips' may be sufficient to cause damage to the hose assembly and to surrounding components.

6.2 The serviceability and life of a hose assembly is considerably affected by the degree of bending of the hose. There may be some variation in the connecting angle and distance between fittings for a particular hose assembly in similar installations and a check should be carried out to ensure that the bend radius is not less than the minimum specified by the manufacturer.

6.3 There are two classes of minimum bend radii recommended by hose manufacturers for each hose diameter. The minimum bend radii recommended for hose in locations where there is no relative movement, are smaller than those recommended for hose in locations where there is relative movement between end fittings, e.g. a hose assembly connected to a flap actuator would have a larger radius bend than a hose assembly connecting two rigid couplings at different angles. The flexing radius should, in general, be twice the bend radius of a static installation. It should also be noted that the recommended minimum bend radii for PTFE hose may vary from those recommended for rubber hose.

6.4 It is important to ensure that the bend radius of hose fitted to moving parts is never less than the recommended minimum, throughout the range of movement of the parts. Correct and incorrect methods of installation are shown in Figure 3, where the different alignment of the hose assemblies resulting from movement of the attached parts is illustrated.

6.5 To allow for shrinkage, vibration, movement of parts and 'whip', all straight hose assemblies should be at least 3% longer than the maximum distance between the fittings to which they are connected. In no circumstances may a hose assembly be under any form of tension (see Figure 4(B)).

6.6 Sharp bends in a hose adjacent to an end fitting must be avoided, as this can cause considerable local strain and rapid failure of the hose (see Figure 4(D)). When fitting hose assemblies with different types of end fittings, the correct method of installation should be observed.

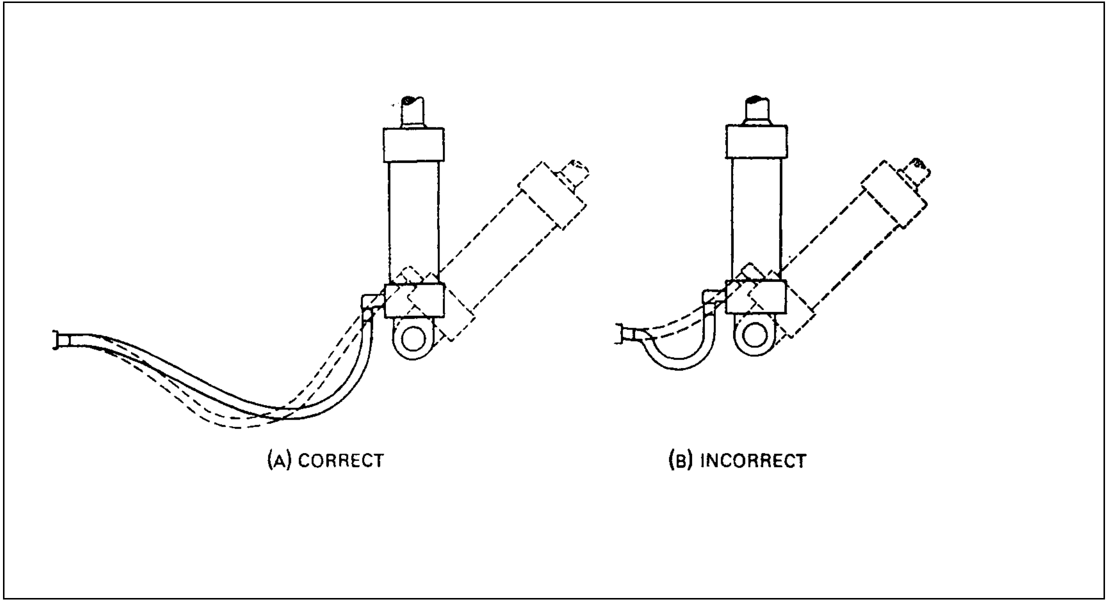

Figure 3 Correct and Incorrect Installations

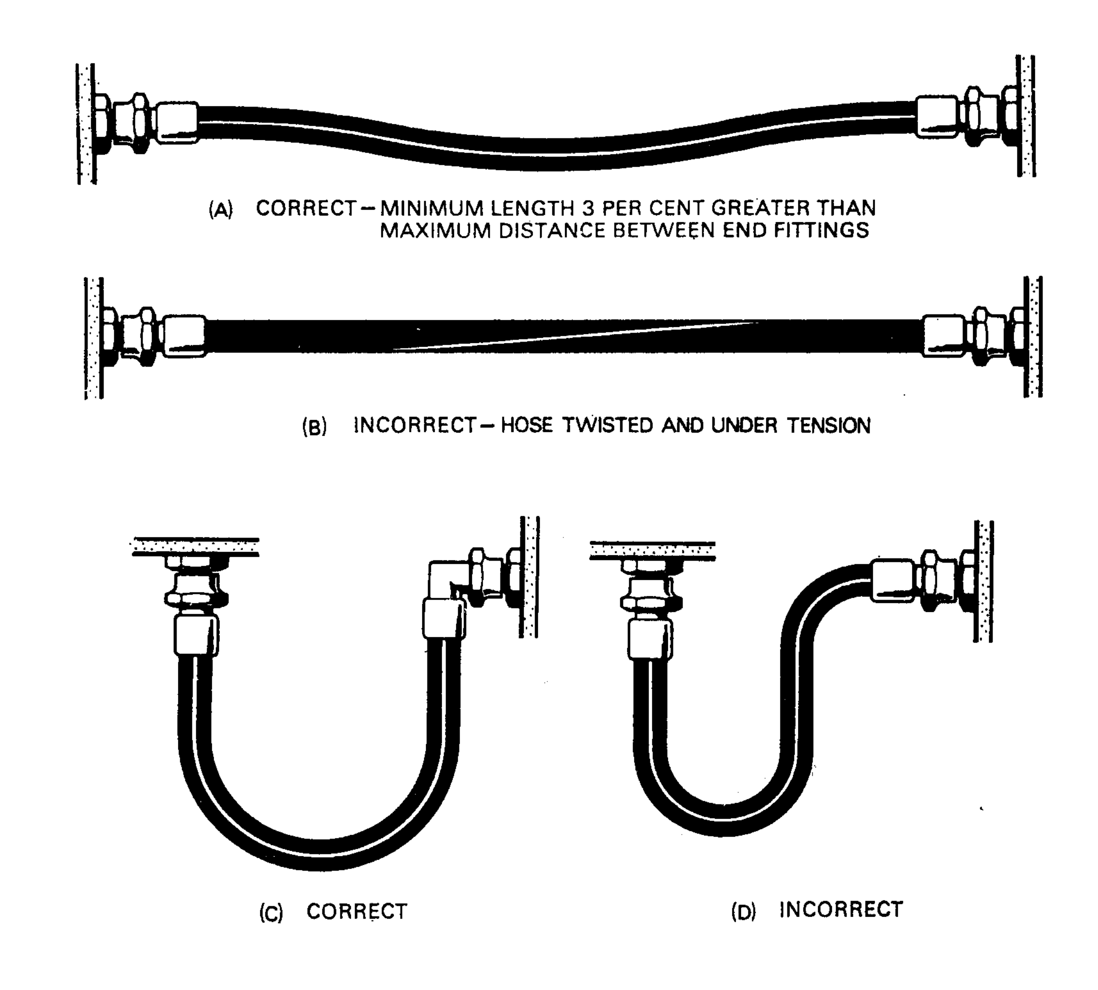

Figure 4 Correct and Incorrect Installations

6.7 **Lubrication of Couplings**

If the lubrication of coupling threads is specified to avoid 'picking up', it is essential to use the lubricant specified by the manufacturer and to ensure that it does not enter the bore of the hose assembly; this can be done by applying lubricant to the external threads only. For connections in oxygen systems, where the presence of oil or grease is very dangerous, only specified lubricants may be used. Because of the sensitivity of oxygen to many substances, it is essential that the instructions given in the relevant manual are followed when applying these lubricants.

6.8 **Tightening of Couplings**

6.8.1 When fitting a hose assembly, it is most important to prevent it from twisting when the connections are tightened. The union nuts at each end should be fitted finger-tight and then, while holding the hose portion firmly as near to the coupling as possible, the union nuts should be tightened with a spanner. On some hose end fittings, flats are provided for holding the hose with a second spanner while tightening the union nuts.

6.8.2 The continuous coloured line which some hose assemblies have on their outer cover will assist in detecting any twist in an installed hose (see Figure 4(B)). In the case of hose with a metal braided outer cover, twist may be detected by distortion of the braid pattern in a helical direction, but careful tightening or loosening of the union nuts is the only safe way of avoiding twist and strain in the hose assembly.

6.8.3 Care must be taken when tightening union nuts or banjo bolts, to avoid damage to the nuts, bolts or threads. Spanners should be of the correct size and in good condition and the bolts and nuts should be tightened to the appropriate torque as specified in the relevant manual.

6.9 **Support Guides**

6.9.1 In many installations, a hose is supported or retained by large 'U' fittings or guides fitted to the adjacent structure to guide the movement of the hose in a particular plane and to prevent it fouling or catching other moving parts of the aircraft installation. These support guides are usually encased in synthetic rubber to prevent damage to the hose. It is important to check the positioning of these support guides in relation to the angular movement of the hose to ensure that the hose movement is not restricted at extreme angles.

6.9.2 **Clipping**

In some installations, where there is no relative movement of the hose assembly, the hose is clipped to give support and minimise vibration. It must be ensured that, where clips are fitted, the hose is not distorted by overtightening or poor positioning of the clip.

6.9.3 **Taping**

Where taping of a hose is considered necessary as a protection against fouling, this should be reduced to a minimum, since, apart from restricting the hose flexibility, deterioration of the hose under the tape often occurs. On no account should leather be used for this purpose, since acid from the leather will corrode any metal parts with which it comes into contact.

6.9.4 **Movement of Hose Assemblies**

Where a hose assembly is connected to a moving part, it is important to ensure that the hose can only move in the plane or planes intended in the design.

a) In the case of a hose assembly having movement in more than one plane, torsional loads will be imposed on the hose at the end fittings. If such movement is the design intention, a hose which has no metal braid or wire spiral in its manufacture is generally used, otherwise the torsional effect would result in early deterioration. In such instances special attention should be given to the locking of end fittings.

b) Each moving hose should be observed during the functioning tests of the component to which it is connected so that it can be checked throughout its travel for evidence of chafing, binding, tight bends and other deleterious effects. An important application of these checks is to brake hose assemblies, which may appear to be of adequate length when the aircraft is resting on its wheels, but may be too short when the undercarriage strut is fully extended. It should be borne in mind, however, that an excessively large loop in the hose may be hazardous during retraction of the undercarriage.

6.9.5 **Tests after Installation**

After installation of a hose assembly, the associated system should be tested for flow, pressure and bonding as specified on the appropriate drawing or in the relevant aircraft manuals. During tests, freedom from leaks and excessive movement under pressure should be verified.

NOTE: In positions where the hoses cannot be seen with the system in operation, every possible precaution must be taken to ensure safety in the known most adverse condition of operation.

7 Maintenance

7.1 The life of a hose assembly varies largely according to environmental and operating conditions, but may also be affected by storage conditions and the care taken during its installation. The life is assessed from experience with a particular installation and it may be specified in a number of ways. Some hose assemblies are given a definite life after which they are scrapped regardless of their apparent condition, some are given an overhaul life which usually coincides with the aircraft overhaul periods and some are renewed only 'on condition'; the life applicable to a particular hose assembly will be specified in the approved Maintenance Schedule. Apart from the replacement of time-expired or unserviceable hose assemblies little maintenance is possible, except in some cases, the replacement of end fittings and protective sleeves, but regular inspections of the condition of the assembly should be carried out and care should be exercised during its service life to prevent deterioration through abuse.

7.2 **Inspection**

7.2.1 The inspection of hose assemblies should normally be carried out in situ, at the intervals specified in the approved Maintenance Schedule. During each inspection the date of manufacture of hose should be checked to ensure that its prescribed life will be valid until the next inspection and the assembly should be examined for defects as outlined in paragraphs 7.2.2 to 7.2.10.

7.2.2 **General Condition**

General deterioration of a hose may be recognised by discoloration, flaking, hardening, circumferential cracking or crazing of the outer cover (Figure 5). These defects do not render the hose unserviceable unless the cracks penetrate to the braid.

7.2.3 **Installation**

The installation of a hose assembly should be checked to ensure that it is not twisted, stressed, or bent through too sharp an angle and that any clips or supports are correctly fitted and not chafing or imposing stress on the hose.

7.2.4 **Chafing and Cuts**

Light chafing and cuts in the outer cover are generally acceptable if the braiding is not exposed, but the reasons for the damage should be ascertained and corrected. In the case of hose assemblies which have no outer covering over the braid, any damage to the braid will normally entail rejection, but some manufacturers permit the acceptance of isolated broken strands. Chafing which occurs under clips may entail changing both the hose and the clips.

7.2.5 **Kinks**

This defect is usually caused by incorrect installation or by mishandling. It shows up as a sharp increase in radius at one point in a bent hose and is usually easy to detect visually unless the hose has a protective cover; finger pressure should be used to check this type of hose. Any kinked hose must be considered to be permanently damaged and must be scrapped.

Figure 5 Ageing Cracks

7.2.6 **Corrosion**

Hose assemblies with corroded wire braid, or end fittings which are corroded (other than very lightly and locally) must be scrapped.

7.2.7 **Contamination**

Contamination of a hose with an outer rubber cover will show up as swelling, sponginess, hardening or disintegration of the surface and is not acceptable. Hose which is contaminated should be rejected and renewed.

7.2.8 **Overheating**

The overheating of rubber covered hose is apparent as scaling, crazing, or discoloration of the surface. Hose with an outer wire braid may assume an overall golden brown colour when exposed to normally high temperature and this is acceptable; patches of discoloration caused by overheating are not acceptable.

7.2.9 **Blisters**

Blisters may form on the outer synthetic rubber cover of hoses, but these do not necessarily affect the serviceability of the hoses provided they are able to withstand the applicable test described in a) or b). Certain factors must be taken into consideration, however, e.g. if the hose is exposed to spray from the tyres, puncturing of the outer cover may allow corrosive elements to attack the wire braiding.

a) **Hose Assemblies in Pneumatic Systems**

i) Remove the hose assembly from the aircraft and puncture the blister with a needle having a chisel point. The needle should be inserted parallel with the outer cover of the hose so that it penetrates the outer cover only. The blister should then collapse.

ii) Pressurise the hose at 1½ times working pressure under water.

iii) When the hose is pressurised, the air supply should be turned off. Bubbles will appear from air trapped beneath the outer cover but eventually disappear if no further bubbles appear, the hose is serviceable.

iv) A constant flow of air bubbles indicates a leak and can be observed as a pressure drop on the pressure gauge. A leaking hose must be scrapped.

b) **Hose Assemblies in Hydraulic Systems**. Remove the hose from the aircraft and puncture the blister as outlined in a). If fluid emerges from the pin hole the hose must be scrapped; if air only emerges the hose should be pressurised with fluid at 1½ times its maximum working pressure for a period of two minutes and, if no fluid leakage occurs, it can be regarded as serviceable.

7.2.10 **Leaks**

A hose assembly should be checked for leakage with pressure in the associated system. A leak may be detected by the presence of fluid on the hose, end fittings or adjacent structure, or by the appearance of blisters on the hose (paragraph 7.2.9). When a protective sleeve is fitted, stains may appear on the sleeve or fluid may emerge from the ends of the sleeve, but if the leak is small and no fluid is visible, the presence of fluid may sometimes be detected by squeezing the sleeve. Hose assemblies in pneumatic systems may be checked by applying, externally, a noncorrosive soapy water solution, by the use of special test equipment, or by carrying out a leak rate check. If there is any doubt the hose assembly should be removed from the aircraft and subjected to a pressure test (paragraph 8). A leaking hose must be scrapped.

8 Pressure Tests

8.1 General

When specified in the approved Maintenance Manual or Schedule, or whenever the serviceability of a hose assembly is in doubt, a pressure test should be carried out.

8.2 Test Equipment

8.2.1 Before pressure testing a hose assembly the following points should be verified:

a) that the test equipment available is adequate for the proposed tests and located in such a position as to preclude cross-contamination with dissimilar fluids,

b) that the test medium is clean and suitably protected against the ingress of dirt,

c) that the test equipment and instruments are checked at regular intervals and a record kept of these checks and

d) that before any tests are made, either in the aircraft or on separate components, the test figures are ascertained from the appropriate drawings or manual.

8.2.2 To prevent injury to personnel in the event of a hose failure during the pressure testing of a hose removed from an aircraft, the hose should be located behind a heavy plastics screen. For tests using air as the test medium the hose should also be submerged in water.

8.3 **Test Medium**

8.3.1 Pressure tests are usually made with a fluid similar to that which the hose will carry in service. However, there are some exceptions, for example, paraffin is usually recommended for testing petrol hoses as it is safer and more searching. Pneumatic and oxygen hoses are usually tested with water then thoroughly dried out with a warm air blast. This is followed by a further test with clean, dry air, in which pressure is limited to maximum system pressure.

8.3.2 Oxygen pipes must not be contaminated with oil and should not be connected to a compressor for test purposes.

8.4 **Hose Flexing**

8.4.1 When under test, the hose should be restrained to approximately the shape it assumes in service. If the hose is non-flexing in service it should be flexed approximately 15° from its normal shape several times each way and the pressure should be maintained for at least two minutes. Low pressure non-flexing hoses used in regions of high ambient temperature should be regarded as exceptions and should not be subjected to flexing during pressure testing, since such hoses, having been subjected to extremes of heat during service, will automatically be rendered unserviceable if treated in this manner.

8.4.2 Hoses which are subject to flexing in service should be tested in a similar manner but, in addition, should be flexed through their normal flexing angle plus 15° each way.

8.4.3 No leakage or malfunction should occur during any of these tests.

8.5 **Test Pressures**

Unless otherwise stated on the appropriate drawing or in the relevant manual, hoses should be pressure tested to 1½ times their maximum working pressure. In some instances hose assemblies are tested in situ, in which case one end should be connected to a universal type of inflation adapter gauge and the other shut off or blanked as required. For information on the universal type of adapter and gauge see Leaflet 5–6.

9 Re-usable End Fittings

9.1 General

The purpose of re-usable end fittings on hose assemblies is to save the cost of renewing a complete assembly when only the hose portion is unserviceable. An end fitting consists basically of two or more components; a socket fits tightly over the hose and a tapered nipple (or insert), when screwed into the hose bore, expands the hose and clamps it firmly against the socket. This is the most common method and is known as a 'compression seal' (Figure 6 (A) and (B)), but a somewhat different method of attachment, known as a 'lip seal' (Figure 6 (C)), is used by some manufacturers; the nipple in this case has a cutting spur or separate collar which separates the inner hose from the braid during the assembly operation. The re-use of end fittings is satisfactory if precautions are taken to ensure that no damage is caused to the hose bore during the assembly operation and the manufacturer's instructions are followed with regard to both assembly and testing. A brief description of a typical assembly technique is given in the following paragraphs and illustrated in Figures 6, 7 and 8, but reference should always be made to the aircraft or hose manufacturer's manuals for specific instructions on measurement, assembly, lubricants, tools, etc.

9.2 **Hose**

9.2.1 The new hose must first be carefully measured and cut to length with a fine-tooth hacksaw or specialised cutting equipment, ensuring that the cut-ends are square and smooth. It should then be thoroughly cleaned and blown out with dry compressed air.

9.2.2 To minimise fraying when cutting off hose which has a cloth or metal sheath, it is advisable to wrap the hose with masking tape and saw through the tape.

9.2.3 High pressure hose usually has a metal braid sheath and, when this has a protective rubber cover, the cover must often be removed to enable the hose to enter the socket. Using a sharp knife, the cover should be cut off to the depth of the socket and the exposed braid carefully cleaned with a wire brush. Care must be taken to avoid damage or displacement of reinforcement wires.

9.3 **Fitting Sockets**

9.3.1 Sockets usually have a form of coarse left-hand internal thread to grip the outside of the hose and threads at the outer end of the bore which mate with threads on the nipple.

9.3.2 To prevent the ingress of moisture on hoses which have a metal braid sheath, it is sometimes recommended that a sealant is applied to the braid and socket bore before assembly.

9.3.3 Large bore hoses are quite rigid and, to facilitate entry of the nipple, it is often recommended that the hose is slightly flared and its bore carefully chamfered before assembly into the socket. Except where a sealant is specified, lubrication of the outer surface of large diameter hose will also ease its assembly into the socket.

9.3.4 Actual assembly of the hose and socket is carried out by holding the socket firmly in a vice and screwing the hose into the socket until it bottoms.

NOTE: Some manufacturers recommend that, after screwing the hose fully into the socket, it should be unscrewed a quarter turn to allow for expansion when the nipple is inserted.

9.3.5 After assembly of the hose to the socket it is recommended that the hose is marked with a grease pencil, paint or tape, at the point where it enters the socket, in order to provide a means of checking that the hose is not forced out of the socket during subsequent insertion of the nipple.

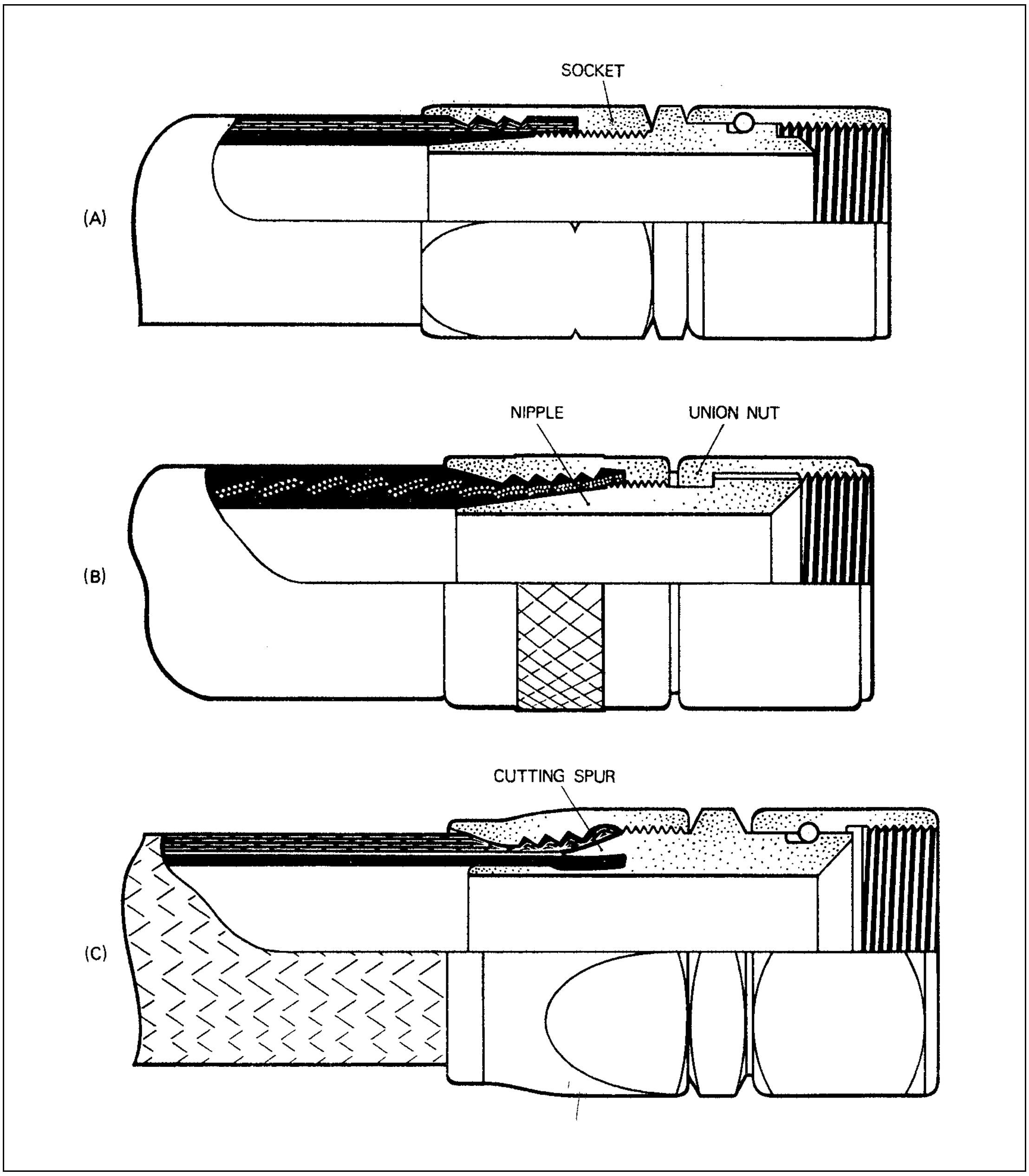

Figure 6 Typical Re-usable End Fittings

9.4 **Fitting Nipples**

9.4.1 To complete the hose assembly, nipples must be screwed into the previously assembled hose and socket. This operation must be carried out with extreme care, as misalignment of the nipple could easily result in its tapered end cutting into the hose wall; slices of rubber dislodged in this way have been known to cause malfunction of associated components.

9.4.2 Nipples are usually tapered over approximately half their length and are often provided with a plain pilot extension to guide the nipples accurately into the hose (Figure 7). When the nipple does not have a pilot extension, an assembly mandrel should be used and should extend at least 6 mm (¼in) beyond the end of the nipple. The assembly mandrel also acts as a means of turning a nipple which does not have an integral hexagon or flats.

NOTE: Because of their design, lip seal fittings do not require the use of an assembly mandrel.

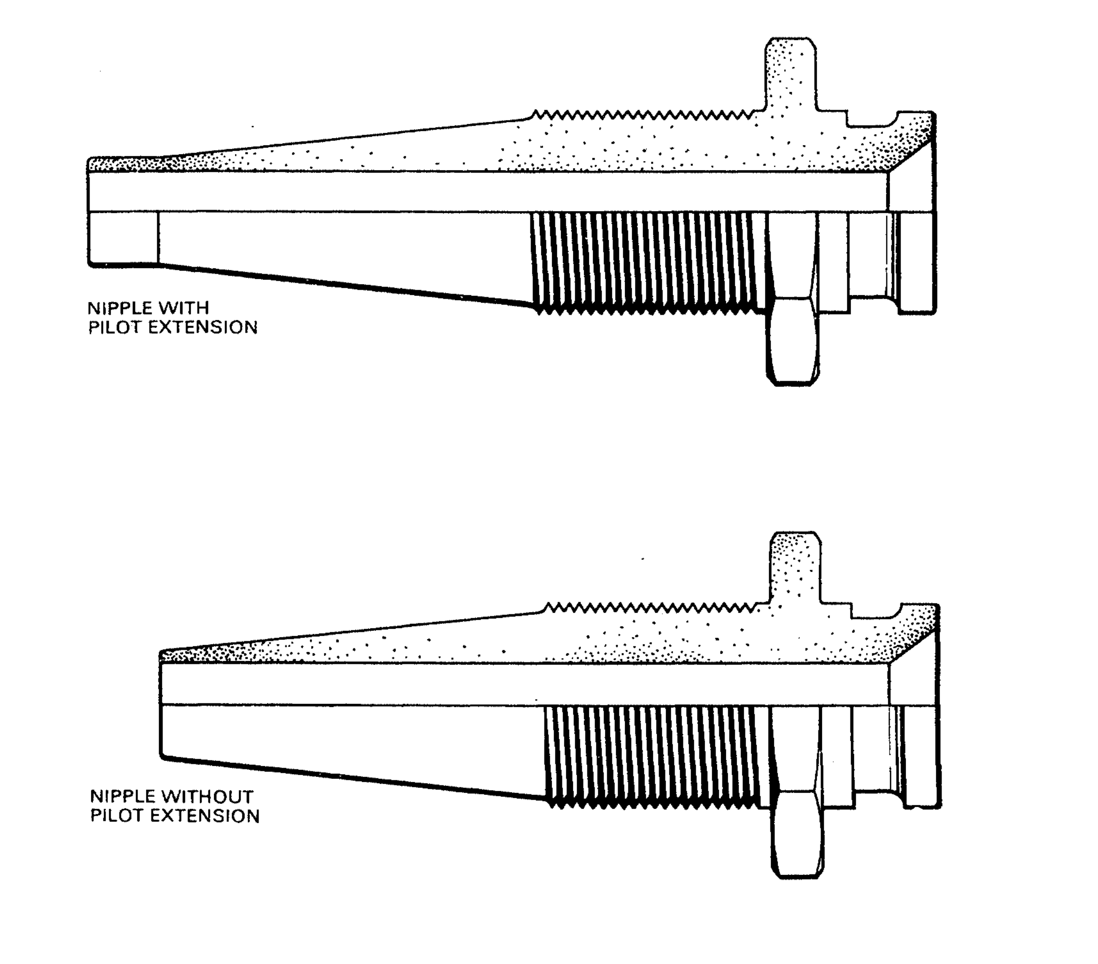

Figure 7 Nipple Characteristics

9.4.3 Angled nipples are always provided with a pilot extension because an assembly mandrel cannot be used, but some manufacturers recommend that a straight nipple should be partially inserted first, to ensure that a concentric thread is started in the hose bore.

9.4.4 To assemble a nipple, the hose and socket should be held in a vice and, where appropriate, the nipple screwed onto a mandrel of the correct size (Figure 8). The hose bore and nipple should then be liberally lubricated with the recommended lubricant and the nipple screwed carefully by hand into the hose and socket until the threads on the nipple engage with those in the socket. The nipple should then be screwed fully home by use of a spanner or tommy bar as appropriate. With the lip seal type of fitting the hose should be pressed firmly into the socket during this operation and particular care taken when engaging the socket threads.

9.4.5 Check by reference to the mark applied to the hose (paragraph 9.2.4) that the hose has not been pushed out of the socket during insertion of the nipple.

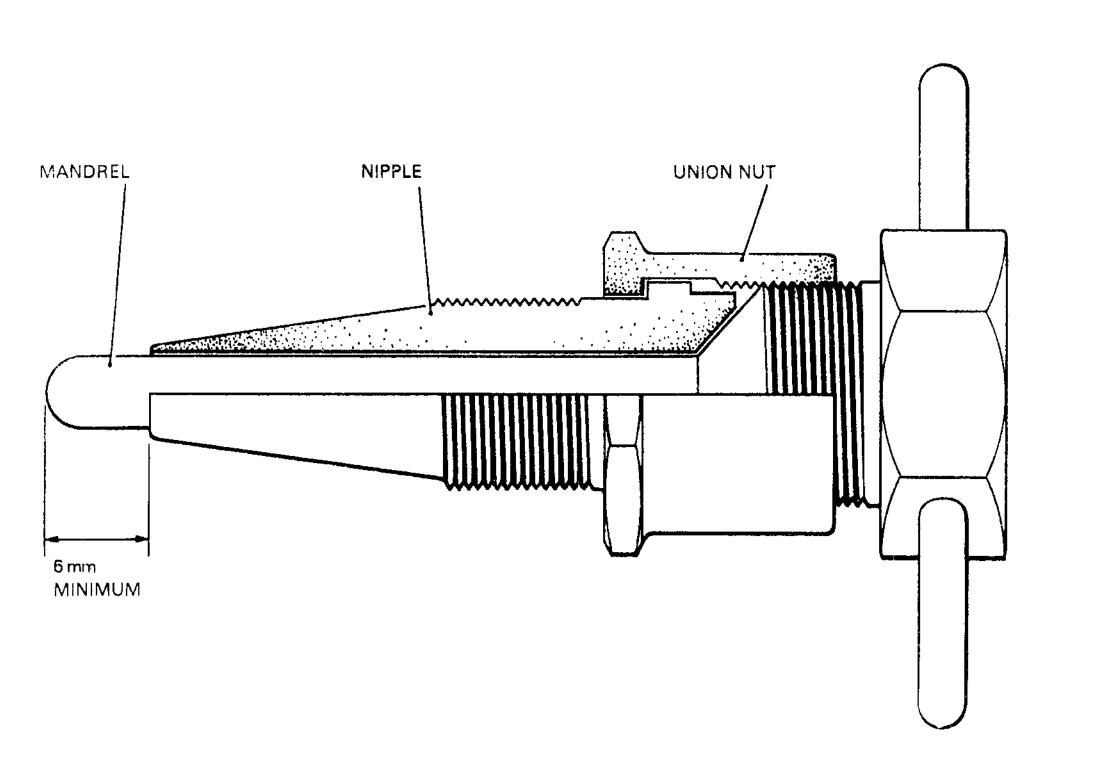

Figure 8 Assembly Mandrel

9.5 **Inspection**

9.5.1 Sockets and nipples which have been removed from an unserviceable hose should be inspected for damage and corrosion and any traces of hose adhering to the threads must be removed. Before re-using a lip-seal type of nipple all traces of rubber should be removed from under the lip and, subject to limitations laid down by the hose manufacturer, the lip should be restored to its original profile. After the hose assembly has been made up it should be thoroughly cleaned and dried, examined and pressure tested to 1½ times maximum system pressure, to ensure that it will withstand the pressure existing in the system with which it is to be used.

9.5.2 **External Inspection**

a) Check all metal parts for signs of damage, particularly of the union nuts and cone faces.

b) Check that the union nuts turn freely.

c) Check that the gap between the socket and union nut (or integral hexagon) is within limits.

d) Check the hose for damage at its point of entry into the socket.

9.5.3 **Internal Inspection**

Internal bulges and flaps can often be detected by looking through the hose with a light held at the opposite end, but a more satisfactory examination can be made using normal inspection equipment (e.g. an Introscope). Hoses which have straight nipples may be readily examined and hoses which have one angled nipple may be examined from the opposite end. Hoses which have an angled nipple at both ends, however, present difficulties and although radiological examination would show if the nipple had been assembled eccentrically it might not reveal damage to the hose bore and would in any case defeat the object of using re-usable fittings. In these cases either a ball test or a flow test is recommended.

a) **Ball Test**

i) With the hose assembly suspended from one end, a ball should pass freely through the assembly under its own weight and without lubrication. The check should be repeated from the opposite end and if the ball fails to pass through the hose in either direction the hose must be rejected as unserviceable.

NOTE: Precautions must be taken to ensure that a hose in which a ball has become lodged is not introduced into service; the hose should be cut immediately and the ball extracted.

ii) The diameter and material of the ball are specified by the hose manufacturer and vary with the design of the hose, but a steel ball having a diameter of approximately 90% of the bore of the end fittings is generally used.

NOTE: It is sometimes recommended that a rod should be used on small diameter hoses.

b) **Flow Test.** In some instances a ball test may be considered to be inadequate and it may be required to be demonstrated that the assembly is capable of passing a given quantity of fluid in the time and under the conditions specified.

9.5.4 **Pressure Test**

Hose assemblies with re-usable end fittings should be given pressure tests identical to those described in paragraph 8 for normal hose assemblies.

9.5.5 **Bonding Test**

Where hose assemblies have metal wire braid reinforcing or embody any form of metal in their manufacture (such as a wire spiral) a bonding test will be specified. An approved type of bonding tester should be used and the resistance recorded should not exceed 0·050 ohm or 0·025 ohm per foot length, whichever is the greater.

10 Flexible Metallic Hose Assemblies

10.1 This type of flexible hose is made entirely of metal, mainly stainless steel and must, therefore, be treated separately from the synthetic rubber and metal composite flexible hoses dealt with in the previous paragraphs.

10.2 **Manufacture**

10.2.1 Flexible metallic hose is manufactured from an annular or spirally convoluted, seamless, flexible inner tube, reinforced by an exterior covering of one or more layers of stainless wire braid.

10.2.2 **Reinforcing Overbraid**

Unless restrained by some means, the effect of internal pressure on the convulated tube would cause elongation and the convolutions would tend to flatten out. Such elongation is prevented by means of a layer, or layers, of wire braid, which is braided upon, or slipped over the inner tube and securely anchored at the end fittings. Special attention is given during the manufacture of the hose to braid tension, pitch angle and final diameter to ensure that change of length of the assembly under pressure is kept to a minimum. This practice obviates the possibility of premature fatigue failure induced by excessive 'panting' and, in addition, 'fretting' on the convolution crests is avoided.

10.2.3 **Function**

The wire overbraid counteracts any tendency of the inner tube to elongate under pressure by containing the end loads thus produced between the fittings. The overbraid also performs other important functions, such as providing protection against damage for the inner tube and by the exertion of a considerable damping influence on the inner tube when the assembly is under the effects of vibration and pressure impulse.

10.3 **End Fittings**

Various types of steel end fittings are available and are designed to effect a pressure-tight seal at the end of the hose. The seal is achieved by mechanical means or by brazing, silver soldering or welding the fitting to the tube. The end fitting also provides an anchorage for the wire braid to take the end loads caused by internal pressure.

10.4 **Storage**

Assemblies which are to be stored should preferably be left in the boxes in which they are received, but in any case they should have their sealed plastics envelopes intact. Under these conditions, the assemblies have no life limitations, provided that normal steps have been taken to prevent corrosion due to atmospheric conditions, physical damage, etc. It is also important in the event of the plastics envelope having been removed or damaged, to fit approved blanks; adhesive tape or rag should not be used.

10.5 **Identification**

Each assembly has a tag, brass band or adhesive label attached to it on which appears the part number of the assembly, the date of manufacture, the manufacturer’s name and inspector’s stamp.

10.6 **Pre-installation Check**

Before a hose assembly is fitted, the following checks should be made:

a) Verify the part number is correct to the drawing or the appropriate manual.

b) Remove the blanking plugs or caps and ensure that the end fittings are undamaged and free from corrosion. Special attention should be given to the seating faces.

c) As far as possible, examine the bore for corrosion.

d) Carry out the pre-installation pressure test, according to the instructions given on the drawing or in the manual.

NOTE: Prior to fitting, cleanliness of the assembly is imperative.

10.7 **Installation**

10.7.1 When 'offering-up' the hose assembly, particularly if considerable manipulation is required to fit it within a confined space, care must be taken to ensure that the minimum bend radius is not less than that specified. Flexible metallic assemblies comprise thin-section, highly-stressed metal components and it is imperative that they are not stressed beyond their elastic limits.

10.7.2 Union nuts at the end fittings should be hand-tightened at both ends and the hose should lie in a natural manner before the union nuts are finally tightened. Due to its manufacture, metallic hose will always tend to lie in its natural manner, but care is required to ensure that no twist is applied to the hose during final tightening.

a) Where provision is made for the use of two spanners, one on the end fitting and one on the union nut, a spanner should always be used on the end fitting to steady the assembly and prevent twisting of the hose on final tightening.

b) Where no provision is made for the use of a spanner on the end fitting, the hose should be firmly gripped by hand as near the end fitting as possible while the union nut is finally tightened.

c) After tightening of the union nuts, a hose assembly should always be checked to ensure freedom from twist and tension. It must also be ensured that the end fittings are relieved of the weight of the hose and its contents by suitable supports.

d) Thread lubricants should only be used if specified on the appropriate drawing or in the relevant manual (see paragraph 6.4).

10.7.3 **Flanges**

In the case of assemblies incorporating 'Vee' band flanges, the correct type of 'O' ring should be carefully positioned in the flange groove and the inner flange brought into alignment before placing the clamping device in position. This type of flange is produced both with and without means of positive lateral positioning – in the former case care must be exercised in engaging the spigot portion provided for the purpose.

10.7.4 **Supports**

Support clips, which may be either of the close-fitting type and support the hose positively, or of the loose guide type which will allow movement of the hose while containing it in a specific space, must be placed as prescribed on the appropriate drawing.

NOTE: Wire locking of union nuts should be made in the approved manner as described in Leaflet 2–5.

10.7.5 **Bonding**

After installation, a bonding check should be made between the assembly end fittings and between the end fittings and the components to which they are connected. The resistance should not exceed 0·050 ohm.

10.8 **Inspection**

10.8.1 When carrying out a visual inspection of flexible metallic hose assemblies installed on an aircraft, any of the following would be cause for rejection:

a) Signs of distortion or damage of the wire braiding, or of the braiding being pulled away from end fittings.

b) Leakage around end fittings.

NOTE: The hose should also be examined for signs of leakage at the lowest points in its run.

c) Abrasion of the hose caused by contact with adjacent components.

d) Signs of twisting of the assembly, generally visible as a distortion of the regular pattern of the overbraid in a helical direction.

e) Corrosion of the external surfaces of the hose end fittings.

f) Visible cracks or other damage pertaining to the end fittings.

NOTE: When hose assemblies are adjacent to the powerplant, a careful examination should be made for any discoloration caused by hot gas leaks which may occur at the shroud ring, exhaust cone or other parts of the engine.

10.8.2 Assemblies should be removed for detailed examination at the periods stated in the Maintenance Schedule or at any time the hose assembly becomes suspect. They should be immersed in a clean non-chlorinated solvent and thoroughly agitated to loosen any oils or deposits on internal and external surfaces and to assist in flushing any deposits clear of the convoluted bore and other parts such as elbow fittings, etc. After cleaning, the assemblies should be inspected as indicated in a) to f).

NOTE: It is important not to use any form of internal brushing such as the type used for rifle or tube bore cleaning, as this may cause damage to the inner diameter of the convolutions when the rod or brush is pushed into the bore.

a) Examine the end fittings for corrosion and damage.

b) Examine all welded or brazed joints for damage, cracks or corrosion.

c) Examine all threads for wear.

d) Check that all mating surfaces (nipple faces) are undamaged.

e) Examine the wire braid for chafing, dents and for looseness at end fittings.

f) Examine the hose for corrosion and discoloration due to overheating.

10.8.3 **Testing**

Assemblies which are considered satisfactory after examination as above should be pressure tested at room temperature using the following procedure:

a) Lay the assembly in a free position on a bench and couple it to a controlled pressure supply of a suitable test fluid, as defined by either manufacturer's requirements or hose usage. After washing through thoroughly, blank off the open end of the assembly. Unless otherwise stated on the appropriate drawing or in the relevant manual, it is usual to pressurise to 1½ times the system maximum working pressure. When the correct pressure has been reached, the pressure supply should be cut off and there should be no indication of a drop on the pressure gauge after a period of 5 minutes.

b) If the hose assembly is part of a pneumatic or air conditioning system, it should be connected to a suitably controlled pressure supply of clean dry air and immersed in clean water or other suitable liquid at a temperature of about 26°C. Air pressure should be applied slowly up to 1½ times the maximum working pressure of the system in which the assembly is used. The pressure should be maintained for 5 minutes and the assembly checked for any signs of bubbles indicating a leak.

NOTES:
1) Water at this temperature assists in the dispersion of any air bubbles trapped under the wire braiding, but the assembly should also be agitated.
2) In the case of hose assemblies with mechanically-attached end fittings, no attempt must be made to seal off a leak by further tightening of the fitting.

c) **Pressure Test Observations.** During operation a) and b) above, the assembly should be checked for the following:

i) Signs of leakage.

ii) Tube distortion under pressure.

iii) Movement of the wire braiding adjacent to its attachment to the end fittings.

d) After the assembly has been uncoupled from the test rig and allowed to remain unconfined for at least one hour, a length check should be made with reference to the length tolerances given on the appropriate drawing or in the relevant manual.

There may be a slight elongation, but if this is beyond acceptable limits, the assembly should be rejected and returned for investigation to the manufacturing organisation concerned.

e) **Ball Test**. A ball test should be carried out as detailed in paragraph 9.5.3 a), but where this is not possible a flow test should be made in accordance with the design requirements for the particular hose.

f) **Drying**. To avoid corrosion, assemblies which have undergone the tests mentioned in this paragraph (10·8.3) must be thoroughly dried by placing them in a forced-draught, hot-air oven for 30 minutes with the air temperature controlled at 100°C to 105°C and the longitudinal axes of the hoses in line with the air flow. However, if paraffin was used as the pressure testing medium, it is sufficient to vibrate and drain the hoses until dry.

g) **Test Identification**. Upon completion of testing, a further identification band or tag should be affixed to the assembly bearing the date of test and the inspection stamp. It is also recommended that an appropriate reference be made in the log book or other records.

Leaflet 5-6 Installation and Maintenance of Rigid Pipes

1 Introduction

1.1 This Leaflet provides guidance and advice on the installation and maintenance of rigid pipes in aircraft and should be read in conjunction with the relevant manuals and the installation drawings for the aircraft concerned.

1.2 Guidance on the installation and maintenance of hose and hose assemblies is given in Leaflet 5–5.

1.3 Information on the identification marking of system pipes is given in British Standard M23, entitled 'Identification Scheme for Pipe Lines'.

2 General

2.1 Certain requirements are general to the installation of all types of fluid systems, e.g. the need to avoid 'U' bends, the relief of pressure which may increase as the result of a temperature rise, the isolation of fuel pipes in certain areas and the need to reduce the possibility of incorrect assembly. All these factors are taken into consideration in the design of a fluid system, but maintenance personnel should also be thoroughly acquainted with the system on which they are working and aware of the problems associated with rigid pipes and their connections, so that any necessary inspection, maintenance or repair, can be carried out in a satisfactory manner.

2.2 Since fluid systems vary widely in purpose and design, it is essential that any work on a particular system is carried out strictly in accordance with the relevant Maintenance Manual.

3 Installation of Rigid Pipes

3.1 Pre-installation Checks

3.1.1 Before a pipe assembly is fitted into an aircraft, it should be checked to establish that it is of the specified type and that there is evidence of prior inspection and testing. The inspector's stamp should normally appear adjacent to the part number.

3.1.2 A pipe should be inspected for damage to the pipe itself, the end fittings and the protective treatment, for correct forming of the flared ends (or correct preset on flareless couplings) and for signs of external corrosion. If damage or deformation is suspected the pipe should be pressure tested or the roundness of the bore checked (as applicable). Such checks are extremely important, since dented or otherwise damaged pipes may cause a restriction to fluid flow which could have serious consequences. Where permitted in the Maintenance Manual, light external corrosion may be blended out and the protective treatment re-applied. Internal or deep corrosion would be causes of rejection of the assembly.

3.1.3 Dirt, swarf, dust, etc., introduced by fitting pipes which have not been adequately cleaned, may not only affect the various services of which the pipe system forms a part, but may increase the wear of the various components in the system and thus cause a malfunction. It is of the utmost importance, therefore, that adequate precautions are taken at all times to ensure the scrupulous cleanliness of individual pipes and the complete pipe system. Prior to assembly, all pipes should be blown out with clean, dry air and, where applicable, flushed with clean, filtered fluid of the type to be used in the particular system in which the pipes are to be installed. For pipes used in oxygen systems an additional approved degreasing process should also be used, since oil or grease in contact with oxygen under pressure may cause an explosion.

3.1.4 If a pipe is not to be installed immediately, its ends should be blanked following pre-installation inspection and tests, using the blanks fitted during storage or suitable alternatives. Plugs and blanks to standard specification are generally suitable for this purpose, but in instances where standard blanks cannot be fitted it must be ensured that the blank used is so made that it cannot be left in position when the pipe is installed. Rag, tape or paper should not be used for blanking purposes.

3.2 **Installation**

3.2.1 When transporting or carrying pipe assemblies, or moving them into position on the aircraft, care should be taken, particularly with long pipes of small diameter, not to damage them and to support them adequately so as to prevent distortion and kinking. Pipes should be loosely fitted into position in the supporting clamps (paragraph 3.2.2) and adjusted so that the connections meet correctly (paragraph 3.2.2). The connections should be completed, the clamps tightened and bonding attached as specified.

3.2.2 **Pipe Supports**

a) Multiple pipe clamps are used to support groups of pipes running adjacent to one another. These clamps are often made of red fibre, aluminium alloy, moulded rubber, nylon or other materials. The two halves of the clamps are usually joined together by bolts, which also serve to secure them to the aircraft structure. It is important to ensure that the semi-circular recesses in each half of a clamp mate correctly, do not have sharp edges and are of the correct size for the pipes they support.

b) In instances where packing is required between the pipes and clamps, the material used should be that specified in the relevant manual or drawing. Typical packing materials are cork sheet, tinned copper or stainless steel gauze and various types of tape or low-friction liners, but leather should not be used since it may cause corrosion of the pipes.

c) To ensure electrical continuity, some pipe clamps are self-bonding, but in other cases the use of metal gauze between the pipes and clamp may be specified. Bonding strips which bridge pipe connections are often used and should be assembled as specified in the relevant manual or drawing.

d) Where individual pipes require support, standard clips are usually specified and usually have a moulded rubber lining which obviates the need for packing. Where individual pipes run close together a double type of 'P' clip is often used to avoid contact between the pipes and to provide support.

e) A minimum clearance of 6 mm (0·25 in) from fixed structure, of 18 mm (0·75 in) from control rods and rigid moving parts and of 25 mm (1·0 in) from control cables, must be maintained, otherwise vibration and movement may cause chafing. Particular care is necessary to ensure that adequate clearance is maintained between pipes and moving parts and tests should be carried out to ensure that clearance is satisfactory throughout the full range of movement of the associated part. Consideration should also be given to effects which it may not be possible to simulate, such as an increase in tyre diameter due to centrifugal force, or in width due to ageing.

3.2.3 Connection of Pipes

a) When connecting pipes with standard brazed, flared or flareless couplings the following points should be verified:

   i) That union nuts rotate freely and can be withdrawn from the pipe end without being impeded by bends or other obstructions.

   ii) That all loose parts such as nipples, non-metallic glands, washers, etc., which form part of the coupling, are of the correct type and are correctly located.

   iii) That the pipe ends align correctly with their mating parts. Pipes should never be forced into position, since this may introduce considerable stress into the connection and result in subsequent leakage or fatigue damage.

   iv) That the pipes are not drawn into position by their union nuts, since this would impose a strain on the flare of a flared coupling or the sleeve of a flareless coupling and cause deformation of the pipe.

b) With pipes which have the compressed rubber gland type of coupling, the pipe end must be hard against the shoulder of the recess in the union adaptor before any attempt is made to tighten the union nut.

c) Where flexible hose is used to connect rigid pipes, it is essential that the correct type of hose is used, since some may not be compatible with the system fluid.

   i) It should be ensured that all sharp edges have been removed from the pipe ends and that, where specified, the pipe ends have been protected against corrosion.

   ii) A gap of 6 to 12 mm (0·25 to 0·5 in) should exist between the pipes to prevent contact when flexing occurs.

   iii) Hose clips should be of the correct size and type and should provide an adequate degree of adjustment for subsequent tightening. Care should be taken to ensure that clips are fitted on the side of the beading remote from the pipe ends and are accessible when all other systems have been installed.

   iv) If a hose proves difficult to assemble, it may usually be lubricated by system fluid. Care must be taken to ensure that pieces of hose are not cut or broken off during assembly and left in the pipe bore.

d) Two spanners should always be used when tightening (or disconnecting) a pipe coupling; one to hold the sleeve or adaptor and one to turn the union nut. Overtightening should be avoided since many standard pipe couplings are made of aluminium alloy, which can easily be strained. Any special tightening techniques or tightening torque values specified in the relevant publication should be carefully observed.

e) If lubrication of threads is specified to avoid 'pick-up', it is essential that the correct lubricant is used and that it does not enter the bore of the pipe. This is particularly important with couplings used in oxygen systems, where dry film lubricants requiring special application procedures are usually specified.

4 Tests After Installation

4.1 All pipes will have been pressure tested following manufacture, but it is usually necessary to carry out pressure and flow tests after installation of a pipe, to ensure that there are no leaks from the pipe and its connections and that, where essential to the correct operation of the associated system, the required flow rate is obtained.

4.2 Power for carrying out the tests may be provided by the aircraft engine-driven pumps or by an external test rig suitable for the system concerned. The tests should be carried out strictly in accordance with the relevant Maintenance Manual. Special note should also be taken of any precautions specified for the safety of personnel or the prevention of damage to the aircraft or its systems.

4.3 While the associated system is pressurised and while the services are being operated, the pipelines should be inspected for flexing or displacement to ensure that the required clearances are maintained. The pipe supports should also be checked for security of attachment and the pipes for local distortion at the clamping points.

4.4 Leakage from pipes in liquid systems (e.g. hydraulic systems) can usually be detected by careful visual inspection and leakage from gas systems (e.g. pneumatic systems) can usually be detected aurally or, after painting the pipes and connections with a solution of water and acid-free soap, be detected by the appearance of bubbles. If the soap solution is used it should be washed off immediately after the test.

4.5 If leakage from a connection is apparent, the connection may be tightened, but should not be over-tightened in an attempt to cure the leak. Leaks are often caused by solid particles at the mating faces of a joint, by misalignment of a nipple, or by damage to one of the components in the joint. Loosening and re-tightening of a coupling will often cure a leak but if it does not do so, the coupling should be disconnected and the cause of the leakage ascertained.

4.6 After all tests have been completed satisfactorily, it is important to ensure that any liquid which may have leaked or been spilled on the airframe structure or components, is removed. In addition to any fire hazard, aircraft liquids may also have deleterious effects on some of the alloys and compounds with which they come into contact.

4.7 Where the work of installing and testing a pipe is complete, the connections should, where applicable, be locked in the appropriate manner (see Leaflet 2–5).

5 Maintenance of Rigid Pipes

5.1 General

The maintenance of these components should be in accordance with the relevant Maintenance Manual, but the factors outlined in paragraphs 5.2 to 5.6 should be taken into account.

5.2 Location of Pipes

5.2.1 Pipes which are attached to the structure of an airframe may often be in a shielded position and will not normally be subject to accidental damage, but other pipes are located in exposed positions where they may be highly susceptible to damage or corrosion. Pipes located in a wheel bay, or attached to an undercarriage leg, could easily be damaged by stones, mud or detached rubber thrown up from the tyres or corroded by regular contact with water. In other positions pipes may be subject to abuse from carelessly performed, unrelated servicing activities. Special care must, therefore, be taken when inspecting pipes in exposed locations.

5.2.2 Chafing may occur under pipe clamps and clips, particularly where vibration is present. Pipes which have sharp bends and which are subject to high pressure pulsations tend to develop an oval section at the bend, which may eventually develop into a crack. The possibility of damage from both these causes should be considered when inspecting pipes in any location.

5.3 **Leaks**

The presence of a leak from a pipe connection in a liquid system will often be shown by the presence of liquid or an accumulation of dust or dirt on the outside of the pipe or connection. Leakage from a gas system may only be detected by the loss of system pressure, but the position of the leak may usually be detected as outlined in paragraph 4.4. The actions described in paragraph 4.5 should be taken to cure a leak, but if these are not effective the pipe assembly should be renewed.

5.4 **Damage**

Reference should be made to the relevant Maintenance Manual when assessing damage, since the acceptability may vary with particular materials and particular systems.

5.5 **Corrosion**

Corrosion may affect pipes of any material, particularly in exposed locations and in the areas of clips and supports, where moisture may be trapped. Corrosion products should be removed and the depth of any pits should be checked. Pipes which have corroded areas which cannot be blended out within the limits specified in the relevant Maintenance Manual should be renewed. If the corrosion can be removed satisfactorily, protective treatment should be re-applied to the affected areas.

5.6 **Rubber Hose Couplings**

5.6.1 Rubber hose couplings can be affected by expansion, contraction, vibration and heat and should be inspected regularly for deterioration and freedom from oil and grease. When couplings are removed from pipe ends it is essential that damage to the pipe be avoided; if the hose is stuck to the pipe it should be carefully cut axially with a sharp knife and peeled off.

5.6.2 Hose clips have a tendency to loosen subsequent to initial installation, due to compression of the rubber and may need to be re-tightened when they have been in service for a short period.

6 Repair of Rigid Pipes

6.1 Damage to rigid pipes which are outside the specified limits for acceptance damage, will usually necessitate the removal of the affected pipe and the fitting of a new or reconditioned item. However, in some cases repairs may be permitted, either by the insertion of a new portion of pipe or by the insertion of a coupling, depending on the extent of the damage. After repairs, the inspections and tests detailed in paragraph 4 should be carried out.

6.2 **Repairs using Standard Couplings**

6.2.1 These repairs will normally involve removal of the damaged pipe, since the pipe ends will have to be flared or flareless couplings fitted and will usually be applied only to straight sections of pipe. However, the addition of a pipe coupling could change the resonant frequency of that portion of pipe and this could lead to vibration and fatigue; these repairs should thus only be used when specified in the relevant Maintenance Manual.

6.2.2 A circumferential crack or deep score may be repaired by cutting out the small damaged section of pipe and inserting a union body and two connections. Care should be taken to ensure that the final length of pipe is correct and that the couplings will not foul parts of the structure when installed. The pipes should be thoroughly cleaned after preparation of the ends and pressure tested before re-installation.

6.2.3 If the damage is in excess of that which could be repaired as outlined in paragraph 6.2.2, the damaged portion of pipe should be cut out and a new section inserted, using two new union bodies and connections, or, if the damaged portion includes one existing end fitting, by replacing that fitting and joining the new section to the old with a union body and two connections. The precautions outlined in paragraph 6.2.2 should also be observed.

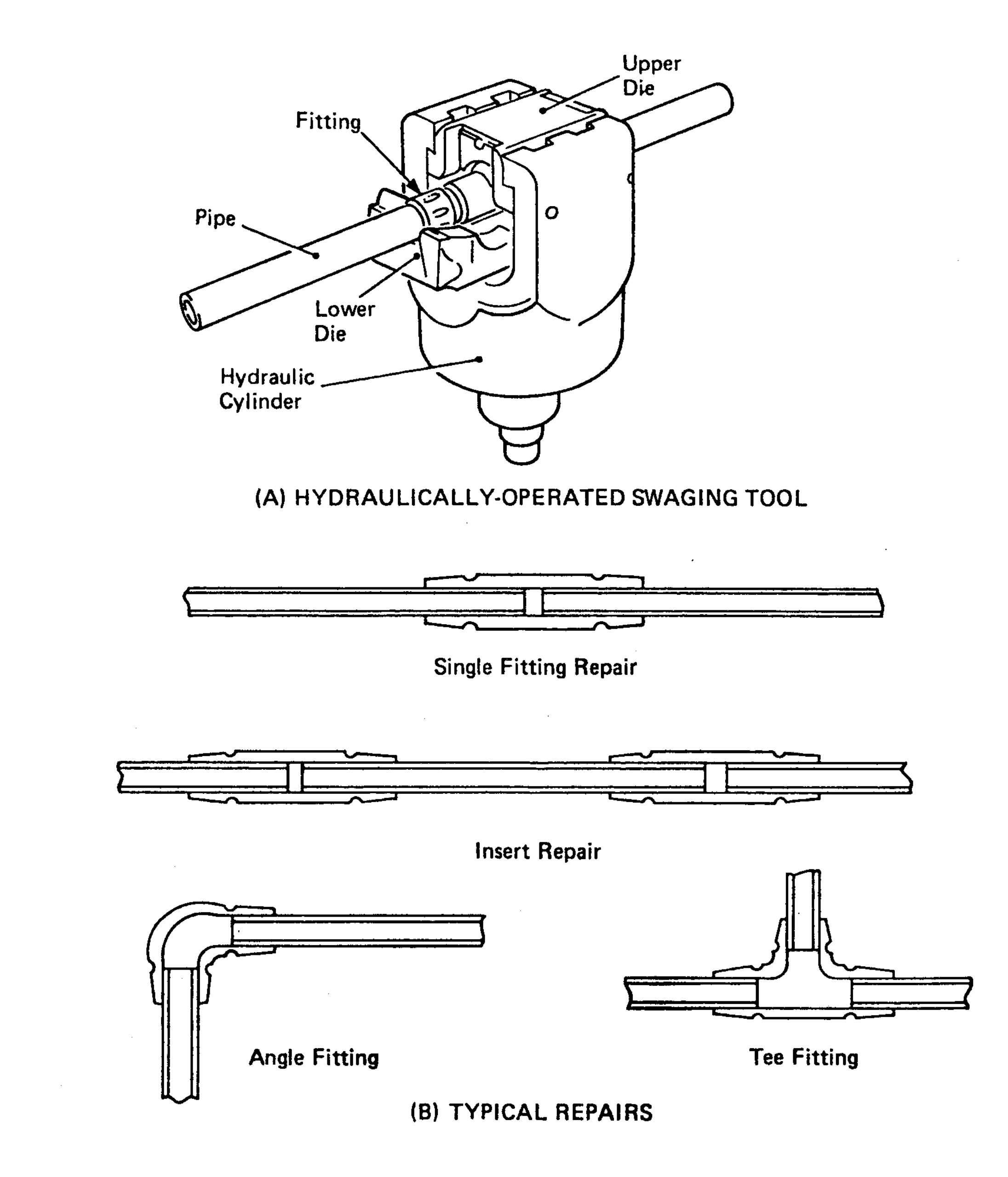

Figure 1 Tools and Typical Repairs for External Swaging Process

6.3 **Repairs using Swaged Fittings**

6.3.1 Some manufacturers specify the use of swaged fittings for carrying out in situ repairs to pipelines. Full details of the processes and of the type of swaged fittings to be used in a particular case are given in the relevant Maintenance Manual and all repairs should be carried out strictly in accordance with those instructions.

6.3.2 External Swaging Process

The damage which can be repaired by this process is broadly as outlined in paragraphs 6.2.2 and 6.2.3 and the repair consists of a tubular fitting which is swaged over a pipe joint. The gap between the pipe ends can be up to 8 mm (0·3 in), thus permitting a degree of latitude when replacing a damaged portion of pipe. Typical repairs are illustrated in Figure 1.

a) The equipment necessary for carrying out externally swaged repairs are available covering a range of pipe diameters and comprising a hydraulically operated swaging tool with pairs of dies to cover the range of pipe diameters, a ratchet pipe cutter and a deburring tool. Various marking gauges are also provided to enable fittings to be correctly positioned and GO/NO GO gauges enable checking of the swaging operation to be carried out.

b) The method of operation of the process is briefly as follows:

   i) Release pipe supports sufficiently to enable the repair to be carried out.

   ii) Select the repair kit appropriate to the pipe diameter.

   iii) Fit and operate the ratchet cutter to remove the damaged portion of pipe.

   iv) Using the deburring tool (which incorporates a rubber plug to prevent swarf being trapped in the pipe), remove the burrs and chamfer the pipe ends.

   v) Clean the pipe ends, then, using the appropriate gauge, mark the pipe so that the swage fitting can be correctly located.

   vi) Select and fit the appropriate fitting and position it over the ends of the pipes being joined.

   vii) Select the appropriate dies, fit them to the swaging tool, position the tool over the fitting and operate the tool in accordance with the manufacturer's instructions to complete the swaging operation.

   viii) Remove the swaging tool and dies and visually inspect the fitting for cracks. Check that the swaging operation is satisfactory by use of the GO/NO GO checking gauge provided.

6.3.3 Internal Swaging Process

The components used in this process are a male externally threaded fitting and a female fitting with either a separate or an attached union nut. This process can be used for repairing the type of damage outlined in paragraphs 6.2.2 and 6.2.3, or for repairing leaking or damaged couplings, using a special repair fitting with an extended barrel. The tools used and some typical repairs, are illustrated in Figure 2.

a) Swaging equipment is provided for each pipe diameter and wall thickness and consists of an expander, a die set, a holding collar and a set ring for checking the expander setting.

b) The method of operation of the process is briefly as follows:

   i) Release the pipe supports sufficiently to enable the repair to be carried out.

   ii) Remove the damaged portion of the pipe using a chipless cutter, then deburr the pipe ends using the tool provided. Clean the pipe ends.

   iii) Select the appropriate tools, check the fit of the holding collar and die set and check the setting of the expander with the associated set ring.

iv) Position the pipe in the fitting and ensure that it butts against the fitting shoulder. Mark the pipe at the end of the fitting for future reference (see 6.3.3 b) ix)).

v) Insert the expander into the pipe with the mandrel retracted and place the assembly in one die half. Push in the mandrel until it stops, then rotate it until finger tight.

vi) Fit the other die half and secure with the holding collar.

vii) Rotate the mandrel with a wrench or rotary tool until the mandrel contacts the stop sleeve, then rotate it a further 10 turns to complete the swaging operation.

viii) Loosen the mandrel and remove the swaging tools from the pipe.

ix) Visually inspect the fitting for damage and check the marking on the pipe to ensure that the fitting is correctly positioned. Measure the internal diameter of the swaged portion of the pipe to ensure that it is within the tolerance specified in the relevant manual.

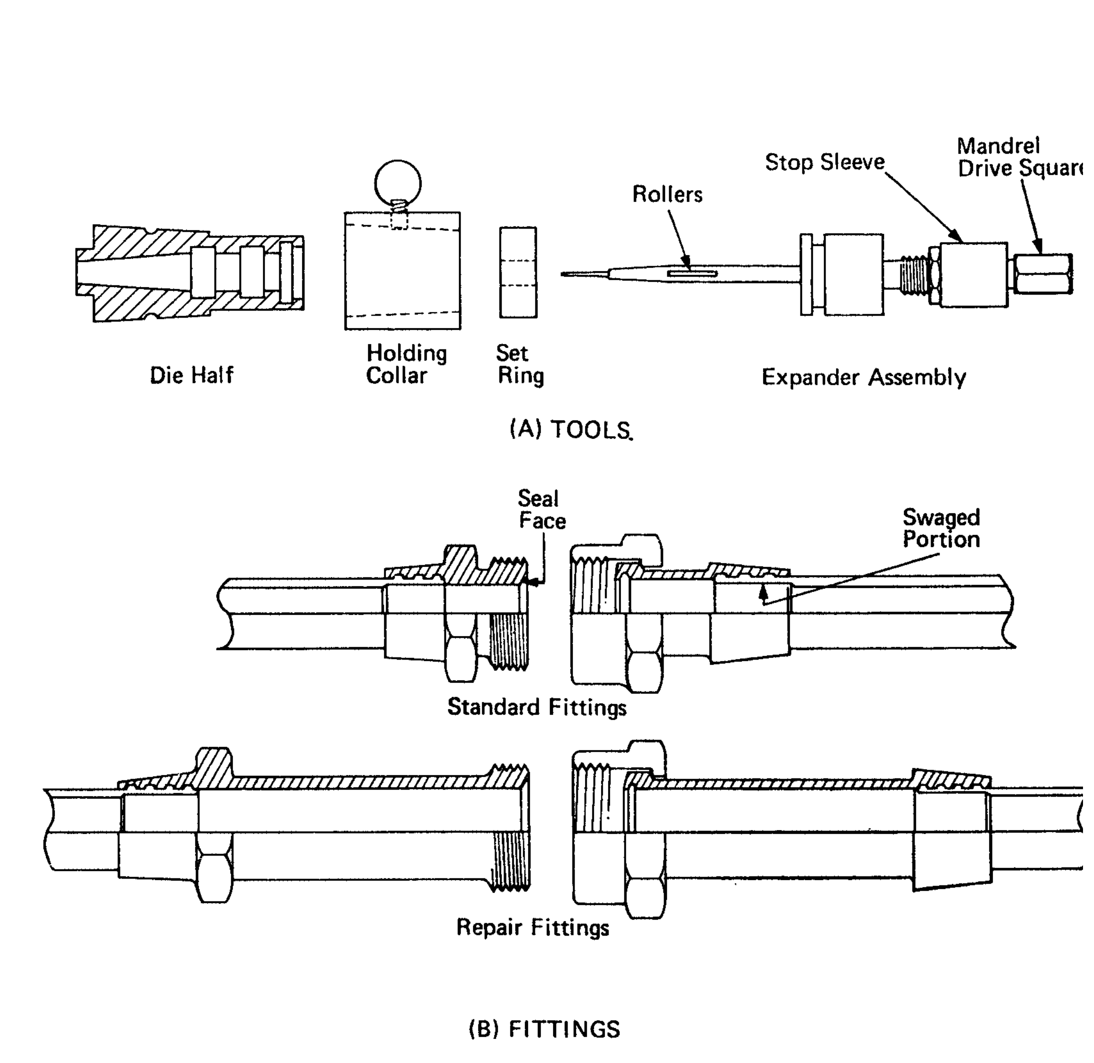

Figure 2 Tools and Typical Repairs for Internal Swaging Process

Leaflet 5-7 Tyres

1 Introduction

1.1 This Leaflet provides general guidance and advice on the care and maintenance of aircraft tyres. It should be read in conjunction with the manufacturer's manuals for the tyres concerned, since minor variations may occur between the various manufacturers' products. The topics discussed are as follows:

1.2 Information on the maintenance and overhaul of wheels and brakes is given in Leaflet 5–8.

1.3 The high take-off and landing speeds of most transport aircraft have resulted in tyres being operated under increasingly severe and intensive loading conditions, therefore a high standard of maintenance and inspection is essential at all times to ensure the continued serviceability of the tyres. The CAA recommends that, in all cases where doubt exists regarding the condition of aircraft tyres, the tyres should be changed and the tyre manufacturer's representative should be consulted.

2 General

2.1 Tubed Tyres

Tubed aircraft tyres consist of two component parts, i.e. inner tubes and outer tyres. The general manufacture of a typical tyre is shown in Figure 1, but the detailed manufacture varies considerably according to the manufacturer and the duties for which the tyre is intended.

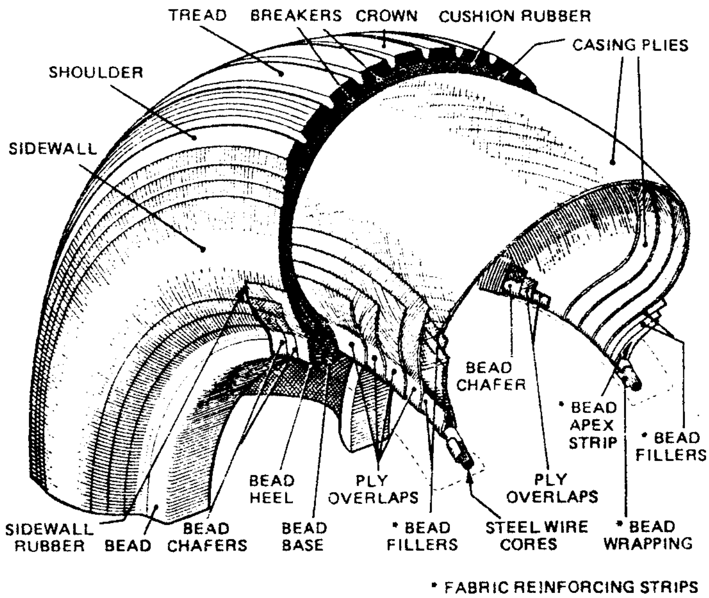

Figure 1 Manufacture of Typical Tubed Tyre

2.2 Tubeless Tyres

Basically a tubeless tyre is identical to a tubed tyre except that the tube is replaced by an air-retaining inner lining and the beads are designed to prevent air leakage at the rim of the wheel. Some of the advantages derived from the use of tubeless tyres include about 7½% saving in weight compared with using a tyre and tube, a reduction in permeability losses, cooler running by about 10°C, less danger of deflation due to puncture and the elimination of tube troubles. Because it is necessary to keep the bead areas in good condition, tubeless tyres are not fitted to well-base wheels.

2.3 High Pressure Tyres

Some aircraft tyres are inflated to pressures of 1400 kN/m^2 (200 lbf/in^2) or more. Because of their strength and rigidity, such tyres, whether tubed or tubeless, are normally fitted only to divided or detachable-flange wheels. Special precautions are necessary to protect personnel from injury during initial inflation (paragraph 7.1).

2.4 Tyre Venting

During manufacture all tubeless tyres are provided with vents by partially piercing the rubber covering with an awl (of approximately 1·5 mm (0·0625 in) diameter) at several places, usually around the tyre immediately outside the area of the wheel flanges, but, in some instances, also on the crown and shoulder areas. These vents are provided as a means of releasing air under pressure from the tyre casing and are marked with a green or grey spot. Such air may be residual air in the casing cords after manufacture, which is compressed to a high pressure on inflation of the tyre, or air which accumulates in the casing by normal permeation through the inner lining. If a free passage of air were not provided, the residual or permeating air could cause looseness or lifting of rubber on the tread or sidewalls of the tyre. Aircraft tyres to which tubes are fitted, are vented through the complete casing at the bead position in order to allow air trapped between the tube and tyre to escape.

2.5 Tread Patterns

2.5.1 The tread pattern on a tyre is usually designed to suit specific operating conditions, aircraft weights and aircraft take-off and landing speeds.

2.5.2 Ribbed (i.e. circumferentially grooved) tread tyres are probably used more than any other types and there are a number of variations on the basic pattern such as the number of ribs and the width of grooves. A ribbed tread provides a good combination of long tread wear, good traction and directional stability, particularly on hard surfaced runways.

2.5.3 Diamond pattern (or 'all-weather') tyres are also widely used and give good performance on all types of surfaces. They are particularly suitable for unpaved (e.g. turf or packed earth) airfields.

2.5.4 Plain tread was at one time very common, particularly on British aircraft, but has gradually been replaced by ribbed and diamond pattern treads. It is, however, still used on some light aircraft and helicopter tyres.

2.5.5 Some nosewheels are fitted with tyres having twin-contact tread, i.e. a tread consisting of a large circumferential rib at each side of the crown, which is designed to assist in preventing shimmy.

2.5.6 Some nosewheel tyres are also fitted with a water deflector (or 'chine') on the upper sidewall, to deflect water away from rear-mounted engines. This deflector may be on one side for twin-wheel installations or on both sides for single-wheel installations.

2.5.7 Water dispersing treads, which have many small holes incorporated in the crown and shoulder rubber, are also fairly common as a means of helping to prevent aquaplaning.

3 Tyre Markings

3.1 Tyres have certain markings imprinted on their sidewalls for identification purposes. These markings vary according to the manufacturer but usually include size, part number, serial number, date of manufacture, tubed/tubeless, speed rating, ply rating and the type and number of retreads carried out. These markings are explained in paragraphs 3.2 to 3.8.

3.2 Size

Tyres are identified for size in the following way:

Example: 26 x 10·00–18.

The first number (26) indicates the outside diameter (A in Figure 2) in inches.

The second number (10·00) indicates the width (C in Figure 2) in inches.

The third number (18) indicates the bead diameter (B in Figure 2) in inches.

It will be found that some tyres do not specify all three dimensions. Some tyres of American manufacture may quote only the outside diameter (e.g. 26) but otherwise the tyre width will always be stated, either preceded by the outside diameter (e.g. 26 x 10·00) or followed by the bead diameter (e.g. 10·00–18).

NOTE: Dimensions (A) and (C) may, alternatively, be quoted in millimetres.

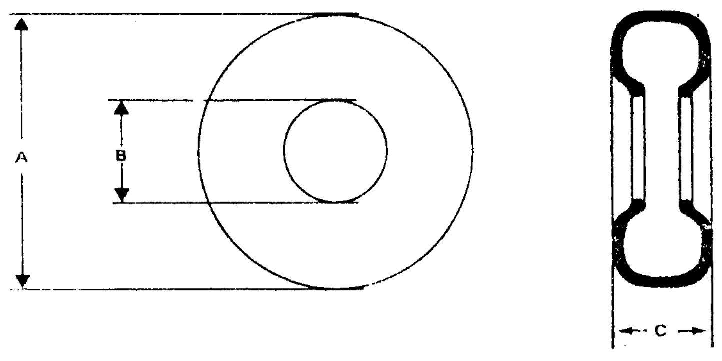

Figure 2 Tyre Dimensions

3.3 **Part Number**

The part number usually includes the manufacturer's identification, the drawing to which the tyre is manufactured and letters to indicate the tread type and whether it is tubed or tubeless. The part number is the only positive means of identifying a tyre and size markings alone should not be used for this purpose. Example: DR 7153 T.

3.4 **Serial Number**

The serial number is usually marked in conjunction with the date of manufacture, which may be in the form of a code indicating the day, week, or month and the year.

Example: 2283 Nov 72 or 23202283.

3.5 **Ply Rating**

The term 'ply rating' is used to identify a tyre with its maximum recommended load and pressure. It is the index of the tyre strength and does not necessarily represent the number of cord plies used in its manufacture. The marking may be imprinted in full, e.g. 10 PLY RATING, or abbreviated, e.g. 10PR.

3.6 **Speed Rating**

Most high speed tyres (i.e. those which may be used at speeds over 160 mile/h) have the speed rating imprinted on the tyre to indicate the maximum speed for which they are designed, e.g. 200 mile/h.

3.7 **Other Markings**

Other markings which may be found on new tyres include the following:

a) Military Stores Reference Number.

b) Green or grey spots indicating the positions of the awl vents.

c) A red spot or triangle indicating the light part of the tyre.

3.8 **Retreads**

Retreaded tyres are usually marked in accordance with a system peculiar to each manufacturer. The markings usually include the tyre part number, the name of the retreader, the number and date of the last retread and in the case of retreads in which the sidewalls are covered with new rubber, the tyre serial number, manufacturer, speed, size and ply rating.

4 Fitting Tubed Tyres

4.1 The successful fitting of tyres is not difficult provided that a suitable procedure is employed and the correct type of tool is used for each operation. However, careful attention to detail is essential throughout the process, since visual inspection after the tyre is fitted is obviously limited.

4.2 When a new tyre is required on those aircraft fitted with tubed tyres, it is advisable to fit a new tube since any stretching or local thinning present in the original tube may result in the formation of wrinkles during refitting, leading to early failure of the tube. If it is decided to refit the original tube it should be carefully examined for signs of damage or defects before refitting.

4.3 Care should be taken to ensure that the tyre and tube are of the correct size and of types authorised for use on the particular wheels of the particular aircraft. It is also important to ensure that the correct type of valve cap is fitted, since an incorrect type of cap may foul the airframe structure when the landing gear is retracted.

4.4 **Tyre Balance**

The balance of tyres and tubes is checked and brought within specified limits by the tyre manufacturer (often by the addition of a balancing patch). Where balance is not perfect the lighter side of the tyre is marked with one or two circular or triangular spots above the bead heel and the heavier side of the tube is marked with a red or yellow band approximately 10 mm (0·375 in) wide; fitting the tyre and tube with these markings together will achieve the best state of balance.

4.5 **General Fitting Precautions**

When fitting tyres and tubes to any type of wheel, the following general precautions should be observed:

a) Care must be taken to ensure that nothing is left inside the tyre, e.g. labels, paper or tools and that the rim of the wheel is clean, free from oil and grease and from damage which, apart from other considerations, might be harmful to the tyre or affect its form.

b) Wheels should be rested on rubber or felt mats to prevent damage during assembly.

c) The outer surface of the tube and the inner surface of the tyre should be dusted with French chalk, any excess being shaken off.

d) Tyre and tube balance marks (paragraph 4.4) should be aligned during assembly.

e) After fitting a tube into a tyre, the tube should be smoothed out with the hand to remove any creases; this will help to prevent the trapping of air inside the tyre during inflation.

f) Care should be taken to ensure that valves of the correct part number are fitted. The inflation valves for all high pressure tyres should have hexagonal valve caps and should be fitted with cores having stainless steel springs.

4.6 **Well-base Wheels**

4.6.1 **Preparation for Fitting**

When fitting a tyre to this type of wheel, all air should be expelled from the tube before it is fitted into the tyre. This should be done by removing the core from the valve and rolling the tube tightly until it is completely deflated; the core should then be refitted.

4.6.2 **Fitting the Lower Bead**

The tyre should be inclined to the wheel and the lower bead pushed on by hand to just over half-way, ensuring that the bead enters the well. The fitting of the bead should be completed in a series of small 'bites' with the appropriate lever, using water or an approved bead lubricant to facilitate fitting.

4.6.3 The tube should be placed on top of the tyre so that the position of the valve stem corresponds to the valve hole in the wheel. The valve-bearing portion of the tube should then be pushed into the tyre, the valve inserted into the valve hole and loosely secured with the valve cap or extension piece. Finally, the remainder of the tube should be pushed into the tyre and, after ensuring it is clear of the bead seat, inflated gently until it adopts its correct contour, so that it can be checked for freedom from twisting or creasing. While it is inflated, the position of the valve should be checked to ensure that it is concentric with the hole.

4.6.4 **Fitting the Top Bead**

The top bead should be fitted with the appropriate lever, ensuring that the bead section adjacent to the valve is the last to be fitted and using a lubricant as before. Care must be taken to ensure that the bead enters the well without nipping the tube.

4.6.5 After the tyre has been fitted it should be inflated to a pressure sufficient to position the beads on the bead seats. The tube should then be slowly deflated, care being taken not to disturb the bead positions and slowly re-inflated and tested as outlined in paragraphs 7 and 8 respectively. The purpose of deflation is to ensure that the tube adopts a position free from creases and that the minimum amount of air is trapped between the tyre and tube.

4.7 **Divided Wheels**

4.7.1 **Preparation for Fitting**

The wheel should be dismantled by removing the nuts, collars, locking plates and bolts and then the upper half of the wheel should be lifted off.

4.7.2 **Fitting the Tyre**

The tube should be placed in the tyre and then inflated until it just adopts its correct contour. Great care is necessary when fitting tyres to this type of wheel, since if the tube is not sufficiently inflated it may become trapped between the two halves of the wheel; conversely, if the tube is over-inflated, the halves of the wheel will not meet. The tyre, with the tube inflated as described above, should be placed on the lower half of the wheel, with the valve in alignment with the valve hole.

4.7.3 The upper half of the wheel should then be fitted, two opposite bolts being inserted to guide it into position; care should be taken to ensure the valve is centrally positioned in its hole. On pressing the two halves of the wheel together, a metallic noise should be heard when they meet; this is a good indication of whether or not the tube has been nipped. When it is ensured that the tube is not trapped, the remaining bolts should be inserted and the nuts fitted, but not tightened at this stage since tightening may cause the wheel to turn in the tyre and so damage the valve stem.

4.7.4 The tyre should now be inflated to a pressure sufficient to position the beads on the bead seats and as soon as one bead grips the wheel, the bolts should be progressively tightened, taking opposite bolts in a sequence similar to that shown in Figure 3. The final tightening should be in the order and to the torque values recommended by the manufacturer.

NOTE: If the tyre has fitting lines on its walls just above the wheel rim, these should be used as a guide to the correct fitting of the tyre.

4.7.5 The nuts should then be locked, as appropriate and the tyre inflated and tested as outlined in paragraphs 7 and 8 respectively.

4.8 Detachable Flange Wheels

4.8.1 Preparation for Fitting

The lock-ring and loose flange should be removed from the wheel, the method of removing the lock-ring depending on the type fitted.

a) To remove the split type lock-ring, a screwdriver should be inserted in the slot and, after the flange has been pushed inward and clear of the lock-ring, the lock-ring should be gently prised from the groove. Lock-rings of the coil type can be removed with the fingers.

b) When the flange has been removed, the wheel should be laid flat on a block to allow the tyre to drop to the full depth of the wheel.

4.8.2 Fitting the Tyre

The tube should be placed inside the tyre and inflated to shape, after which the tyre should be positioned on the wheel, care being taken to ensure that the valve is correctly positioned in relation to the valve slot.

4.8.3 The loose flange should be placed in position and pushed down clear of the lock-ring groove in the wheel; the lock-ring should then be fitted. If the lock-ring is of the split type, care must be taken to ensure that the collar, if fitted, is correctly positioned in the notches in the wheel and the flange. Coil type lock-rings must be fitted by hand. Finally, the tyre should be inflated and tested as outlined in paragraphs 7 and 8 respectively.

5 Fitting Tubeless Tyres

5.1 General

Prior to fitting the tyre, the wheel should be examined for scratches and other damage in the flange, bead seat and rim areas. Any damage should be blended out within the limits permitted by the relevant Maintenance or Overhaul Manual. The beads and inner liner of the tyre should be checked for damage and the wheel sealing ring should be checked for defects such as deformation, permanent set and ageing. The precautions outlined in paragraph 4.5 should be observed, as applicable.

5.2 Fitting the Tyre

5.2.1 The seal spigot joint faces of divided wheels and seal register area, should be cleaned and lightly lubricated with a preparation recommended by the manufacturer. The seal should then be stretched evenly onto the wheel, ensuring that it is seating correctly in its location groove.

5.2.2 The tyre bead and wheel bead seat areas should normally be kept dry, but some manufacturers permit or recommend the use of a bead lubricant to facilitate mounting. The tyre should be positioned on the wheel with the balance mark on the tyre in alignment with the balance marks (if any) on the wheel. When the wheel has no balance marks, the tyre balance mark should be aligned with the valve location.

NOTE: It is important that the tyre beads should not become contaminated with wheel grease.

5.2.3 With divided wheels, the bolt threads should be lightly lubricated with a grease recommended by the manufacturer and the bolts progressively tightened, in a sequence similar to that shown in Figure 3, to the recommended torque value. Wet assembly of the bolts may be specified by the manufacturer.

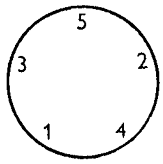

Figure 3 Tightening Sequence

5.2.4 With the valve core removed to permit the maximum flow of air, the tyre should be inflated as rapidly as possible to spread the tyre walls until the beads seat on the rim. Once this condition has been achieved, inflation should be discontinued immediately. If inflation cannot be effected, as a result of, for instance, tyre distortion caused by storage or transit, the assembly should be stood vertically and a load applied to the crown.

5.2.5 When the beads are correctly seated, the valve core should be refitted and the tyre should be inflated and pressure tested as outlined in paragraphs 7 and 8 respectively.

5.3 **Sidewall Valves**

Some tubeless tyres are fitted with a sidewall valve (Figure 4) which is in the form of a rubber self-sealing insert in the tyre wall. A central aperture in this insert permits the insertion of a servicing needle for inflation and deflation purposes. Before inflating a tyre of this type, the servicing needle must be inspected for cleanliness and lubricated with the felt pad contained in its sheath.

NOTE: Servicing needles should be inserted and removed using a twisting motion.

6 Wheels Suitable for Tubed or Tubeless Tyres

6.1 Detachable flange wheels are available to which either tubeless tyres or tubed tyres can be fitted. This is effected by means of special adaptors which permit an inflation valve assembly to be used for both purposes. For tubeless tyres the special adaptor is secured by a nut and washer and is made leakproof by a rubber 'O' ring clamped between the washer and the outer chamfered seating of the adaptor housing, as illustrated in Figure 5(A). For tubed tyres the adaptor is integral with the inner tube and is similarly secured by a nut and washer, but in this instance an additional rubber 'O' ring is fitted between the head of the adaptor and the inner chamfered seating of the adaptor housing, as shown in Figure 5(B).

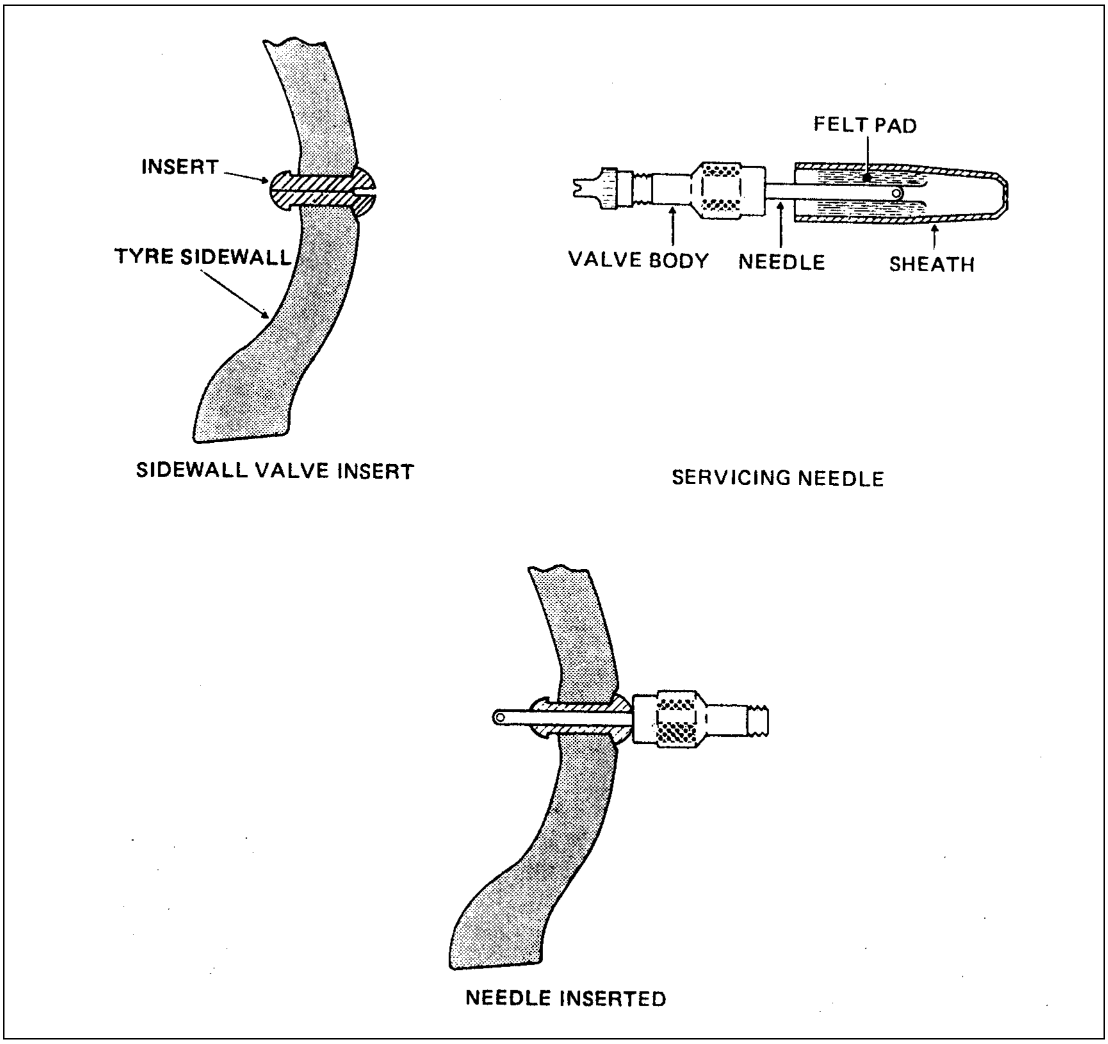

Figure 4 Sidewall Valve

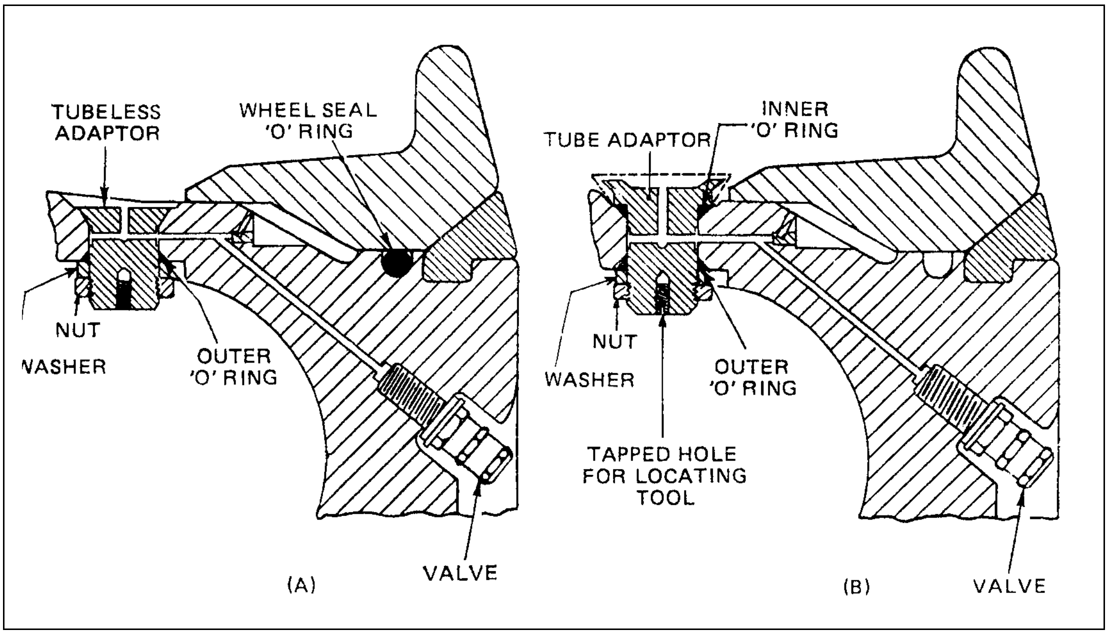

Figure 5 Adaptors For Combination Scheme

6.2 Fitting Tubeless Tyres

If the adaptor has been removed, ensure that its sealing face and also the sealing face of the wheel are not damaged or corroded. The adaptor should be placed in position and the outer 'O' ring should be lightly lubricated with an approved grease and carefully passed over the adaptor threads. The assembly should be secured to the wheel with the washer and nut and the adaptor should be wirelocked to its retaining nut. The tyre should be fitted as recommended in paragraph 5.2 and should be pressure tested as indicated in paragraph 8. If the duration pressure test (paragraph 8.3) is employed, the efficiency of the outer 'O' ring and the inflation valve seal should be checked by the local application of an acid-free soapy water solution (prepared with non-corrosive soap). After this test the solution must be washed off with clean water and the part thoroughly dried.

6.3 Fitting Tubed Tyres

6.3.1 The tube must be fully deflated (paragraph 4.5.1) before it is fitted into the tyre. The inner 'O' ring should be lightly lubricated with an approved grease and carefully passed over the adaptor threads until it seats around the shoulder adjacent to the tube.

6.3.2 The end of a special adaptor locating tool should be screwed into the end of the adaptor and the tyre should be placed on the wheel, aligning the adaptor with its housing.

6.3.3 The locating tool should be passed through the adaptor housing in the wheel and, after rechecking the alignment, the tyre should be fitted, ensuring that the adaptor remains located in its housing. Finally, the wheel should be assembled, but in this instance the 'O' ring between the loose flange and the wheel (Figure 5(B)) should not be fitted.

6.3.4 Assembling the Wheel

The wheel should be placed with the fixed flange upper-most and the adaptor should be pulled carefully into position. The outer 'O' ring should be greased and threaded over the locating tool, followed by the washer and nut, after which it should be passed carefully over the adaptor threads. The adaptor should be secured by finger-tightening the nut and the locating tool should be removed. The special retaining tool should be used to compress the inner 'O' ring, after which the adaptor nut should be fully tightened. The loose flange should then be fitted (paragraph 4.7.3).

6.3.5 Inflation and Testing

The tyre should be inflated (paragraph 7) and pressure tested (paragraph 8) and on completion of the test, the tightness of the adaptor nut should be rechecked, after which it should be wirelocked. The sealing efficiency of the outer 'O' ring should be checked by applying an acid-free soapy water solution over the crevices between the wheel, lock-ring and flange. The gap between the ends of the lock-rings should be blocked with rags or paper to prevent the solution draining into the wheel.

NOTE: This test on the inner 'O' ring should not be carried out until at least one hour after inflation in order to allow air trapped between the tyre and tube to escape first.

7 Inflation after Fitting

7.1 General

After fitting, both tubed and tubeless tyres should be inflated to the test pressure specified in the relevant manual.

7.2 A suitable supply of dry air or nitrogen should be connected to the valve; nitrogen is preferred (see CAP 747 Madatory Requirements for Airworthiness Generic Requirement (GR) No. 16), but air may be used provided that the moisture content, measured in the expanded condition, is less than 0·02 g/m^3. A screw-on type of connector should be used on tyres which are to be inflated to a pressure in excess of 700 kN/m^2 (100 lbf/in^2) and the tyre and wheel assembly should be contained within a safety cage to prevent injury to the operator.

7.3 All tyres should be inflated slowly and this is particularly important with tubed tyres. With tubed tyres, inflation to 140 kN/m^2 (20 lbf/in^2) should take at least two minutes and further inflation to full test pressure should take at least another four minutes. This procedure will reduce the possibility of trapping air between the tyre and tube.

8 Testing

8.1 The testing of either tubed or tubeless tyres should normally be by means of a duration pressure test, but an immersion test may sometimes be permitted on tubeless tyres when insufficient time is available. Pressure loss will occur on most tyres during a test, because of tyre stretch and will be most apparent during the first 12 hours; the figures quoted for the duration pressure test take account of this loss.

8.2 **Venting**

With a tubeless tyre, venting from the awl vents (paragraph 2.4) occurs in three stages. The first stage of venting results from residual air in the casing and may be fairly rapid, but virtually ceases after 20 minutes. The second stage is a slow seepage of residual air from the casing and may last for several hours. The third stage is a continuing process and results from normal permeation through the inner lining. Tubeless tyres should, therefore, be tested after the first stage of venting has ceased, or misleading results could be obtained.

8.3 **Duration Pressure Test**

This test should normally be carried out as follows:

a) The valve cap should be removed and the valve checked for leakage.

b) The actual tyre pressure should be checked and recorded.

c) The assembly should be left for 12 hours and the pressure should again be checked and recorded.

d) If the loss in pressure from that originally recorded exceeds 10% the assembly should be rejected. If the loss in pressure is less than 10% the tyre should be re-inflated to the original pressure.

e) The assembly should be left for a further 12 hours and the pressure again checked and recorded.

f) If the pressure loss is more than 2½% the assembly should be rejected, but if less than 2½% the assembly may be considered serviceable and returned to service.

NOTE: When recording tyre pressures allowance should be made for changes in ambient temperature. A temperature change of 3°C will result in approximately a 1% change in pressure. Application of the tyre pressure gauge will also result in a slight loss of pressure.

8.4 **Immersion Test**

After the first stage of venting, i.e. 20 minutes after inflation, the wheel and tyre should be mounted on a suitable bar and suspended in a tank of water so that the water covers the lower cross-section of the tyre and valve, but does not reach the wheel bearings. The wheel should then be slowly rotated and checked for leakage from the bead seats, seal area, valve, fusible plugs (see CAAIP Leaflet 5–8) and wheel hub. A continuous stream of bubbles from any of these areas is cause for rejection. After testing, the wheel and tyre assembly should be thoroughly dried, using a jet of compressed air.

8.5 After tests have been satisfactorily carried out, the pressure should be reduced to 20% of unloaded inflation pressure for storage and transit and the valve cap should be refitted and tightened to the specified torque value.

9 Tyre Creep

9.1 When wheels are first fitted to an aircraft, the tyres tend to move slightly as they settle down on the rims, the initial movement varying according to load, pressure, braking, shimmy and outside diameter of the tyre in relation to rim diameter. After the settling down period, circumferential movement may continue gradually and, if this extends beyond a certain limit, the valve may be torn from the tube.

9.2 In order that creep may be detected, marks are moulded into the lower wall of most tyres. The marks usually consist of two arrows, spaced 25 mm (1 in) apart on tyres up to 600 mm (24 in) nominal outside diameter and 38 mm (1·5 in) apart for all larger tyres. The marks usually commence at the wheel rim and extend outward, the surface between being knurled.

9.3 The knurled surface should be painted white, the paint mark being carried down onto the rim. The width of this mark represents the maximum circumferential movement permitted with tubed tyres and if the tyre creep mark becomes out of alignment with the mark on the wheel by more than the width of the mark, the wheel should be removed and the tyre and tube taken off and reassembled; before reassembly, the valve should be checked to ensure that it is undamaged. In the case of tubeless tyres, creep is not considered to be detrimental provided that bead condition is satisfactory and any pressure loss is within limits.

9.4 When tyre replacements are made, the old marking on the wheel should be removed with a suitable solvent and a new creep mark applied.

10 Maintenance of Tyres

10.1 Unsatisfactory tyre maintenance can significantly affect tyre performance and reliability and jeopardise aircraft safety. Serious accidents and incidents have occurred when engine, airframe and aircraft systems have suffered damage as a result of neglected or incorrect tyre maintenance. Various studies indicate that a significant number of tyre failures and premature removals could have been prevented by careful attention to recommended tyre maintenance procedures and practices.

NOTE: Where removal of a tyre is recommended in this paragraph, it should be understood that this implies removal of the tyre and wheel assembly from the aircraft.

10.2 **Tyre Pressures**

10.2.1 The importance of keeping tyres inflated to the correct pressure cannot be overstated. Underinflated tyres may creep to such an extent that the valve could be torn out, causing the tyre to deflate rapidly, whilst over-inflation can cause excessive vibration when taxying, uneven tyre wear and high pressure bursts. In addition, where two wheels and tyres are mounted on the same axle, unequal tyre pressures will result in one tyre carrying a greater share of the load than the other, with possible operation above its rated capacity; the undercarriage may also be subject to additional stress.

10.2.2 Tyre manufacturers specify a rated inflation pressure for each tyre, which applies to a cold tyre not carrying any load. The pressure to which a tyre should be inflated when it is subject to aircraft weight, is determined by adding a pressure allowance (normally 4%) to the rated inflation pressure. A tolerance of 5% to 10% above the loaded inflation pressure is generally specified and tyre pressures up to this maximum are permitted and may benefit tyre reliability. The loaded inflation pressures for the tyres on a particular aircraft may be specified in the relevant Maintenance Manual as the maximum and minimum pressures permitted, or in the form of a graph with pressure being a function of aircraft weight.

10.2.3 After an aircraft has landed, or has been subject to prolonged taxying, individual tyre pressures may vary because of the absorption of energy by the tyre and heat transfer from the brake units and a pressure rise of up to 10% can be expected. This pressure should not be reduced to normal working pressure as this could result in under-inflation at normal temperatures.

10.3 Inflation Procedures

10.3.1 Dry air or nitrogen should be used for inflating all tyres and the applicable precautions outlined in paragraph 7 should be observed. The particular gas specified by the aircraft manufacturer should always be used and should not be mixed with the alternative unless specifically authorised (see CAP 747 GR No. 16). If a dial-type gauge is used, the required inflation pressure should register in the centre of the dial; all gauges should be checked for accuracy at frequent intervals. When using a high pressure storage bottle, a pressure reducing valve must be incorporated in the delivery line.

10.3.2 The normal procedure for inflating a tyre is as follows:

a) Check the pressure required by reference to the aircraft Maintenance Manual.

b) Remove the valve cap and connect the supply to the valve (ensuring that a screw-on connector is used for pressures above 700 kN/m^2 (100 lbf/in^2)).

c) Adjust the regulator on the inflation trolley to the required pressure.

d) Slowly inflate the tyre to the required pressure.

e) Disconnect the supply, check the valve for leakage, then refit the valve cap.

10.3.3 Cold Tyres

When checking the pressure of tyres which are at ambient temperature, any tyre which is more than 10% below loaded inflation pressure should be rejected, together with the companion tyre on the same axle. Any tyre which is between 5% and 10% below loaded inflation pressure should be re-inflated to the correct pressure and checked at the next daily check; if the pressure is again more than 5% low the tyre should be rejected.

10.3.4 Hot Tyres

It may often be necessary to check the pressures of tyres which are still hot following a landing. The pressure of each tyre should be checked and noted and compared with the pressures of the other tyres on the same undercarriage leg. Any tyre with a pressure of 10% or more below the maximum recorded on the same leg should be re-inflated to that maximum pressure but should be rejected if a similar loss is apparent at the next check.

10.4 Examination of Fitted Tyres

10.4.1 A careful visual examination of tyres should be carried out prior to each flight, rotating the wheels wherever possible to ensure that the whole surface of the tyre is checked. Manufacturers prescribe limits of damage within which a tyre may be kept in service; tyres damaged in excess of these limits should be removed from the aircraft and repaired or scrapped as appropriate. The following paragraphs summarise the actions which should be carried out.

10.4.2 Embedded Stones, Flints and Glass

The outer surface of the tyre should be examined for embedded objects and any found should be carefully removed.

10.4.3 Cuts and Scores

All cuts should be probed with a suitable blunt tool in order to assess the depth and extent of any damage to the casing. Minor damage may be defined as that which does not affect the casing cord: cuts in both the tread and side rubber, providing they do not expose the casing cord, do not appreciably weaken the tyre. Such defects should be filled with a tyre dough compound, since continued exposure permits the entry of water and grit, which tends to cause chafing and rotting. Tyres damaged beyond the limits described above should be rejected.

10.4.4 Bulges

The presence of bulges may indicate a partial failure of the casing and the tyre should be removed for further examination. If it is obvious that the casing has failed, i.e. if the fabric is fractured, the tyre should be rejected, but if not it should be returned to the manufacturer for possible repair.

10.4.5 Wear

The extent to which tread has been removed from a tyre is not always easy to assess and may be either general or local; methods of indicating wear are shown in Figure 6. Local wear may be in the form of a 'flat spot' caused by severe abrasion or skid burns and these may occur as a result of excessive braking, hard touch-downs or aquaplaning. The probability of aquaplaning increases as the depth of tread is reduced. It is recommended that tyres be removed when wear has reached the limits defined below:

a) Patterned tread tyres may be used until the tread is worn to the depth of the pattern.

b) Ribbed tyres with marker tie bars may be used until worn to the top of the tie bars.

c) Ribbed tyres without marker tie bars may be used until worn to within 2 mm (0·080 in) of the bottom of the wear indicator grooves.

d) Twin contact tyres may be used until the centre of the crown shows sign of having been in contact with the ground.

e) Plain tread tyres may be used until either the grey cushion rubber is exposed (on early tyres only), or when the shape of the casing cords can be seen through the cushion rubber.

NOTE: On tyres with reinforced tread, several layers of fabric are moulded into the tread rubber and will become visible during normal use; the threads so exposed should not be confused with the casing cords. These tyres are provided with marker tie bars which should be used to assess the wear as in b).

10.4.6 **Creep**

Tyre creep should be dealt with as indicated in paragraph 9.

10.4.7 **Sponginess**

Tyres which are only slightly affected by fuel, oil or glycol and which, after being wiped and allowed to dry, show no appreciable signs of swelling or softening, may be considered serviceable; tyres affected beyond this stage should be rejected.

10.4.8 **Flat Spots on Nylon Tyres**

Tyres having nylon casings may, due to their lack of elasticity, develop a temporary 'flat spot'. This should not be confused with the flat worn on the tread as described in paragraph 10.4.5 but is caused by the local relief of tension in the cords at that section of the tyre and is usually the result of the tyre being subjected to static load for a lengthy period.

a) Stretch of the nylon cords is considerable and progressive and when the load is removed the cords do not immediately resume a tension equal to that of the cords in the rest of the casing.

b) Normally the flat spot works itself out during the period of taxying before take-off, but should this not be the case, the tyre will be out of balance and set up vibration in the aircraft during take-off.

c) Precautions against the occurrence of flat spots can, however, be taken; these include occasionally moving aircraft which are to be stationary for lengthy periods in order to transfer the load to different sections of the tyres.

d) If a flat spot has developed, it can normally be remedied by rolling or taxying the aircraft for a short distance.

10.4.9 **Heat Transmission**

On aircraft main wheels, excessive braking may result in the transmission of heat to the beads of the tyres. If this is evident from indications of excessive heat on the wheels (such as discolouration, paint flaking or melting of fusible plugs) the tyres should be carefully examined. The results of overheating are indicated by 'tackiness' of the tyre bead and, in severe cases, a deposit from the tyre will adhere to the wheel flanges and bead seats. Tyres affected in this manner should be rejected.

10.4.10 **Deflated Tyres**

Tyres which have been under load while in a deflated condition should be removed from the aircraft. If the aircraft has taxied with a tyre in this condition, the deflated tyre and its axle companion should be scrapped, but if a single tyre deflates while static (except when deflated for servicing purposes) it should be removed and inspected in accordance with the relevant Maintenance Manual. If more than one of the tyres on a multi-wheel undercarriage are found to have been run in a deflated condition, all the tyres on that undercarriage should be scrapped.

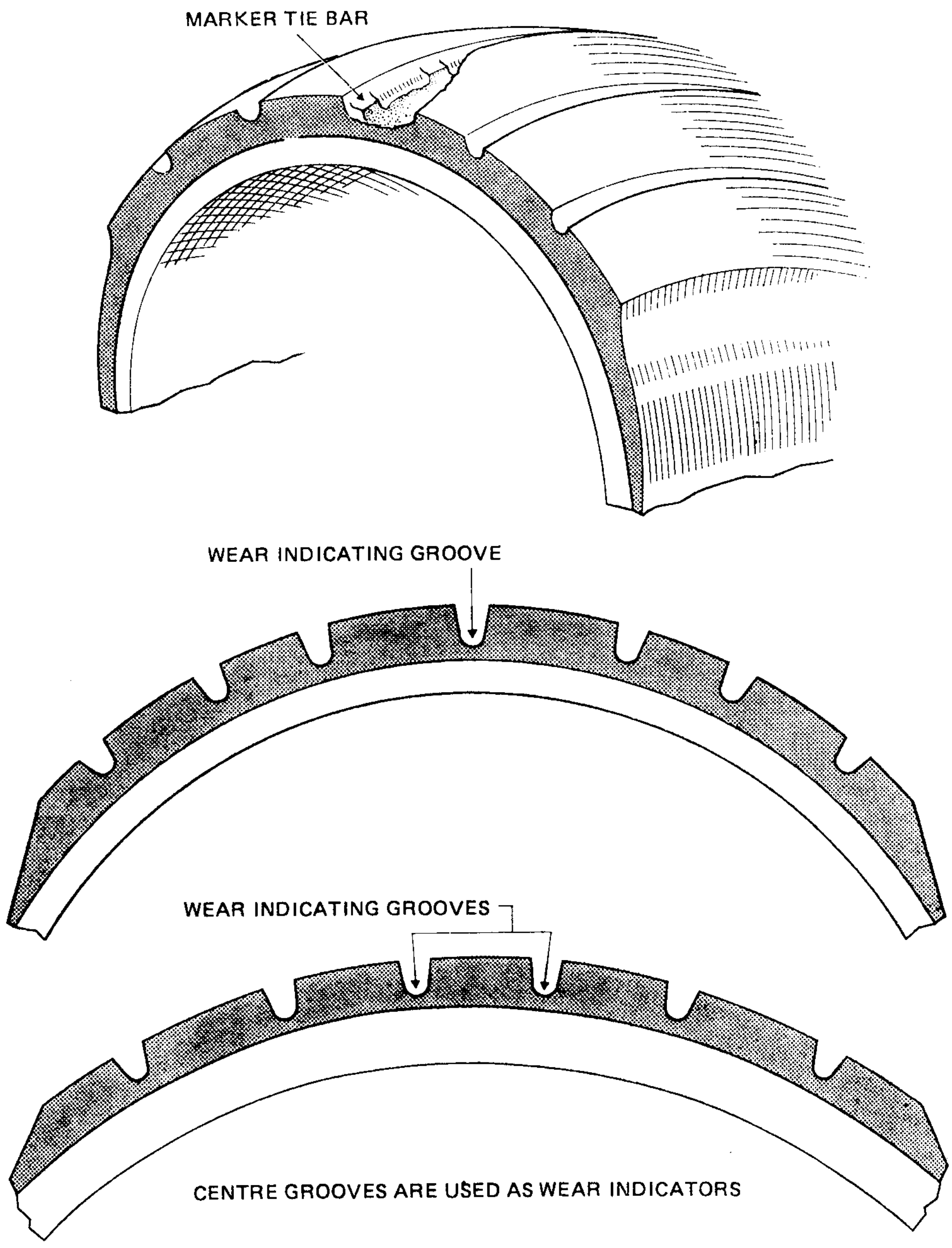

Figure 6 Indication of Tyre Wear

10.4.11 **Rejected Take-offs**

A rejected take-off at high energy levels may have resulted in the overstressing or overheating of all the main wheel tyres, although no evidence of damage may be visible. Reference should be made to the relevant Maintenance Manual for guidance on the action to be taken.

10.4.12 **Replacement Tyres**

New and retreaded tyres have slight differences in external diameters and replacement tyre and wheel assemblies for twin or multi-wheel undercarriages should be selectively fitted to ensure that both or all tyres take an equal share of the load.

10.5 **Protection**

Tyres must be protected from excessive heat, dampness and bright light and from fluids such as oil, fuel, glycol and hydraulic fluid, since all of these have a harmful effect on the rubber. If the aircraft is to be parked for any length of time, or if any of the above-mentioned systems are to be drained, an oilskin cover should be placed over the tyre. Any fluid inadvertently spilt or allowed to drip onto the tyre should be wiped off immediately.

11 Removing Tyres

11.1 Defects in tyres, particularly those which would be difficult to find once the air pressure is released, should be marked with wax crayon before the tyre is removed. It is recommended that the tyre pressure should always be reduced before removing a wheel from an aircraft and that a screw-on type deflator is used to deflate a tyre or tube.

11.2 **Tubed Tyres**

11.2.1 **Well-base Wheels**

a) The tube should be deflated and the valve core removed; the bead should then be unseated by levering it away from the rim of the wheel on the valve side.

b) The valve should be pushed in and tucked away under the tyre, the bead being levered off by commencing at approximately 60° from the valve and working away from it, using levers lubricated with acid-free soapy water.

c) The wheel should be turned over and the other bead unseated as in a). Some difficulty may be experienced in levering the bead from the rim on this side of the wheel, owing to the heat generated by the brakes. In this instance also, the levers should be lubricated with acid-free soapy water.

d) The tube should be removed by grasping it diametrically opposite the valve and pulling it out of the tyre, the valve being the last part of the tube to emerge.

e) The bead should be pressed into the well of the wheel and a lever placed between the bead and the wheel flange with its tip positioned at the valve hole. When pressure is applied to the lever, the tyre should come off quite easily.

11.2.2 **Divided Wheels**

Great care must be taken to ensure that the tyre is completely deflated before any attempt is made to remove the loose members (see also paragraph 11.4).

a) The tube should be deflated and the valve core removed; the bead opposite to the valve should be unseated by levering it away from the wheel rim, using acid-free soapy water as a lubricant.

b) The second bead should be unseated in a manner similar to that used for the first bead and the bolts should be removed from the wheel.

c) An aligning mark, to assist reassembly, should be placed on both halves of the wheel below the valve, after which the upper half of the wheel should be lifted off and the tyre removed.

d) If a tyre is not to be fitted to the wheel immediately, the wheel should be reassembled.

11.2.3 Detachable Flange Wheels

Great care must be taken to ensure that the tyres are completely deflated before any attempt is made to remove the loose members. (See also paragraph 11.4).

a) The tube should be deflated and the valve core and flange locking device removed; the detachable flange may then be levered away from the tyre bead. The wheel should be turned over and the second bead loosened, after which the tyre and tube should be removed from the hub, care being taken to ensure the tube valve is not damaged in the process.

b) If a tyre is not to be fitted to the wheel immediately, the wheel should be reassembled.

11.2.4 Wheels Embodying Combination Adaptor Scheme

Deflate the tyre by removing the valve cap and core, but before attempting to remove the flange and locking device, remove the adaptor nut, washer and outer 'O' ring. The adaptor should be pushed well into the tyre with a blunt wooden probe to avoid the possibility of damage to the adaptor during dismantling. The wheel and tyre assembly may then be dismantled as outlined in paragraph 11.2.3.

11.3 Tubeless Tyres

The tyre should be deflated and the valve core removed, or, where a sidewall valve is used, deflated by removing the core from the servicing needle and inserting the needle in the valve insert. The valve core and cap should be refitted or the servicing needle removed as appropriate. The beads should be unseated from the taper bead seat by means of a special tyre removal machine which exerts an even pressure circumferentially round the wheel on both sides of the tyre. Sharp tools or tyre levers must not be used to unseat the beads as this may impair the sealing properties of the tyre and wheel. Finally, the wheel assembly should be dismantled according to its type and the rubber sealing rings removed.

11.4 High Pressure Tyres

During deflation of these tyres the valve stem may become blocked with pieces of ice. The use of probing devices to remove the ice is unnecessary, since the ice formation will break down under normal ambient temperatures, permitting the further passage of air. However, it must be noted that blockage of the valve by ice may take place several times during deflation and it is essential to allow sufficient time to elapse between the removal of the valve core and the commencement of dismantling to ensure that the air has been completely exhausted.

12 Inspection of Tyres and Tubes Removed from Aircraft

12.1 Paragraph 10 details the checks to be made on tyres during running maintenance; at the periods specified in the Maintenance Schedule, the tyres should be removed from the aircraft and examined as described in the manufacturer's Service Manual. Guidance on inspections and typical defects is given in this paragraph.

12.2 **Tyres**

12.2.1 **Fractures**

The inside of the tyre should be examined for fractures caused by fatigue or concussion. The latter defect may be caused by heavy impact on a protrusion, e.g. striking a stone during touch-down. External detection of the fracture may be difficult, but a dark stain on the tyre, or a very slight smooth bulge, may be visible where the rubber is bruised.

a) If a fracture has occurred, internal inspection will reveal a diagonal line or a 'star', dark in colour, at the point where the impact occurred.

b) The interior examination of a large tyre may be facilitated by rolling it along the floor and observing closely the area which is flattened by contact with the ground, since this tends to open the fracture.

c) Tyres so damaged should be scrapped and labelled accordingly.

12.2.2 **Bead Failure**

Tyres showing any signs of bead chafing or break-up of the bead should be returned to the manufacturer for assessment of possible repair.

12.3 **Tubes**

12.3.1 The base of the tube, i.e. that part of the tube which has been in contact with the tyre, on the brake side, should be examined for evidence of thinning of the rubber caused by heat generated during normal braking operations.

12.3.2 Tubes which have thinned at the base, are perished or cracked, have 'grown' or stretched unduly, or show bad creases, must be discarded.

12.3.3 Valve stems should be examined for bending, cracks or damaged threads and if damaged beyond local repair, the tube should be rejected. Valve cores with bent pins or damaged threads, or showing signs of corrosion, should be renewed.

12.3.4 Cuts in tubes may be repaired by a vulcanising process, except where they occur in the region of the valve. Vulcanising is a specialised process and should only be done by trained personnel using suitable equipment.

12.4 **Tubeless Tyres**

The tyre should be thoroughly cleaned with clean water and inspected for damage, paying particular attention to the inner lining and the entire bead area. It is essential that the beads should be clean and free from grease.

13 Repair of Tyres and Tubes

13.1 Tyres and tubes which have been removed from aircraft because of damage which is considered to be in excess of the limits defined in paragraph 10, may still be repairable locally provided the necessary tools and vulcanising equipment are available. These repairs must not exceed the limits laid down in the manufacturers' Repair Manual and must be carried out by personnel having the specialised knowledge and experience necessary and using only those materials specified by the manufacturer. The method of repair is to remove the damaged rubber and replace it with unvulcanised sheet rubber repair compound which is then vulcanised to the existing rubber by heat and pressure. During the vulcanising process the repair compound is converted into a material with properties almost identical to the surrounding rubber. A typical procedure for carrying out a repair is summarised in the following paragraphs.

13.2 **Classification of Damage**

The tyre or tube should be carefully inspected and all damage marked. A probe should be used to ascertain the depth and extent of cuts.

13.2.1 Minor damage to tyres is damage to tread or sidewall rubber not affecting the casing cords, up to a maximum of 38 mm (1·5 in) diameter. Numerous repairs of minor damage may be carried out.

13.2.2 Damage involving cut cords may be repaired in the tread area only, provided that not more than 20% of the cord layers or a total of four are damaged.

13.2.3 Small holes in tubes may be plugged with compound and larger damaged areas may be repaired up to an area of 50 mm x 50 mm (2 in x 2 in). Both types of repair must be vulcanised.

13.2.4 Tyres or tubes which are damaged beyond these limits should be returned to the manufacturer for possible repair.

13.3 **Repairs to Tyres**

13.3.1 For all types of repair, the tyre should be mounted on a wheel and inflated to a pressure of 140 to 210 kN/m^2 (20 to 30 lbf/in^2) for crown and shoulder repairs, 70 to 140 kN/m^2 (10 to 20 lbf/in^2) for sidewall repairs. A chalk line should be drawn round the damaged area to indicate the extent to which the rubber is to be removed.

13.3.2 The rubber is removed within the chalk circle by using a hollow drill, rotary rasp or knife as appropriate to the area affected, bevelling the edges at 45° and taking care not to damage the cords.

13.3.3 Where cords are damaged, the gap between the cord ends should be treated with tyre repair solution and filled with a suitable piece of tyre repair compound well rolled down.

13.3.4 The walls of the cavity and surrounding rubber should now be roughened with a rotary wire brush and the rubber remaining on the cord surface removed to expose the cords. The roughened rubber surface and exposed cords should now be given two coats of the tyre repair solution, the first coat being brushed well in and allowed to become tacky before lightly applying the second coat.

13.3.5 The repair area should now be built up with successive layers of tyre repair compound, each layer being well rolled down to exclude any air bubbles. When the level of the repair is slightly higher than the surrounding rubber, the surplus compound should be removed with a sharp knife (lubricated with water as necessary), leaving a slightly raised crown in the centre. The surface should then be cleaned, dried and dusted lightly with French chalk.

13.3.6 The pre-heated vulcanising unit, fitted with a suitably-shaped base plate, should now be clamped centrally over the repair and left in position for a period of time appropriate to the thickness of the repair as specified by the manufacturer. The temperature is controlled automatically at approximately 150°C (300°F).

13.3.7 After removal of the vulcanising unit, the repair should be tested by probing with a blunt pencil point; if the pencil springs back the repair is correctly vulcanised, but if an indentation is left in the rubber the vulcanising unit should be replaced for a further 15 minutes.

13.3.8 The final stage of repair is the replacement of the tread pattern, which should be re-cut using either a hollow drill or knife.

13.4 **Repairs to Tubes**

13.4.1 **Solution**

The solution used for repairing tubes is prepared by cutting thin strips of tube repair compound, covering them with the solvent specified by the manufacturer and leaving them for 24 hours in a sealed container. The liquid thus obtained is then stirred and thinned down with solvent to the consistency of thin paint. Only small quantities of solution should be prepared as it is highly volatile and deteriorates quickly.

13.4.2 **Small Holes**

The hole should be roughened right through and the adjacent area cleaned with solvent and treated with solution. The plug should be made from a strip of tube repair compound, fed through the hole and trimmed off slightly proud of the surrounding material. The repair is completed by rolling down the plug and vulcanising for a period of time specified by the manufacturer.

13.4.3 **Large Holes**

A circular hole should be cut round the damaged area using a pair of curved scissors. Holding the scissors flat against the tube and working in a clockwise direction will ensure that the edge of the hole is correctly bevelled. The edges of the hole and surrounding area should now be roughened with a wire brush and cleaned with a muslin cloth dipped in solvent.

13.4.4 To prevent the repair from sticking to the opposite wall of the tube, a thin piece of paper, slightly larger than the hole, should be inserted through the hole and located centrally. The solution should then be applied on top of the paper and the roughened tube area and rubbed well in. When the solution has reached a dry, tacky, state the repair should be built up and vulcanised in the same manner as described for tyres in paragraphs 13.3.5 and 13.3.6, but using a flat base plate on the vulcanising unit and working on a suitable flat bench.

14 Remoulding Tyres

14.1 Most aircraft tyres, when worn beyond safe, usable limits, may have their useful life extended by replacement of the tread rubber; this operation may, however, only be carried out by the original manufacturer or by an approved specialist organisation. The term 'retread' is normally used where the crown and shoulder rubber is replaced and cured in a specially designed mould. The term 'remould' is normally used where the tyre is similarly processed, but is cured in a mould similar to that in which the tyre was originally made; the new tread is therefore cured and the sidewall rubber re-cured without being renewed. Tests have shown that the strength of a tyre casing does not deteriorate appreciably throughout its life; up to 10 remoulds have been carried out on specific tyres with only a 1% decrease in strength. The casing life for almost all aircraft tyres is therefore determined by initial tyre quality and the exercise of proper maintenance practices while the tyre is in service. One exception to the general rule is the case of the high performance aircraft where skin friction temperatures in continuous high-speed flight could result in prolonged high wheel-bay temperatures and consequently a diminished tyre life.

14.2 On new aircraft types the first few tyres are returned after service for a thorough examination by the manufacturer. If this examination is satisfactory the next few tyres are used to develop a remoulding technique and to evaluate the tyre's structural life. On successful completion of these tests the tyre is approved for one remould life. From this stage the process is repeated until a particular type of tyre can be released for its optimum number of remoulds.

14.3 **Initial Inspection**

The initial inspection of a tyre received by a manufacturer for repair or remould is carried out by personnel with a wide experience in the manufacture and servicing of tyres. The degree of damage which can be allowed depends on the use for which the tyre was designed and the aircraft type to which it is to be fitted. The inspector must take account of every type of deterioration to which the tyre has been subjected throughout its service life. Even though individual damage may be repairable, the general condition of a tyre often results in its rejection. The various types of damage which can occur are cracking, skin burns, oil contamination, excessive wear, tread separation, cuts, ply separation and damaged cords. The most highly stressed portion of the tyre is the bead area where only very minor damage is permitted.

14.4 **Buffing**

Depending on the extent of remoulding approved for a particular tyre the required amount of rubber is removed on a buffing machine. This operation also provides the opportunity for a further inspection of the tyre, as many defects such as cuts and broken cords, can only be seen when the tread is removed.

14.5 **Remoulding Process**

After the original rubber is removed, the casing is treated with a layer of cement and the complete new tread carefully rolled on under pressure. The whole assembly is then mounted in the appropriate mould, where heat and pressure are applied until vulcanising is complete. The vulcanising time and temperature are pre-determined by the manufacturer for the type, size and ply rating of the tyre.

14.6 When the remoulding process has been completed the tyre is balanced and re-inspected before being finally released for further service.

15 Storage

15.1 Excessive light and heat will cause cracking and general deterioration of rubber, therefore tyres and tubes should be stored in a darkened room having a dry temperature of from 10 to 27°C (50 to 80°F) and should be kept away from radiators, steam pipes, electric motors or other sources of heat. It should be ascertained that the possibility of contamination from oil or grease does not exist, since this would also cause rapid deterioration of the rubber.

15.2 **Tyres**

15.2.1 Preferably, tyres should be stored vertically in special racks embodying support tubes, so that each tyre is supported at two points. Two-thirds of the tyre should be above the support tubes and one-third below. By this method, the weight of the tyre is taken by the tread and distortion is reduced to a minimum. The tyres should be turned to a new position every two or three months.

15.2.2 Where space does not permit the use of the above method, tubed tyres may be stored horizontally in stacks on a level floor. The height of stacks should be limited to four tyres so that the weight does not cause distortion of sidewalls and tread on the lower tyres which could lead to failure in service. Staggering the tyres in piles tends to distort the bead wires and casing. If possible a stack of tyres should be graded so that the largest tyre is at the bottom and the smallest at the top. This method of storing should not be used for tubeless tyres, as the beads could be pressed close together and make mounting and inflation more difficult.

15.2.3 Where tyres are delivered in bituminised hessian wrappers, the wrappers should be left on during storage.

15.3 Tubes

Tubes should preferably be stored in their original wrapping; if they cannot be stored in this manner they should be slightly inflated and stored inside tyres of appropriate size.

15.4 Assembled Wheels

The tyres on assembled wheels not required for immediate use should be inflated to a pressure of 140 to 210 kN/m^2 (20 to 30 lbf/in^2) for storage and shipment.

15.5 Shelf Life

Provided that the ideal storage conditions are maintained, tyres and tubes may be kept in storage for up to seven years from the date of manufacture, without deterioration. It is recommended, however, that stocks be limited to a quantity which will ensure that a storage life of four years is not exceeded. This will ensure that the most advantage is taken of improvements in design and manufacturing techniques. After seven years in storage, tyres should be returned to the manufacturer for assessment.

16 Records

When required by the Maintenance Schedule, a record should be kept of the number of landings for each tyre on the aircraft.

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Leaflet 5-8 Wheels and Brakes

1 Introduction

This Leaflet provides guidance and advice on the installation and maintenance of aircraft wheels and brakes. It should be read in conjunction with the relevant approved Maintenance and Overhaul Manuals and Maintenance Schedule, from which details of the manufacture and maintenance requirements of the particular components may be obtained. Information on flexible pipes is contained in Leaflet 5–5, on rigid pipes in Leaflet 5–6 and on tyres in Leaflet 5–7.

2 General

2.1 Aircraft wheels and wheel brakes are often subjected to severe conditions of operation including, shock loading and exposure to high temperatures. Therefore, the utmost care is necessary during installation and maintenance to ensure that their condition remains satisfactory during service.

2.2 Because of the risk of explosion caused by heat generated by friction in the brakes during landing and taxying, special safety precautions may be necessary when handling or servicing brake, wheel and tyre assemblies, particularly in an extreme situation such as immediately after an abandoned take-off, when the components may be overheated.

2.3 On light aircraft, where aircraft weight and landing speed are low, single wheels are fitted at all landing gear positions. Wheel brakes on older types of aircraft are often of the expanding shoe type, similar to conventional automobile practice. These may be operated by cables or by a simple independent hydraulic system. A single hand brake lever may be used to apply both brakes together, or each brake may be operated individually from a pedal attached to the rudder bar. Modern high performance light aircraft are usually fitted with hydraulically operated disc brakes.

2.4 With larger and modern types of aircraft, where aircraft weight and landing speed are high and aerodynamic drag is low, multiple wheels are generally used at all undercarriage positions, to spread the aircraft weight over a greater area and facilitate stowage in the airframe structure. Some older types of medium sized aircraft are fitted with large single wheels and pneumatically actuated drum brakes, but most modern transport aircraft are fitted with twin nose wheels and twin wheels or a four-wheel bogie arrangement at each main undercarriage position. Brakes are of the multiple disc type and are operated from the normal aircraft hydraulic system.

3 Wheels

3.1 Manufacture

3.1.1 Wheels are usually made from aluminium or magnesium alloy forgings or castings and are of three main types (Figure 1), known as well-base, detachable flange and split hub. Well-base wheels are only fitted on light aircraft and are normally used in conjunction with tubed tyres. Nose wheels which do not house brake units, are usually of simpler manufacture than main wheels, but in some instances all wheels on an aircraft are interchangeable for ease of provisioning.

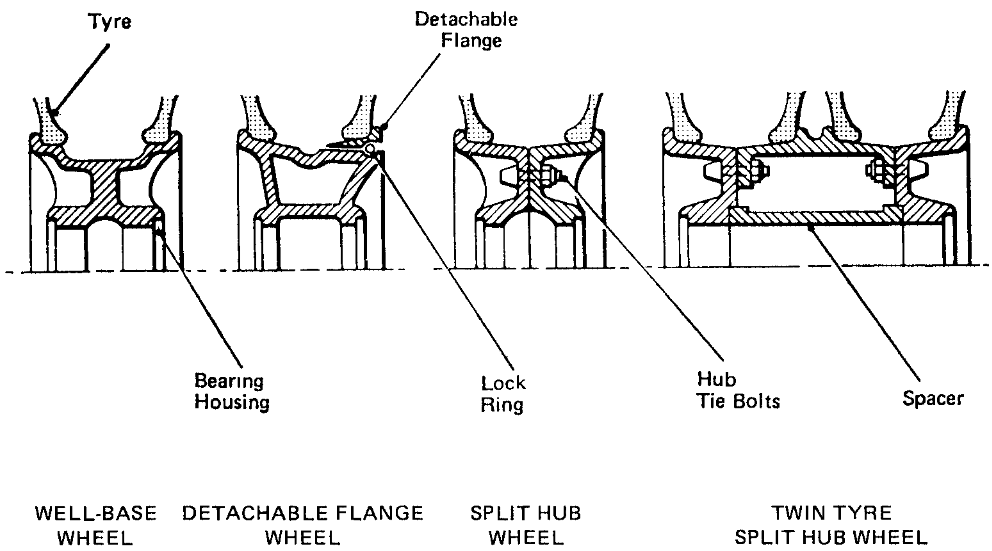

Figure 1 Wheel Types

3.1.2 Heat generated by braking action is dissipated by radiation and conduction through the wheel and tyre and every effort is made to keep heat transference to a minimum. Wheels are designed to permit optimum ventilation and cylindrical stainless steel heat shields may be installed around the brake unit. On some aircraft, an electric motor mounted within the axle, or a series of motors installed in the brake housing, drive fans which provide a forced draught through the wheel and relieve the build-up of heat.

3.1.3 To prevent the danger of tyre explosion, the main wheels of many modern aircraft are fitted with fusible plugs which melt at a predetermined temperature (approximately 150°C), allowing a piston to be blown out of the plug bore and thus deflating the tyre.

3.1.4 Some aircraft wheels are also fitted with a pressure relief valve, the purpose of which is to prevent over-inflation of the tyre.

3.1.5 In general wheels are mounted on ball or roller bearings which fit directly onto the axle, or onto a bearing sleeve which is keyed to the axle. In some cases, nose wheels are mounted rigidly onto a 'live' axle, which itself rotates within bearings in the nose wheel leg.

3.2 **Removal**

3.2.1 Before removing a wheel, the aircraft must be prepared and jacked up in accordance with the approved Maintenance Manual. These preparations may be very simple, such as chocking the opposite wheels and lifting the wheel which is to be removed by means of a bottle jack. On large transport aircraft additional procedures, such as fitting ground locks to the landing gear, landing gear doors and steering mechanism, may be necessary. In some cases one wheel of a twin wheel arrangement may be lifted clear of the ground by running the other wheel up an inclined block. On aircraft with multi-disc brakes it is usual to set the brakes on before removing the wheel in order to keep the rotating discs in alignment with the driving keys in the wheel hub; on aircraft with drum brakes, however, application of the brakes would prevent removal of the wheel and they should be released.

3.2.2 A typical removal procedure is described below:

a) Prepare aircraft for jacking in accordance with the appropriate aircraft Maintenance Manual.

b) Raise axle or bogie, as appropriate, until the tyre is clear of the ground.

c) Deflate tyre or reduce pressure to a low value.

NOTE: During release of tyre pressure, icing of the valve may occur and give a false indication of complete deflation. Sufficient time must elapse after the air flow has ceased to ensure that any ice has melted and that the tyre is sufficiently deflated.

d) Where applicable, remove cooling fan or hub cap assembly.

e) Remove axle nut locking device.

f) Remove axle nut and install thread protector.

g) Position wheel trolley and remove wheel carefully so as not to damage the axle.

NOTE: On some aircraft it is recommended that an approved extractor is used when removing the wheel.

h) Remove grease seals and bearings.

i) Install axle protector.

j) Fit protective cover over the brake assembly if the wheel is not to be re-fitted immediately.

3.3 Installation

3.3.1 Before installing a wheel and tyre, the general condition of the wheel, tyre and bearings should be checked (paragraph 3.4 and Leaflet 5–7). The axle should also be checked for corrosion, scores and other damage, particularly in the bearing support area and, if an axle sleeve is fitted, this should be checked for allowable wear at the bearing area and correct fit on the axle. Bearings on new or replacement wheels may be packed with storage grease and this should be cleaned out and replaced by grease specified for service use.

3.3.2 A typical installation procedure is described below:

a) Grease inner bearing and seal with the specified grease and install on axle.

b) Slide wheel into position on axle, using the appropriate aligning fixture as necessary to line up the brake disc driving keys in the wheel hub with the slots in the rotating discs.

c) Grease and install the outer bearing and seal.

d) Remove thread protector and lubricate axle threads.

e) Install axle nut and tighten to the recommended initial torque, rotating the wheel as the nut is tightened.

f) Slacken axle nut then, again rotating the wheel, tighten to the specified final torque and fit the locking device.

g) Replace cooling fan or hub cap assembly.

h) Check tyre pressure and tyre growth clearance, retracting landing gear where necessary to facilitate this check, then lower the aircraft and remove the ground locks installed to prevent operation of the steering mechanism or landing gear doors.

3.4 **Maintenance**

3.4.1 **General**

A superficial inspection and minor repairs may be carried out with the wheel installed on the aircraft. A more detailed inspection is made when the wheel is removed for tyre replacement following operation with a deflated tyre (or with the companion tyre deflated on a twin wheel arrangement) and at the intervals specified in the approved Maintenance Schedule. Some wheels may require overhaul after a specified number of landings.

3.4.2 **Installed Wheels**

a) The wheel should be examined for cracks, corrosion, distortion, dents and scores, particular attention being given to the wheel flanges. Small dents on the outside of the flanges may usually be blended within specified limits, but in general no damage is permissible where the flange is in contact with the tyre. When a dent or abrasion is blended out, the exposed metal should be closely inspected for cracks and the protective treatment renewed. It is particularly important to give prompt attention to protective treatments following repairs to magnesium alloy wheels.

b) Wheel hub tie bolts and nuts, inflation valves, balance weights and, where visible, the axle nut locking device, should be inspected for security and damage. If any tie bolt is found defective, the wheel should be removed and the complete set renewed.

c) The wheel, brake and tyre should be examined for signs of overheating, such as blistered or discoloured paint, distortion and leakage of grease from the wheel bearings.

NOTE: If a fusible plug is found to be blown out, the tyre should be scrapped and all fusible plug seals renewed, but the wheel may be satisfactory subject to certain checks (paragraph 3.4.3).

d) Periodically the wheels should be raised clear of the ground in order to check for free rotation and end float in the bearings.

3.4.3 **Wheels Removed from Aircraft**

a) The tyre must be completely deflated before any attempt is made to dismantle or remove a wheel or tyre.

b) Dismantled wheels should be thoroughly cleaned in a suitable cleaning fluid and then examined for cracks, corrosion, distortion or other damage.

c) Some manufacturers require that paint should be completely removed from wheels before checking for cracks. Where chemical paint strippers are used it is essential that the chemical is removed by thorough washing.

d) A careful examination should be made for cracks around bolt holes, in the radius at the base of the wheel flange (tyre bead seat) and at other highly stressed points or changes of section. These examinations are normally made using ultrasonic or eddy current methods.

e) Light surface corrosion can be cleaned off and damage blended out within specified limits, but deep corrosion, scores, dents or cracks beyond these limits will render the wheel unserviceable.

f) Brake drums should be examined for signs of distortion, wear, scores and cracking and there should be no evidence of drum movement relative to the wheel. With disc type brakes the drive blocks in which the discs are tenoned should be checked for security, damage, wear and hammering.

NOTE: The braking surface of bi-metal brake drums is subject to crazing; this condition is acceptable until it advances beyond the limits specified in the relevant manual.

g) Wheels should also be inspected for distortion and concentricity, by mounting the wheel on a mandrel in vee-blocks and checking at the flange with a dial test indicator. Distortion may also be checked using large calipers. After this check the wheel should be statically balanced.

h) Wheels which may have been damaged by overheating but which are not found to be distorted and are otherwise serviceable, may be required to be given a check for material hardness. When this check is specified, the method and the acceptable range of hardness numbers will be found in the approved Maintenance Manual.

i) Bearings may sometimes be inspected in position, but they must often be removed (using an extractor where necessary) in order that they may be thoroughly cleaned and inspected. They should be cleaned in a solvent such as white spirit and examined for corrosion, brinelling of the races, chipped balls or rollers, retaining cage condition, roughness and discolouration. If serviceable, bearings should be packed with approved grease immediately after inspection and protected from dust and dirt.

j) Tie bolts, i.e. those used for clamping the two halves of a split hub, should be checked for corrosion, distortion, cracks and condition of threads. Any damage found on these bolts will necessitate their replacement. In some instances, self-locking nuts which are found to have a satisfactory locking torque may be re-used, but the manufacturer may require all stiffnuts to be discarded after disassembly.

k) Wheels should be painted and reassembled in accordance with the manufacturer's recommendations and particular care should be paid to the sequence of assembly and torque tightening of the tie bolts. It is usually recommended that new seals should be fitted during re-assembly.

l) When a tyre is assembled on a wheel, the complete unit should be statically balanced.

4 Drum Brakes

4.1 General

Although used extensively on earlier aircraft, drum brakes have largely been superseded by hydraulically operated disc brakes, on most modern high performance aircraft. Pneumatically operated drum brakes may still be found in service, however and the manufacture, operation and maintenance of a typical brake unit of this type is described in the following paragraphs.

4.2 Manufacture

4.2.1 The main components of the brake unit are the back plate, brake drum, expander tube (pressure bag) and brake linings (Figure 2).

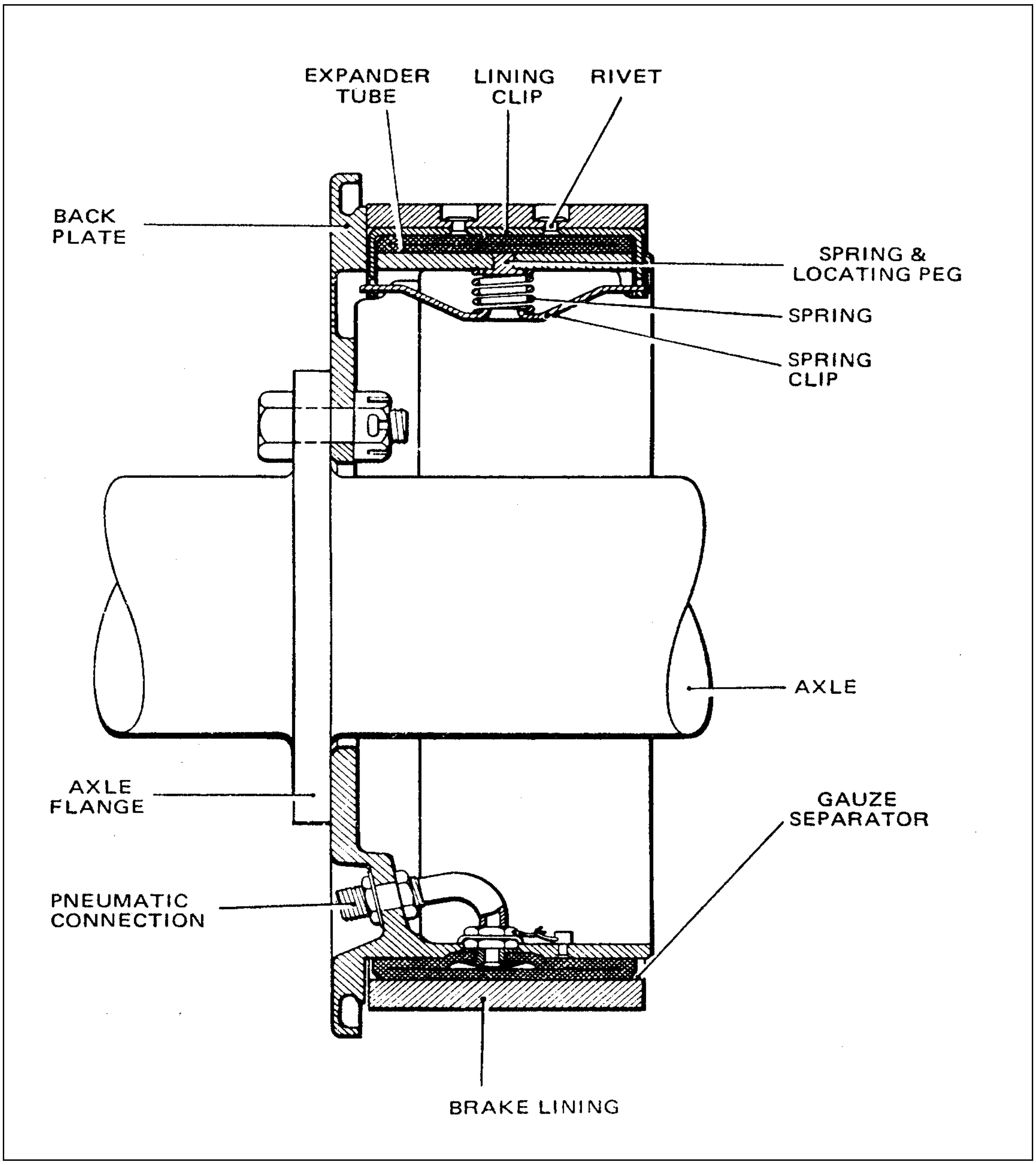

Figure 2 Drum Brake

4.2.2 **Back Plate**

This unit is cylindrical in shape and is attached to a flange on the axle. It houses the expander tube, brake linings and pneumatic connections.

4.2.3 **Expander Tube**

This is a circular, reinforced rubber tube of flat cross-section and is fitted around the back plate. It has a pneumatic connection leading through the back plate to the aircraft pneumatic system.

4.2.4 **Brake Linings**

The complete brake lining assembly is made up of a number of segments of heat-resisting friction material which form a ring around the expander tube and are shaped to conform to the inside radius of the brake drum. Each segment is bonded or riveted to a metal fitting, which protrudes through the back plate and is secured by a spring clip.

4.2.5 **Separators**

Phosphor-bronze gauze separators are fitted between the ends of the brake lining segments to reduce heat penetration to the expander tube and to exclude carbon particles.

4.2.6 **Brake Drum**

The brake drum is a heavy steel cylinder, attached to and rotating with the wheel and against which the brake lining segments expand to produce the braking action.

4.3 **Operation**

When the pilot's control is operated, air pressure is applied to the inside of the expander tube, which expands and forces the brake linings against the brake drum. When air pressure is released the expander tube collapses and the brake linings are withdrawn from the brake drum by the action of the return springs.

4.4 **Removal/Installation**

4.4.1 Before attempting to work on the brake system or to remove a wheel, it is important to ensure that all air pressure is exhausted from the system. Disconnecting a pipe joint containing air pressure is a dangerous practice and if a wheel is removed with the brake system connected and pressurised, inadvertent operation of the brake could cause the expander tube to burst and possibly damage other parts of the system. In many pneumatic systems a pressure maintaining valve is used to safeguard the brake pressure in case of a leak elsewhere or failure of the compressor, so that lack of pressure in the brake system must be confirmed from the brake system pressure gauge and not by reference to the general system pressure.

4.4.2 When the wheel has been removed, the brake unit can be removed by disconnecting and blanking the air pressure connection and removing the bolts attaching the back plate to the axle flange.

4.4.3 When installing a new brake drum, the protective treatment applied for storage purposes should first be removed with a suitable solvent such as methylated spirits; petrol or paraffin should not be used.

4.4.4 When installing the brake unit, care must be taken to ensure that oil or grease do not come into contact with the linings; operators should also avoid handling the linings as the natural oils from the skin may have an adverse effect. If brake linings do become contaminated they must be considered unserviceable; no attempt should be made to clean the surface with solvents.

4.5 **Inspection**

4.5.1 Drum brakes are not normally accessible for visual inspection when installed on the aircraft. During a pre-flight inspection the back plate and wheel should be examined for signs of overheating and the flexible pneumatic hose between the brake units and the landing gear leg should be checked for damage, security or leaks. Operation of the brakes may be checked by means of the brake pressure gauge and also by checking that air is discharged from the brake relay valve when the brakes are released.

4.5.2 At the times specified in the approved Maintenance Schedule and whenever unsatisfactory operation is suspected, the brake unit should be removed for inspection and overhaul. Disassembly, which should be carried out on a rubber or felt covered bench, is normally straightforward, but reference should be made to the approved Maintenance Manual for details of any special procedures or tests required. It may be found that the expander tube is stuck to the back plate and extreme care is necessary to prevent damaging the tube; the careful use of smooth, broad tyre levers is sometimes recommended. The assembly position of each brake segment should be marked so that, in the event of their being suitable for further service, they can be returned to their original positions.

a) Brake segments should be examined for wear by measuring the thickness of the remaining material, the minimum thickness permitted for replacing the linings being stipulated in the approved Maintenance Manual. Any carbon deposits which may have been formed should be removed with a stiff bristle brush.

b) The back plate should be examined for distortion, damage or corrosion and elongation or cracking at bolt holes and lining clip slots. Protective treatment should be renewed as necessary.

c) The expander tube should be examined for signs of overheating, which is usually indicated by hardening or flaking of the rubber. The connection threads and nuts should also be in good condition.

d) The brake lining rivets should be examined for security and the lining clips for cracks or damage, particularly at the corner radii.

e) The brake drum should be checked for cracks, corrosion and distortion. The friction surface should be free from deep scoring which is likely to cause excessive lining wear and any trace of grease or dirt should be removed with a suitable solvent. If any grease or oil is found on the drum, the cause should be investigated to prevent a recurrence.

f) New separators should be fitted when the brake is reassembled.

4.5.3 **Test After Reassembly**

Following reassembly the complete brake unit should be installed in an appropriate sized test brake drum and submitted to pressure tests as prescribed by the manufacturer. No leakage should occur and the linings should return to the 'off' position as soon as air pressure is released. The most suitable means of detecting a leak in the expander tube connection is by applying a solution of non-corrosive soapy water which, subsequently, must be washed off. Bubbles will indicate the position of a leak.

5 Disc Brakes

5.1 Most modern aircraft are fitted with hydraulically-operated disc brakes (also known as plate brakes). Light aircraft generally have a single-disc type and larger aircraft a multi-disc type.

5.2 **Single-disc Brake Units**

5.2.1 A simple single-disc brake unit is shown in Figure 3 and is of a type found on many light aircraft. A single operating cylinder is shown but two or three are often used for increased braking performance and larger aircraft may have brakes using five or six cylinders. The brake unit consists basically of a light alloy torque plate shaped for attachment to the landing gear leg or axle flange, housing a caliper-type hydraulic jack unit and a pair of friction pads. A steel disc is slotted into the wheel and rotates between the friction pads. When the brakes are operated, fluid pressure is applied to the cylinder and forces the operating piston towards the disc, thus squeezing the disc between the operating and fixed friction pads and thus resisting wheel rotation. When the brakes are released the disc is free to rotate between the friction pads.

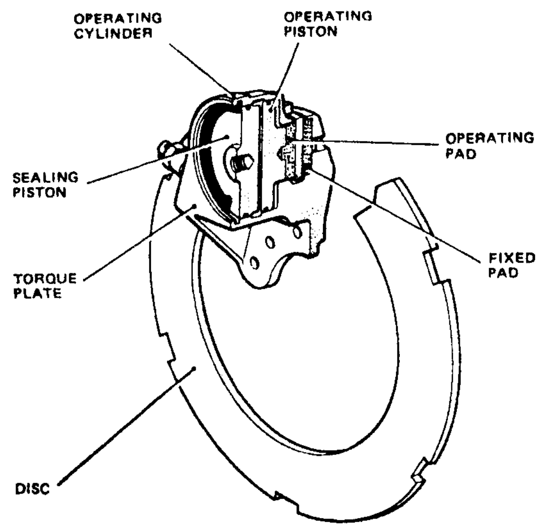

Figure 3 Single Disc Brake

5.2.2 The brake unit should be examined periodically for fluid leaks, damage or corrosion, the friction pads for wear and the disc for scoring or pick-up of surface plating. The single discs used on light aircraft brakes are prone to corrosion and pitting during periods of idleness and this may lead to rapid wear of the friction pads. Discs in poor condition should be replaced or machined to give a clean surface as appropriate. Replacement of worn pads is normally a very simple procedure once the wheel has been removed and often does not necessitate breaking down the hydraulic system. The servicing and repair procedures discussed in paragraph 5.3 are also applicable to single disc brakes but reference should be made to the approved Maintenance Manual for details of any particular limitations, procedures, tests or special tools recommended by the manufacturer.

5.3 **Multi-disc Brake Unit**

5.3.1 Multi-disc brakes are designed to provide increased friction surfaces for braking purposes. The general arrangement is basically similar to the single-disc brake, but the single disc is replaced by a stack of alternate stationary and rotating discs and a number of operating cylinders are equally spaced around the torque plate. The friction elements are normally in the form of pads attached to either side of the stationary discs, but on some types the rotating discs have sintered surfaces or pads. This type of brake is operated from the aircraft's main hydraulic system, through valves connected to the pilot's rudder pedals.

5.3.2 **Manufacture**

A typical multi-disc brake unit is shown in Figure 4. In this unit a torque plate and torque tube assembly fits over the axle and is bolted to a flange on the axle; alternative designs are often similarly mounted but prevented from rotating by means of a torque arm attached to a suitable fixture on the landing gear leg or bogie. A number of cylinders are spaced around the torque plate, connected to the hydraulic brake system and house pistons which apply load to the pressure plate. The disc pack (also known as the heat pack) contains alternate stationary and rotating discs, the stationary discs being keyed to the torque tube and the rotating discs being keyed to drive blocks in the wheel hub. In this unit the stationary discs house the brake pads and the rotating discs are segmented to prevent heat distortion and brake drag. Correct working clearance in the disc pack is maintained by means of adjuster assemblies (paragraph 5.4). Pins attached to the pressure plate and protruding through the torque plate on this brake unit, indicate the amount of wear which has taken place in the disc pack.

5.3.3 A further type of multi-disc brake is known as a trimetallic brake. Manufacture is similar to the brake described in paragraph 5.3.2, except that the rotating discs have a metallic compound sintered to their faces and steel segments, known as wear pads, are riveted to the faces of the stationary discs. Alternatively, the faces of both sets of discs may be sintered, or the stationary discs may be plain.

5.3.4 **Operation**

When the brakes are selected 'on', hydraulic pressure is admitted to the cylinders and moves the operating pistons against the pressure plate. The disc pack is clamped between the pressure plate and thrust plate and the friction loads generated between the stationary and rotating members provide the required braking action. When the brakes are released, springs in the adjuster assemblies move the pressure plate back to maintain a working clearance in the disc pack and permit free rotation of the wheel.

5.3.5 **Maintenance**

Contamination of the friction surfaces of a brake unit by fluids used in aircraft servicing operations is highly detrimental to brake operation. It is essential, therefore, to protect brakes from contamination by fuel, oil, grease, paint remover, de-icing fluid, etc., when operations involving their use are undertaken and the condition of the brake units should subsequently be confirmed by inspection.

5.3.6 Installed disc brakes may be inspected for signs of fluid leakage, external damage, corrosion, disc pack wear and overheating and the associated hydraulic pipes for security, distortion, chafing or leaks. Brake disc pack wear can be checked by measuring wear pin protrusion, the limits being specified in the approved Maintenance Manual.

5.3.7 In some installations a worn disc pack may be exchanged after removing the wheel and thrust or back plate and without disconnecting the hydraulic system, but in order to carry out a detailed inspection the brake unit must be removed from the axle.

5.3.8 At the periods specified in the approved Maintenance Schedule the brake unit should be removed for inspection and overhaul. The wheel should first be removed (paragraph 3.2) and the hydraulic pipe couplings should be disconnected at the brake and fitted with suitable blanks. In some cases fluid will drain from these pipes and bleeding will be necessary (paragraph 5.5) after re-connection, but in other cases connection is by self-sealing couplings which isolate the hydraulic system from the brake unit. The brake unit attachment bolts (and, where fitted, the torque link) should then be removed and the unit carefully withdrawn.

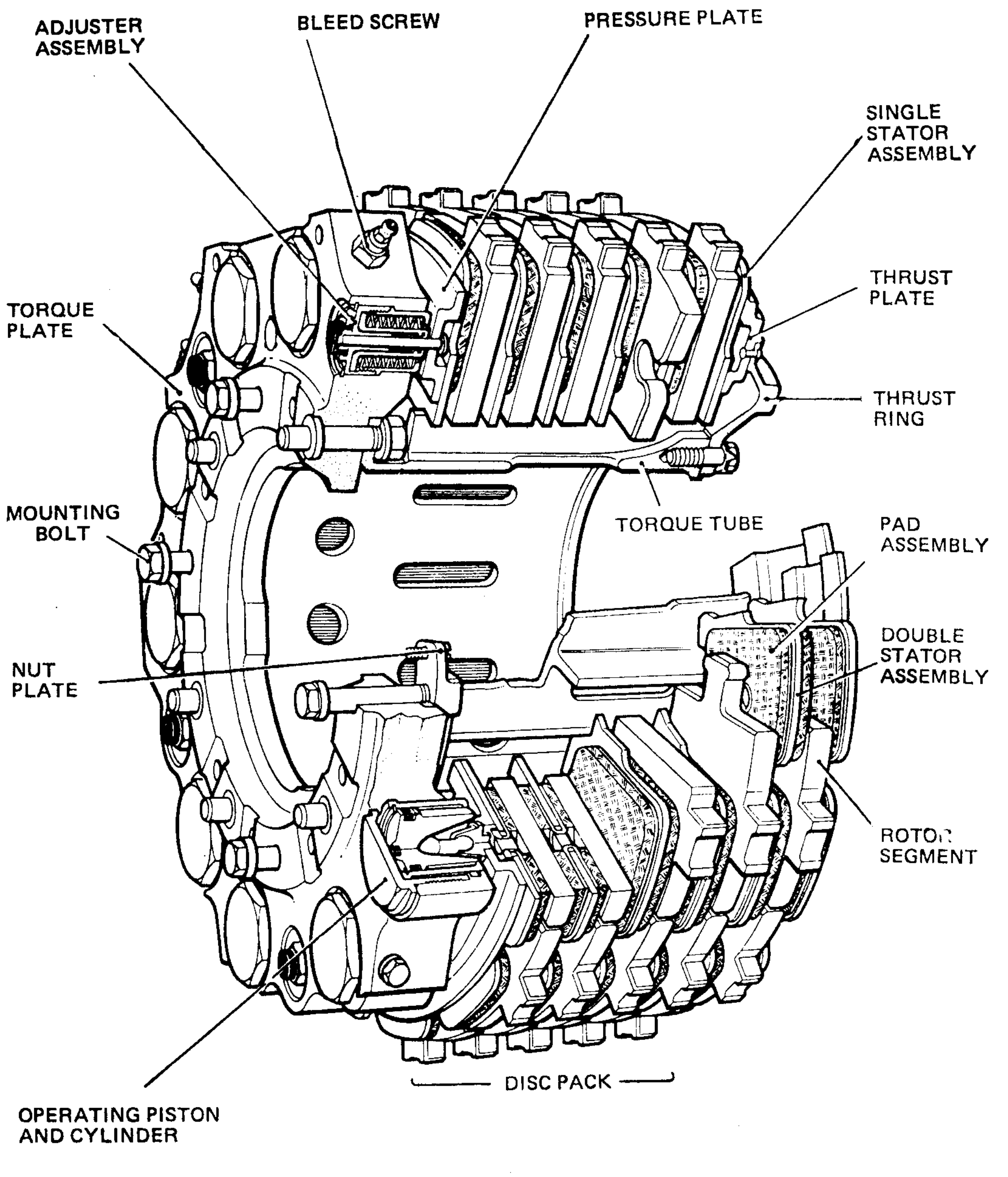

Figure 4 Multi-disc Brake

5.3.9 Following its removal, the brake unit should be dismantled, cleaned and inspected. All metallic components should be thoroughly cleaned and dried; if chemical solvents are used they must not be allowed to come into contact with the elastomeric seals. Inspection of components should be related to any limitations or repair schemes specified by the manufacturer and will normally include the following:

a) Rotating discs should be checked for excessive scoring, corrosion, distortion and wear on the friction surfaces and driving slots. Light surface damage which would not cause excessive wear of the friction pads may be acceptable, but deep scores or corrosion should be ground out within prescribed limits. Heat damage may cause surface cracking and, if present, must be within limits specified by the manufacturer for the disc to be re-used.

b) Brake friction pads should be inspected for excessive wear (normally checked by measuring individual pad thickness and weighing the complete pack), burning, flaking, cracking, security of attachment to the stationary disc and contamination by oil or grease. It is normally specified that, if any pad is damaged or worn beyond limits, or contaminated with oil or grease, the complete set should be changed. In some instances it is also specified that the rotating discs should be changed. If part-worn pads are to be re-used they must be reassembled in their original location.

c) The torque plate, torque tube and thrust plate should be examined for cracks, corrosion, distortion and damage, particular attention being paid to bolt holes and other highly stressed areas. Cylinders and pistons should be inspected for scores or other damage and springs inspected for corrosion and given a load/compression test as specified by the manufacturer.

d) Operation of the self-adjusting mechanism should also be checked and the friction force applied to the retraction pin measured (Figure 5).

5.3.10 Protective treatment should be applied as necessary to the metal components and the brake unit reassembled and tested for leaks and correct operation. It is normally specified that new seals, gaskets and self-locking nuts should be used for reassembly and all fasteners torque loaded in accordance with the manufacturer's recommendations. The unit should be primed with hydraulic fluid and blanks fitted to all connections.

5.3.11 When re-installing the brake unit on the axle, care must be taken not to spill fluid on the disc pack. Jointing, sealing or anti-seize compounds should be used where specified and all fasteners and pipe connections should be torque loaded and locked to the manufacturer's requirements.

5.4 **Adjuster Assemblies**

5.4.1 The diagrammatic arrangement of a typical adjuster assembly is shown in Figure 5. At least two adjuster assemblies are fitted to the majority of disc brakes, their purpose being to maintain a suitable running clearance in the brake pack. In a single-disc brake the retraction pins are often attached directly to the operating pistons but on multi-disc brakes they are usually attached to the pressure plate. In operation, movement of the piston or pressure plate is transmitted via the retraction pin and friction bush to compress the adjuster spring and move the guide until it abuts the torque plate. When the brakes are released the adjuster spring pulls the guide back until it contacts the spring housing, the clearance between the guide and torque plate being the designed running clearance. As wear takes place in the discs the pressure plate has to move further forward, thus pulling the retraction pin through the friction bush by an amount equal to disc wear, but maintaining the design clearance when brakes are released. On some brake units wear may be assessed by measuring the protrusion of the retraction pin.

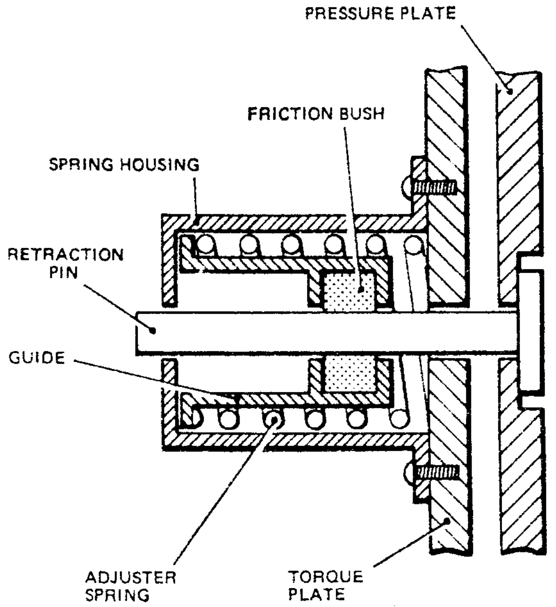

Figure 5 Adjuster Assembly

5.4.2 On initial assembly of the adjuster a special tool is used to position the retraction pin at the position of maximum protrusion through the friction bush. The pin takes up its initial operating position when the brakes are first pressurised.

5.4.3 On some types of disc brakes a conical friction bush is used and friction is adjusted by torque loading the retaining nut to a specified value, whilst on others, provision is made for manual adjustment of the working clearance.

5.4.4 Correct operation of the adjuster assemblies must be checked whenever the brakes are tested and should result in free rotation of the wheel when brakes are released.

5.5 **Bleeding the Brakes**

5.5.1 **General**

The presence of air in the hydraulic brake system will degrade the performance of the brakes and must be removed after initial installation and whenever brake response becomes sluggish.

5.5.2 The exact method of bleeding the brakes will depend to a large extent on the particular aircraft system and reference should be made to the approved Maintenance Manual for the aircraft concerned. However, the normal method of bleeding is to pressurise the brake system and open the bleed screws fitted to the brake units, allowing hydraulic fluid to flow through the system until bubble-free fluid is discharged; the bleed screws are then closed and brake operation tested. Bleed fluid should be piped to a suitable container and must not be allowed to come into contact with the disc pack.

5.5.3 On low pressure systems fluid is forced through the brake unit by slowly pumping the appropriate brake pedal. Care must be taken to ensure that the reservoir is kept topped up during this operation, since further air might be introduced if the fluid level is allowed to fall too low.

5.5.4 On high pressure systems the associated hydraulic accumulator is pressurised and as the brake pedal is depressed, fluid is forced out of the bleed screws under pressure. In this type of system it is sometimes recommended that only a specified quantity of fluid is discharged and it may be necessary to bleed other parts of the system such as, where fitted, the servo system from the brake pedals to the control valves, or the normal and emergency accumulators, before bleeding the brakes. After bleeding, the appropriate reservoir should be topped up as necessary.

5.6 **Testing the Brakes**

Brakes are normally tested after overhaul and after installation on an aircraft, while the aircraft is still jacked up. The brakes should be applied several times then released; there should be no leakage and the brakes should restrain wheel movement when pressurised and permit wheel rotation when released (free rotation is important, because binding brakes can cause overheating and increase take-off ground-run distance). Operation of the emergency and parking brake controls should be checked and, on completion, a full brake sense check should be carried out in a manner which will ensure correct brake operation for any brake application. Special care should be taken to ensure that the hydraulic systems are correctly connected and in particular that the main system and not the emergency system, is connected through the anti-skid device.

6 Brake Temperature Monitoring System

6.1 On some aircraft, in order to inform the pilot of excessive build-up of heat in the wheel brakes, a brake temperature monitoring system is fitted. A typical system includes a temperature sensor at each wheel, which supplies information to a central monitor and warning unit on the flight deck. The monitor contains a temperature gauge and a selection button for each wheel. The gauge normally records the temperature at the hottest brake and a button illuminates when the associated brake temperature exceeds a predetermined amount. When any button is pressed, the gauge records the temperature at the associated brake.

6.2 For testing purposes, operation of a test switch on the control unit will cause all buttons to illuminate and the gauge to read within a test signal range when all circuits are serviceable.

6.3 Installations vary considerably between aircraft and trouble-shooting charts are normally included in the appropriate Maintenance Manual to enable faults to be traced. Routine maintenance should include inspection of the sensors and associated wiring for security and damage and functional tests of the system using the appropriate test switches.

7 Skid Control

7.1 The braking systems of most modern aircraft are provided with a means of preventing the wheels from skidding on wet or icy surfaces and of ensuring that optimum braking effect can be obtained under all conditions, by modulating the hydraulic pressure to the brakes. Anti-skid units sense the rate of change of wheel deceleration, decreasing the hydraulic pressure applied to the brakes when a high rate of increase in deceleration (i.e. consistent with an impending skid) occurs and restoring it as the wheel accelerates again. A modulator is often fitted in conjunction with the anti-skid unit, to restrict the flow of fluid to the brakes after initial brake application and to conserve main system pressure. There are basically two types of anti-skid systems in use, the mechanically controlled and the electronically controlled.

7.2 Mechanical System

7.2.1 General

The anti-skid unit is mounted either on the brake unit torque plate or within the axle bore and is connected into the brake hydraulic circuit at the brake unit. The anti-skid unit consists of a valve assembly connected to a flywheel, which is driven by the associated wheel.

7.2.2 Operation

During normal braking action (i.e. when no skid is present) the flywheel rotates at the same speed as the drive and the valve is closed, allowing maximum hydraulic pressure to be applied to the brake operating pistons. When the rotational speed of the wheel decreases rapidly, as when a skid begins to develop, the inertia of the flywheel alters its angular relationship with the drive shaft and, through the action of a cam and push rod arrangement, the valve opens to relieve the pressure applied to the brake, thus reducing braking action and allowing the wheel to increase its rotational speed. As the wheel accelerates, the angular relationship between flywheel and drive returns to normal and the valve closes, increasing pressure to the brake. If the wheel bounces clear of the ground after brakes are applied, the adjustment of the anti-skid unit allows the brake to be completely released for a sufficient period of time to ensure that the brake is off when the wheel contacts the ground again.

7.2.3 Installation

The mounting details of the various types of mechanical units vary considerably and reference should be made to the appropriate Maintenance Manual for details of any particular installation. An external unit is driven by means of a rubber tyre surrounding its flywheel housing and engaging in a track on the landing gear wheel. The whole unit is spring-loaded, or the mountings shimmed, to maintain satisfactory driving contact with the track. The tyre loading is normally checked after installation by measuring the flat produced on the rubber tyre at its point of contact with the track. An axle mounted unit is driven by means of a shaft, which is splined into the anti-skid unit at one end and into a drive housing bolted to the wheel hub, at the other. All types of units are marked with the correct direction of rotation and this must be checked before installation.

7.2.4 Bleeding of the anti-skid unit is normally achieved when bleeding the main brake system but independent bleeding may be necessary after installing a unit. This is accomplished by fitting a drain pipe at the exhaust connection, rotating the drive smartly in the direction of rotation, then bringing it to rest. Each time rotation is stopped fluid will be discharged from the exhaust port and bleeding should be continued until the discharged fluid is free from air, then the pipe connections remade.

7.2.5 Inspection

At the periods specified in the approved Maintenance Schedule, the anti-skid unit should be inspected as follows:

a) The unit should be cleaned and inspected for security, signs of corrosion, external damage and cracks.

b) With brakes applied, the unit should be checked for signs of external leakage of hydraulic fluid.

c) The pipelines should be checked for damage or distortion and the connections for security of attachment.

d) The driving tyre and wheel track should be inspected for correct loading and alignment and the tyre for excessive wear.

NOTE: It is possible to lock the spring-loaded type units out of contact with the wheel track by inserting a pin in the mounting stud. This is normally done to facilitate wheel removal, but it is recommended that a red streamer should be attached to the pin as a visual reminder that the anti-skid unit is out of operation.

7.2.6 At the end of its overhaul life an anti-skid unit should be returned to the manufacturer or an approved firm for overhaul. Testing after overhaul requires the use of specialised equipment which is not normally held by operators. After removal, all fluid connections and orifices should be properly blanked, the fluid being retained as a guide to the internal condition of the unit. Packing should be suitable for the method of transit and the destination.

7.3 Electronic System

7.3.1 The system comprises a wheel speed transducer, a control unit and an anti-skid valve in the brake pressure line, together with associated switches and check-out and warning lamps. The wheel speed unit may supply either d.c. or a.c. depending on the type of system used. Operation is basically similar to the mechanical system but the use of sophisticated logic circuits in the later types of electronic control units enables much finer control to be exercised. Further refinements such as strut oscillation damping circuits, touch-down protection and locked wheel protection, may also be incorporated and some systems automatically de-activate at low speed to prevent interference with normal taxying manoeuvres.

7.3.2 The method by which the wheel speed signal is processed in the control unit varies from type to type, but all operate on the basis that if any brake produces more torque than can be supported by the friction between the tyre and ground for the existing wheel load, the resulting impending skid will produce a smaller rotational velocity signal from the affected wheel. This reduced signal is detected by the anti-skid control circuits, which send a signal to the anti-skid control valve, causing brake pressure to be reduced sufficiently to correct the skid condition. Brake pressure will be re-applied to a level just below that which caused the skid and will then increase at a controlled rate.

7.3.3 Control units normally contain circuits which provide warning of failure in the system and a self-test facility which enables the serviceability of the various components to be checked. Controls for the operation and testing of the anti-skid system are contained in the control unit and in the flight compartment.

7.3.4 Some systems operate by providing a continuous bleed from the brake pressure line and in these cases the parking brake operates a cut-off valve in the brake return line.

7.3.5 Maintenance

The inspection, testing and maintenance of any particular anti-skid system will vary considerably between different installations and details should be obtained from the approved Maintenance Manual. However, the self-test facility normally enables complete testing of the system to be carried out and the test circuit is designed to facilitate location of faulty components. A visual inspection of the system should include the following:

a) The various components should be examined for damage, security and where appropriate, fluid leaks.

b) Pipelines should be examined for security, chafing and fluid leaks, particularly at connections.

c) Electrical cables should be examined for security, chafing and damage by fluids or heat.

7.3.6 The removal and installation of components in the anti-skid system often requires the observance of certain safety precautions. These precautions are detailed in the approved Maintenance Manual and normally include the fitting of landing gear ground locks and door locks and depressurising the appropriate hydraulic system.

8 Low Pressure Brake Systems

8.1 General

Most light aircraft are fitted with an independent hydraulic system for each brake, similar to that shown in Figure 6. On some aircraft a handbrake system is connected to each brake through a shuttle valve, while on others a parking brake control applies a mechanical lock to the footbrake linkage when brakes are applied. The main components in each system are a fluid reservoir and master cylinder, connected mechanically to the brake pedals and hydraulically to the brake operating cylinder.

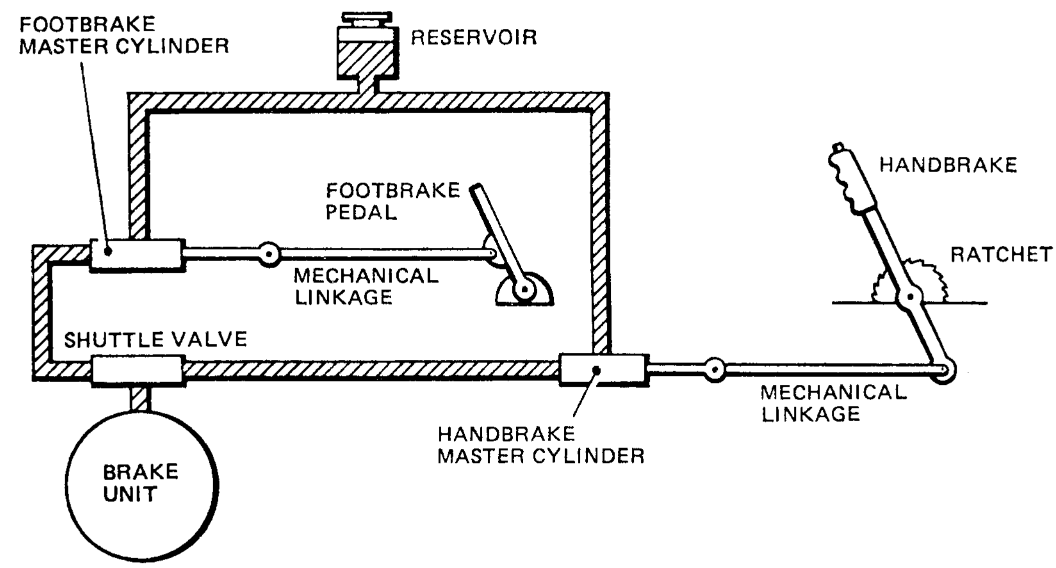

Figure 6 Simple Low-pressure Brake System

8.2 Operation

As the brake pedal is pressed, a piston in the master cylinder forces fluid through the pipelines to the brake operating cylinder, the braking force depending on the force exerted on the brake pedal. When the pedal is released, a return spring in the master cylinder returns the piston to its original position and pressure is relieved. Handbrake operation is similar except that the shuttle valve moves to allow pressure to the brake unit and close off the port from the footbrake master cylinder; brakes are held on by a ratchet device in the handbrake mounting. With the alternative parking brake system, the brake should be set by applying pressure with the footbrake, then the parking brake operated to lock the footbrake linkage; subsequent footbrake application will release the locking catch.

8.3 **Bleeding and Testing**

After installing the braking system and whenever faulty system operation is suspected, the aircraft should be jacked up and the following procedure carried out, subject to specific instructions contained in the approved Maintenance Manual.

a) Ensure that the brake fluid reservoir is topped up.

b) Undo the bleed screw in the brake unit and position a container to catch draining fluid. It is usually advisable to fit a tube between the bleed screw and container, to avoid contaminating the brake pads.

c) Pump the brake pedal slowly until bubble-free fluid issues from the bleed screw, topping up the reservoir as necessary, then tighten the bleed screw.

d) Apply the footbrake and ensure that the brake is operating, then release the brake and ensure that the wheel rotates freely.

e) Hold the footbrake fully on for 30 seconds and check for hydraulic leaks. The brake should still be applied, with no apparent pedal movement, at the end of this time.

f) Repeat e) using the handbrake or parking brake as appropriate.

8.4 **Maintenance**

8.4.1 Little maintenance is required with this type of brake system except for ensuring that the reservoir is kept topped up to the required level with the specified fluid. Use of the correct fluid is most important, since the piston and shuttle valve seals are often manufactured from a material which is compatible with a limited range of fluids and might deteriorate rapidly if a different fluid were introduced. Cleanliness is also an important aspect and every care should be taken to prevent the introduction of dust and dirt into the system when topping up the reservoir.

8.4.2 The components and pipelines should be inspected periodically for security, fluid leakage and correct operation. Flexible pipes are often fitted between the brake unit and landing gear leg and it should be confirmed that the pipes are secure and have freedom of movement throughout the range of movements of the landing gear.

8.4.3 Spongy operation of the brakes may be caused by air in the system, which should be bled as described in paragraph 8.3. Fluid bled from the brakes should not be replaced in the system.

8.4.4 Loss of brake pressure, or inability to hold the brakes on, may be due to faulty or worn seals in the master cylinder or shuttle valve. Extreme care is necessary when replacing these seals, as they usually have to be expanded over the valve or piston. The use of an assembly tool is often recommended and the seals should be lubricated with system fluid before fitting. Cleanliness is of the utmost importance since dirt and grit could prevent proper sealing and possibly score the piston or cylinder surfaces.

9 High Pressure Brake Systems

9.1 High pressure braking systems use the normal aircraft hydraulic system to provide fluid, under pressure, to the brake units. A brake system accumulator stores energy in the brake system for use in the event of normal system pressure not being available and an emergency pneumatic system is frequently included to safeguard brake operation in the event of complete hydraulic failure. A simplified system is shown in Figure 7.

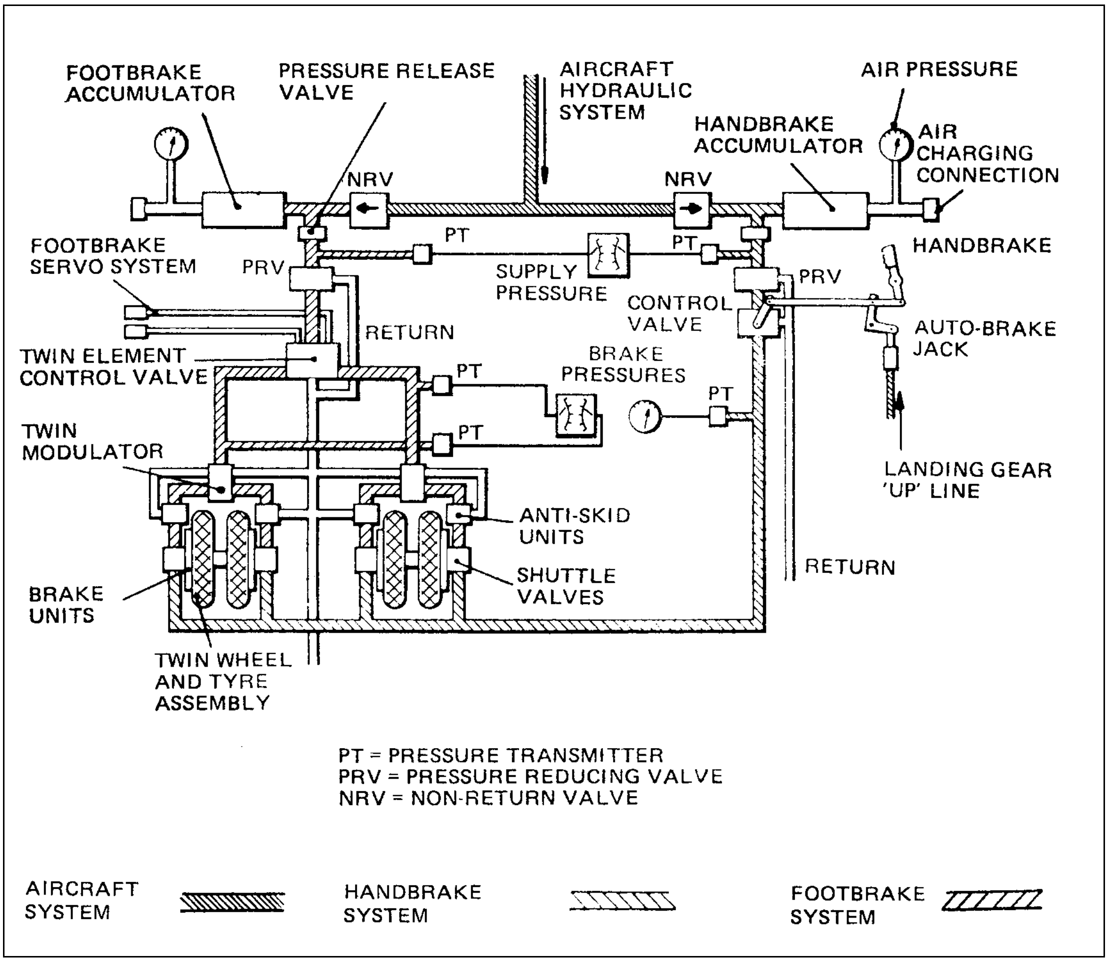

Figure 7 Simple High-pressure Brake System

9.2 Operation of the brakes can be controlled from either pilot's position, by brake pedals attached to the rudder bar. Application of left or right pedals at either pilot's station causes operation of the associated left or right brakes.

9.3 The brake pedals are linked through a system of levers and cables, or a hydraulic servo system, to a control valve (normally located adjacent to the main wheel bays to minimise the length of pipe run) which controls hydraulic pressure according to the position of the brake pedals. This pressure is often reduced through a pressure reducing valve and modulated by an anti-skid valve, before being applied to the brake cylinders.

9.4 **Adjustment**

The accurate setting-up of the mechanical linkage between the rudder pedals and control valve is very important since it controls the brake pressure in relation to pedal movement and must be identical in both left and right braking systems. Details of the setting-up procedure for a particular aircraft system will be found in the approved Maintenance Manual, but in a normal system, levers and bellcranks are locked in position by the insertion of rigging pins and the connecting rods and cables adjusted to fit these fixed locations. Alternatively, graduated quadrants may be fitted to show the angular positions of particular levers so that the connecting components may be correctly adjusted. Cables should be tightened to the tension quoted in the Maintenance Manual.

9.5 **Bleeding**

Bleeding of the hydraulic braking system is normally carried out using an approved hydraulic servicing rig connected into the aircraft system at selected quick-release couplings. It is normal practice to bleed the main hydraulic system first to ensure the fluid passing to the brakes is free from air. A typical procedure would be as follows:

a) Install landing gear ground locks and door locks and chock wheels.

b) Release parking brake.

c) Connect hydraulic servicing rig to aircraft system and adjust to normal operating pressure.

NOTE: Cleanliness of the rig connections and fluid are most important and every precaution must be taken to prevent the ingress of foreign matter into the aircraft system.

d) Apply and release brakes several times.

e) Set hydraulic pressure to a low value (as specified in the Maintenance Manual) and slowly pump the brake pedals to discharge the brake accumulator, then set the parking brake.

f) Release brake unit bleed screws and bleed until bubble-free fluid is discharged, then close bleed screws.

g) Reset hydraulic pressure to normal system pressure and release parking brake.

h) Operate foot brakes several times and check operation and release of brakes by observing movement of the disc return springs.

i) Remove servicing rig, check level of fluid in hydraulic reservoir and restore aircraft to normal.

9.6 **Testing**

Operation of the wheel brakes may be checked by operating the brakes normally and visually observing the action of the disc return springs and their efficiency may be assessed during taxying. When a full functional check is required however, such as after initial installation or following major component change, a more detailed procedure must be followed. This will normally entail the installation of landing gear ground locks and door locks, or jacking the aircraft and carrying out the following operations:

a) Install a suitable pressure gauge at each brake unit bleed fitting.

b) Provide hydraulic power (by connection of a hydraulic test rig or by running an aircraft hydraulic pump).

c) Check operation of brake system warning lights and gauges by reference to the relevant Maintenance Manual.

d) Fully depress each brake pedal in turn, note the pressure recorded at each pressure gauge and check brake operation.

e) Release brake pedals, visually or physically check that the brakes are off and check that the readings on the pressure gauges are zero or less than a specified maximum pressure.

f) Repeat checks with parking brake and, where fitted, the alternative hydraulic system.

NOTE: On some aircraft which are fitted with an automatic brake system to stop the wheels during landing gear retraction, the test may also include selecting the landing gear up and carrying out a function check.

9.7 Maintenance

9.7.1 The main items of maintenance common to all modern aircraft with high pressure braking systems are the checking of fluid levels and accumulator gas pressures, followed by replenishment as necessary. When recharging the gas in accumulators the system hydraulic pressure should be fully released and when topping up a hydraulic reservoir it must be ensured that all the hydraulic rams are in their appropriate positions. The various components and pipelines should also be inspected at frequent intervals for chafing, security, satisfactory bonding and freedom from leaks.

NOTE: High pressure air or nitrogen charging cylinders should be fitted with relief valves and extreme care taken to ensure that specified accumulator gas pressures are not exceeded.

9.7.2 The procedure necessary for the replacement of components in a braking system will be found in the approved Maintenance Manual and particular attention should be given to the prescribed safety precautions. In particular, since a high pressure braking system contains a pressurised accumulator, the system will always be under pressure whether the normal aircraft hydraulic system is operating or not and this pressure must be released before a disconnection is made. The normal method is to slowly pump the brake pedals until the accumulator is discharged and this also provides a means of checking internal leakage in the system by observing the number of full brake applications available.

10 Overheated Brakes

10.1 The action of braking converts kinetic energy into heat and the temperature of brake units will, therefore, rise during use. There is a limit to the amount of heat which can be absorbed and dissipated by a brake and wheel unit and excessive use of the brakes, such as during a rejected take-off or prolonged periods of taxying, can lead to overheating and combustion and, in extreme cases, result in rupture of a wheel assembly.

10.2 One of the main problems associated with overheated brakes or brake fires, is how to cool the wheel without inducing uneven contraction of the metal. This could cause fracture of the wheel and explosive release of the air in the tyre. Serious and sometimes fatal, accidents have been known to occur as the result of the application of an incorrect extinguishant to a brake fire.

10.3 A small fire, due perhaps to combustion of grease on the wheel, would probably cause less damage in burning itself out than might be caused by attempting to extinguish it. A short period should be allowed, therefore, to check the progress of the fire before attempting to put it out. In some cases however, such as when the fire is fed by leaking hydraulic fluid, immediate action will be necessary; some aircraft wheels are made from magnesium alloys which, once ignited, burn fiercely and are difficult to extinguish.

10.4 Tests have shown that the safest extinguishant to use is a dry chemical agent and this must be used whenever possible. It should be applied by an operator standing in line with the tyre’s rolling path and at a safe distance; an overheated wheel should never be approached in line with the axle.

10.5 If a wheel fire has to be extinguished and no dry chemical is available, CO_2 or foam may be used but extreme caution is necessary. The extinguishant should be applied as lightly as possible from a distance of at least 6 metres (20 feet) to reduce the likelihood of uneven cooling and the area should be kept clear after the fire has gone out, until such time as the wheel and brake are completely cooled.

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Leaflet 5-9 Oxygen Systems

1 Introduction

1.1 This Leaflet provides information of a general nature on the types of gaseous oxygen systems and equipment used in aircraft, installation and maintenance practices and precautions to be observed. Because of the wide variation in the design of oxygen equipment installed in different types of aircraft it is important that this Leaflet is read in conjunction with the appropriate aircraft Maintenance Manual and the approved Maintenance Schedule. The following CAAIP Leaflets contain information associated with the subject covered by this Leaflet and reference should be made to these as appropriate:

5–6 Installation of Rigid Pipes in Aircraft

9–1 Bonding and Circuit Testing

1.2 The Air Navigation Order 2005 (as amended) prescribes the conditions under which oxygen equipment is required and British Standards N1, N100 and N2 specify general requirements for aircraft oxygen equipment and materials and processes to be used in its manufacture. The breathing oxygen used in aircraft systems should comply with British Standard N3 and International Standard ISO 2046.

2 Purpose of Oxygen Systems

2.1 With increase in altitude the pressure of the atmosphere and the partial pressure of its oxygen content decreases, resulting in a deficiency of oxygen in the blood and tissues of individuals subjected to such pressures. This condition known as 'anoxia', seriously impairs physical and mental abilities and prolonged exposure to it can prove fatal. The purpose therefore of oxygen systems in aircraft, is to offset the varying effects of anoxia by supplying oxygen through a breathing mask at a controlled rate of flow.

2.2 Information on the physiological effects of altitude may be obtained from BS N100, but for the purpose of this Leaflet the following is quoted from that document: 'Unless oxygen is administered at high cabin altitudes unconsciousness and finally death will occur, the time of onset of unconsciousness depending on the cabin altitude, for example, without added oxygen the time of useful consciousness at 25 000 feet is approximately three minutes and at 40 000 feet it is twenty seconds.' Table 1 also contains some relevant information extracted from a more detailed Appendix to the British Standard N100.

Table 1

Physiological Effects of Altitude	Feet
Maximum altitude without oxygen at which flying efficiency is not seriously impaired	8000
Altitude at which the incidence of decompression sickness increases rapidly with exposures exceeding ten minutes	25 000
Maximum altitude at which sea level conditions can be maintained by breathing 100% oxygen	33 000
Maximum allowable altitude without pressure breathing	40 000

3 Oxygen Systems

3.1 Civil transport aircraft cruise at altitudes where cabin pressurisation is necessary to maintain conditions inside the cabin approximately equal to a maximum altitude of 8000 feet, regardless of the actual altitude of the aircraft above this figure. Under such conditions oxygen is not normally needed for the comfort of the passengers and crew. However as a precaution, oxygen equipment is installed for use in the event of a cabin pressurisation system failure. In addition, portable oxygen sets are also provided for therapeutic purposes and for cabin attendants' use while moving about the passenger cabin during low cabin pressure emergencies.

3.2 In some of the smaller and medium size aircraft designed without a cabin pressurisation system, oxygen equipment may be installed for use by passengers and crew when the aircraft is flown above 10 000 feet. In other cases where there is no oxygen system installation, passengers and crew depend on portable oxygen sets stowed in convenient positions.

3.3 The design of the various oxygen systems used in aircraft depends largely on the type of aircraft, its operational requirements and, where applicable, the pressurisation system. In some aircraft the continuous flow oxygen system (see paragraph 3.4) is installed for both passengers and crew but the diluter demand system (see paragraph 3.5) is widely used as a crew system, especially on the larger types of transport aircraft. Many aircraft have a combination of both systems which may be augmented by portable sets.

3.3.1 The oxygen is normally stored in gaseous form but, in some cases, systems may be used in which oxygen is produced when required, by special oxygen generators operating on a chemical reaction principle (see paragraph 3.6). Gaseous oxygen is stored at approximately 1800 lb/in^2 and is reduced to the low pressure required for breathing purposes by pressure regulator valves or reducer valves. In oxygen generator systems the gas is produced directly at low pressure.

NOTE: The pressure in most systems is normally reduced in one stage from high to low, but in some aircraft a two stage reduction is effected, i.e. from high pressure to medium and then to low pressure.

3.4 Continuous Flow Oxygen Systems

3.4.1 A typical continuous flow oxygen system is illustrated in simplified form in Figure 1. When the line valve and cylinder valve are turned 'on' oxygen will flow from the charged cylinder through the high pressure pipe to the pressure reducing valve which reduces the pressure to that required at the mask connection points. Reducing valves may be fitted directly to cylinders together with shut-off valves, or they may be separate units designed for 'in-line' coupling. A calibrated orifice is normally provided in the sockets to control the flow of oxygen delivered to the mask.

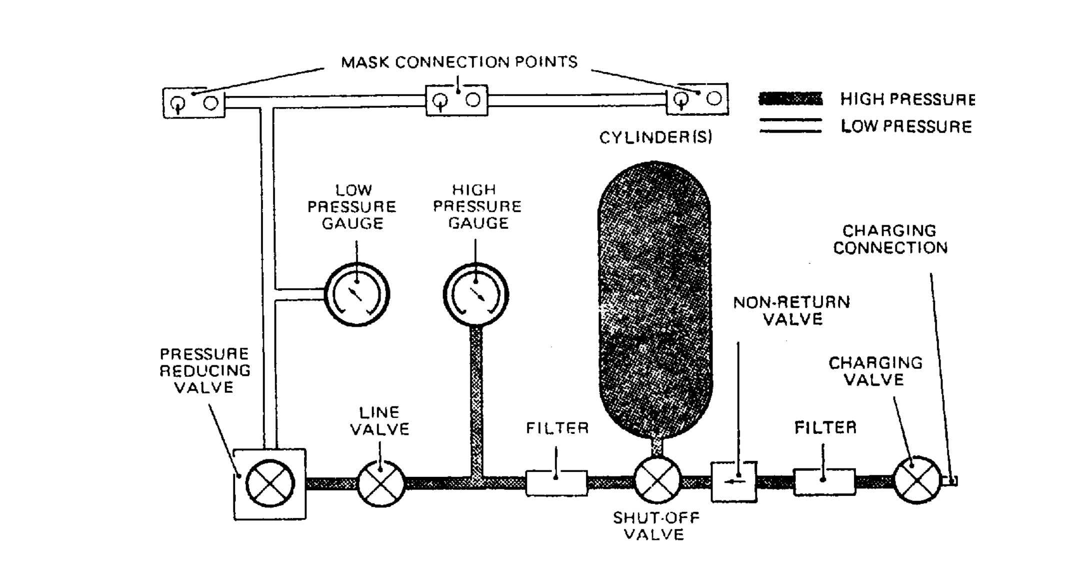

Figure 1 Typical Continuous Flow System

3.4.2 The passenger system may consist of a series of supply sockets with mask plug-in connections at each passenger seat group, or it may be the 'drop-out' mask arrangement where, in the event of pressurisation system failure, individual masks are presented automatically to each passenger from service units. When the masks are pulled to the useable position, valves are opened to permit oxygen to flow to the masks, the flow being indicated by a simple flow indicator within each mask hose. Any automatic control (e.g. barometric control valve) in the ring main supply can be overridden manually by a member of the crew. Service units are also provided with a plug-in receptacle for attaching a separate mask for therapeutic use.

3.4.3 Figure 2 illustrates a continuous flow system commonly used in some types of light aircraft carrying a pilot and five passengers. The cylinder contains gaseous oxygen at 1800 lb/in^2 and has the pressure regulator and pressure gauge fitted directly to it. The shut-off valve is also on the regulator and is opened and closed by a mechanical linkage connected to a control knob in the cockpit. Mask connections are of the plug-in type and each mask hose contains a simple device which indicates that oxygen is flowing. A cylinder charge valve is incorporated in the system and is usually of the self-sealing, automatic opening and closing type.

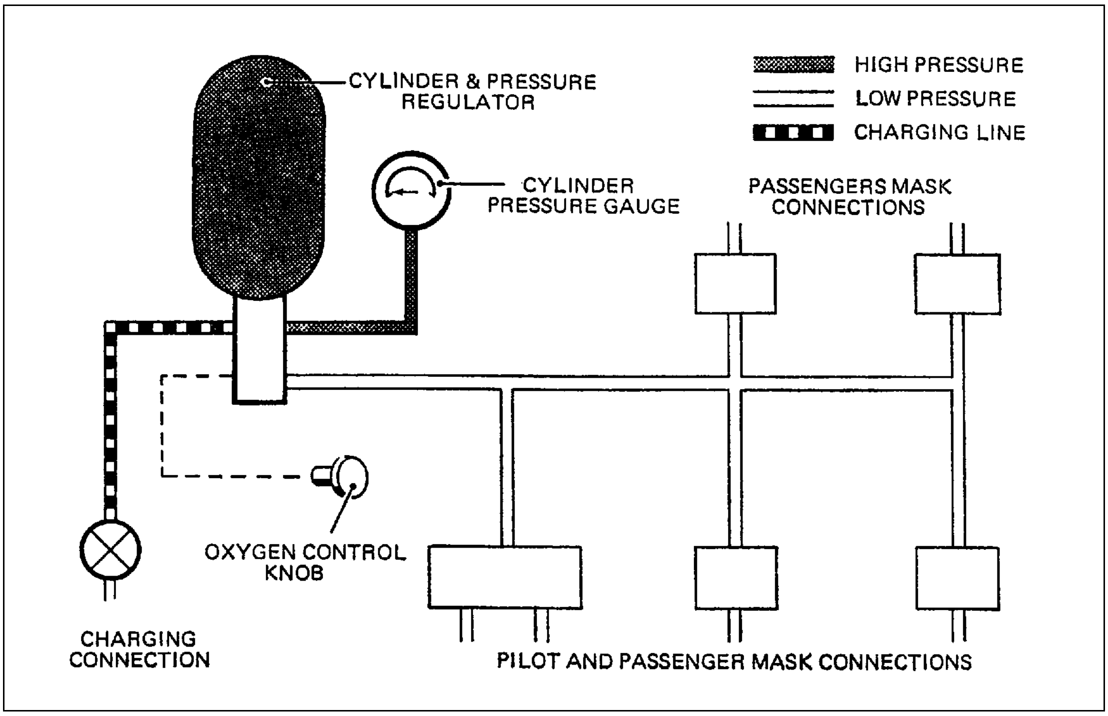

Figure 2 Typical Light Aircraft System

3.5 **Diluter Demand System**

A diluter demand system is one in which the oxygen is diluted with air and the mixture is supplied only when the user inhales, i.e. as demanded by an individual respiration cycle. The interconnection of a typical system is illustrated in simplified form in Figure 3. It will be noted that there is a regulator for each crew member who can control the regulator according to his requirements. The operation of a typical regulator is described in paragraph 4.7.

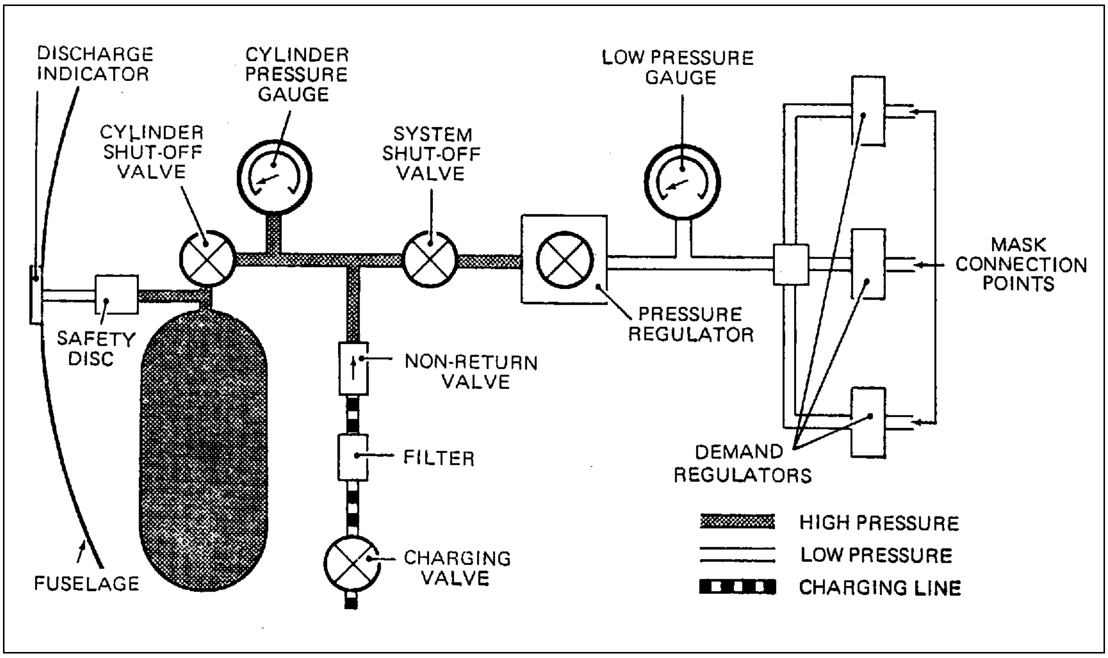

Figure 3 Typical Diluter Demand System

3.6 **Chemical Oxygen Generator Systems**

3.6.1 In these systems, oxygen is produced by chemical generator and dispenser units which are contained within service panels at each group of passenger seats and other essential locations.

3.6.2 In the basic form, a unit consists of a generator, a 'drop-out' mask and hose. The generator (see Figure 4) is comprised of a corrosion resistant steel cylinder containing a thermal insulating liner, a compressed block of sodium chlorate and iron powder, a filter and an electrically operated firing mechanism mechanically connected to the mask by a lanyard. The power supply required for electrical operation is 28 volts d.c. The mask is ejected automatically from the service panel by a release mechanism controlled by an aneroid switch, the contacts of which are set to make at the appropriate cabin altitude, e.g. 14 000 feet.

3.6.3 When the mask is pulled towards the user, the lanyard trips the generator firing mechanism which then ignites the sodium chlorate charge block. As the temperature of the block is raised a chemical reaction is created, thereby producing a supply of low pressure oxygen which flows through the filter to the mask. This process continues until the charge block is expended. Oxygen normally flows for a period of 15 minutes and although extremely high temperatures are generated, the temperature of the oxygen delivered at the mask does not exceed 10°C above ambient.

NOTE: In some generator systems, the sodium chlorate charge block is ignited by current supplied through the aneroid switch.

3.6.4 Oxygen generators are made in three sizes depending on the number of passenger masks to be supplied. A valve to relieve any excess pressure is incorporated and an indication of an expended generator is also provided by the change in colour of a band of thermal paint around the outside of the case.

3.7 **Portable Oxygen Sets**

3.7.1 A typical portable oxygen set consists of an alloy steel lightweight oxygen cylinder fitted with a combined flow control/reducing valve and a pressure gauge. A breathing mask, with connecting flexible tube and a fabric carrying bag with the necessary straps for attachment to the wearer completes the set. The charged cylinder pressure is usually 1800 lb/in^2. The capacities of sets vary, a size most commonly used being 120 litres.

3.7.2 Depending on the type of set, it is normally possible to select at least two rates of flow, 'Normal' and 'High'. With some sets three flow rate selections are possible, i.e. 'Normal', 'High' and 'Emergency' which would correspond to 2, 4 and 10 litres per minute with an endurance under these flow rates of 60, 30 and 12 minutes respectively for a cylinder of 120 litre capacity.

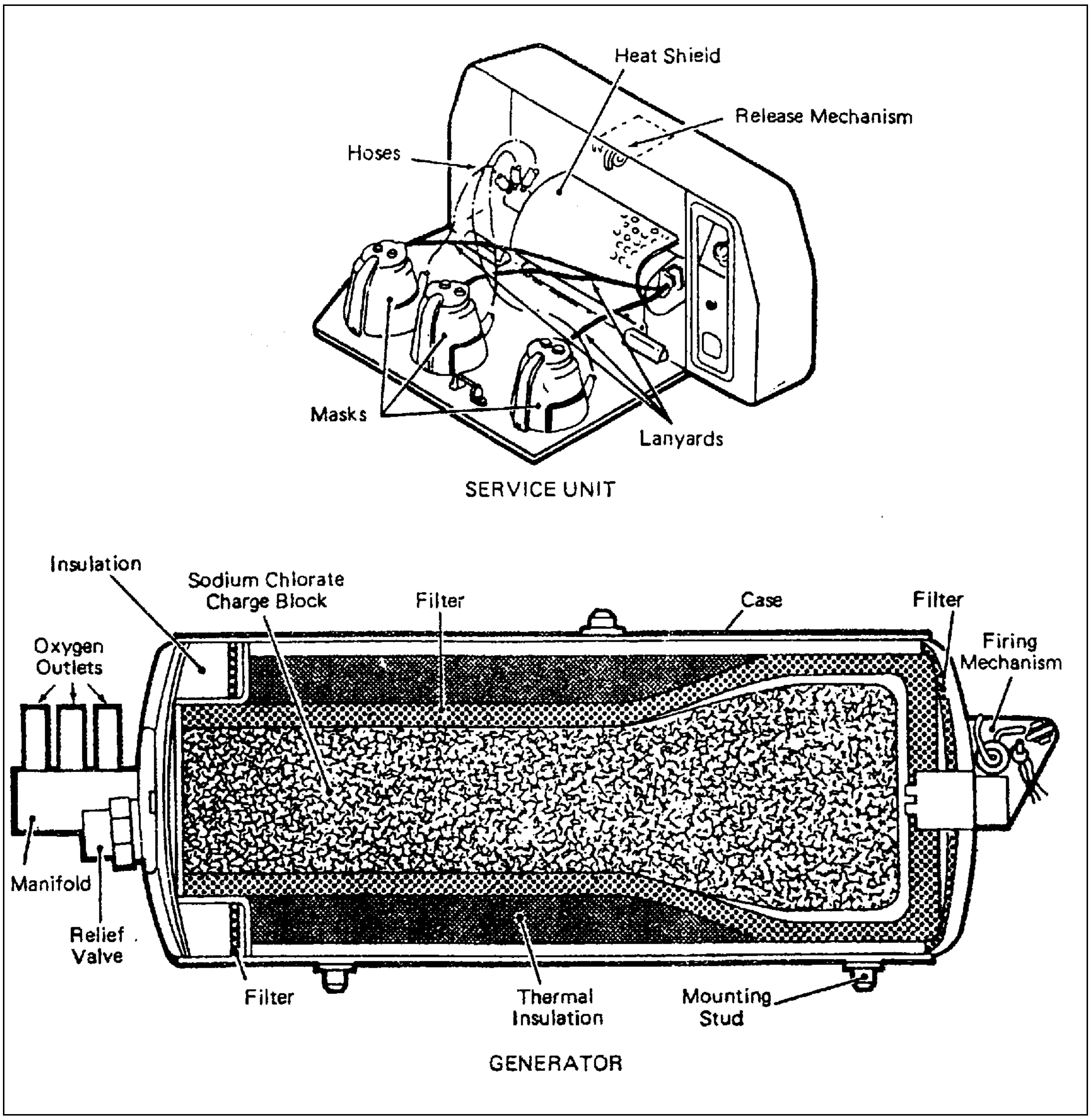

Figure 4 Chemical Oxygen Generator System

4 Components

4.1 Brief details of some of the components commonly used in oxygen systems are given in the following paragraphs. Full descriptive details of the components installed in specific types of aircraft are contained in the relevant Maintenance Manuals and reference should be made to these documents.

4.2 Oxygen Storage Cylinders

4.2.1 Cylinders designed for the storage of gaseous oxygen are made from drawn high tensile alloy steel and normally have a manual stop valve and, in many instances, a pressure regulator and a pressure gauge threaded into the neck of the cylinder. The charged pressure is usually 1800 lb/in^2 and capacities vary from 80 litres for portable sets to 2250 litres for large installations.

4.2.2 Cylinders are often provided with an excess pressure rupture disc, usually fitted in the valve body, which vents the cylinder contents to the outside of the aircraft in the event of a dangerous pressure rise. An indicator is provided in some aircraft to indicate discharge resulting from pressure relief (see paragraph 4.13).

NOTE: The disc is designed to rupture before excessive pressure could cause damage.

4.2.3 Cylinders for use in aircraft oxygen systems are colour coded for identification purposes and there are two codes presently adopted:

a) black for the main body and white for the top hemispherical portion (the valve end), and

b) green for cylinders of American origin.

As a means of further identification of cylinder contents, it is also necessary for the name of the gas and its chemical formula to be marked at the valve ends of cylinders in accordance with British Standard N100 and International Organisation for Standardisation recommendation ISO R448. In addition, the following information is painted or stencilled on the bodies of the cylinders:

a) In red letters on a white background: 'Use No Oil'.

b) In white letters on the black cylindrical portion:

Name of manufacturer

Drawing assembly No.

Capacity . . . . litres

Test pressure . . . .

Working pressure . . . .

Test date . . . .

NOTE: The test date refers to a pressure test and may also be stamped on the neck ring of a cylinder.

4.3 **Pipe Lines**

4.3.1 The characteristics of the pipe systems vary widely between different types of aircraft and the particular oxygen system installed and reference should be made to the relevant manuals for full details. High pressure pipes are usually made of either stainless steel or copper-based alloys, while pipes for low pressure areas of systems are made of aluminium based alloys. Pipes also vary in size and some typical values are $^{3}/_{16}$ to $^{1}/_{4}$ inch outside diameter for high pressure pipes and $^{5}/_{16}$ inch outside diameter for low pressure pipes.

4.3.2 The types of couplings normally used for pipe joints are of the standard AGS type and MS flareless tube type. Because of the difficulty of ensuring the complete removal of flux and scale, silver soldered connections are, generally, not used.

4.3.3 Identification of pipes in the system by symbols and colour coding is widely used and should comply with BS M23. Tie-on metal tags or metal identification rings should not be used as they may cause damage through vibration, or become detached and foul moving parts of control systems.

4.4 **Non-Return Valves**

These components are designed to prevent flow reversal and are installed in a pipe line or at a connector adaptor. Of the two basic types commonly used, one consists of a housing containing a spring-loaded valve which is forced against the spring when pressure is applied to the inlet side, thus breaking the seal and allowing oxygen to flow. When pressure is equalised the spring returns the valve onto its seating, so preventing any reversal of oxygen flow. The other type is a bell-mouthed hollow cylinder fitted with a captive ball in its bore. When pressure is applied at the bell-mouthed (i.e. inlet) end, the ball is forced onto the seating of a port at the opposite end and at the same time, its displacement uncovers holes in the wall of the valve to allow oxygen to flow into the pipe or connection. Any tendency for the flow to be reversed is prevented by the oxygen forcing the ball back onto its seating at the inlet end. The normal direction of flow for both types of valve is indicated by an arrow on the valve body.

4.5 **Filters**

Filters, generally of the gauze or sintered bronze type, are provided at points downstream of oxygen cylinders and in some cases, immediately after the ground charging connection. In most systems in current use a filter, usually of the sintered bronze type, is normally embodied in the supply connection of a particular component, e.g. a regulator or a reducing valve. In some instances the charging connection is counter-bored to house a slugtype sintered bronze filter which also acts as a restrictor to guard against too rapid charging of the system.

4.6 **Pressure Reducing Valves**

4.6.1 These valves reduce the high pressure oxygen from the storage cylinders to the pressure required in the low pressure part of the system. In a continuous flow system the reduced pressure is supplied to the mask connection points. In a pressure demand system the pressure from the reducing valve is comparatively higher than that for a continuous flow system and further pressure regulation is necessary at each regulator.

4.6.2 Design features vary considerably, but in general, reducing valves comprise a pressure reducing pre-set spring and valve control mechanism with a relief valve to safeguard against overloads. Pressures can be reduced to the pressure required for a particular system (e.g. from 1800 lb/in^2 to 80–100 lb/in^2).

4.7 **Oxygen Diluter Demand Regulators**

These regulators are used in crew oxygen systems (see paragraph 3.5) and are designed to adjust the output ratio of oxygen and air in accordance with cabin pressure and to supply, on demand, the correct air/oxygen mixture. A typical diluter demand regulator operates as follows:

a) With the oxygen supply 'on' and 'normal oxygen' selected by the appropriate control lever on the regulator, diluted oxygen in accordance with cabin altitude will be supplied to the crew member’s mask when the user inhales. The amount of air mixed with oxygen is controlled by the regulator and the air decreases with increase in cabin altitude until a cabin altitude of 32 000 feet is reached when approximately 100% oxygen is supplied.

b) If the crew member selects '100% oxygen' the regulator air valve is closed and 100% oxygen is supplied when the user inhales, irrespective of cabin altitude.

c) If 'Emergency' is selected, e.g. to provide protection against smoke and other harmful gases, a flow of 100% oxygen is supplied at a positive pressure to avoid any inward leakage into the mask. Depending on the type of regulator, the oxygen may either flow only when the user inhales, or continuously and irrespective of the user’s respiration cycle.

d) When 'Test mask' is selected oxygen is supplied at a higher pressure than that provided for the 'Emergency' condition and is used for testing the masks and equipment for fit and leakage.

4.8 **Supply Sockets**

These components provide connections between the aircraft system and individual oxygen mask connecting tubes. Some embody two socket points for 'Normal' or

'High' flow and others may have only one socket point with a flow selector lever. Calibrated orifices in the socket points of continuous flow systems control the flow rate to the masks. Socket points are made with self closing shut-off valves, spring loaded in the closed position and open when the mask tube connecting plug is inserted in the socket.

4.9 **Pressure and Contents Indicators**

4.9.1 Pressure indicators are provided to indicate cylinder pressure and, where necessary, medium and low pressure in the supply lines. The indicators are normally of the direct-reading Bourdon tube type calibrated in lb/in^2 and may be located on cylinders, pressure regulators and at oxygen system servicing panels. In aircraft requiring monitoring of system high pressure, electrical indicating systems are also employed at a flight engineer’s station. These consist of a transducer which senses high pressure and converts it to a variable electrical signal for controlling an indicator at the flight engineer’s panel. The power supply required for operation is 28 volts d.c. and a regulating circuit is incorporated to ensure that pressure indicators are not effected by fluctuations in supply voltage.

4.9.2 Pressure switches are installed in the low pressure sections of some passenger oxygen systems to illuminate warning lights, thereby indicating that a system is in use. The lights are located on a cockpit overhead panel and on cabin attendants’ panels.

4.9.3 Contents indicators, as opposed to pressure indicators, are fitted to some types of cylinders and they are normally marked with coloured sectors to indicate contents in terms of 'FULL', '¾ FULL', etc.

4.10 **Oxygen Masks**

4.10.1 There are numerous types of oxygen masks in use which vary widely in design and detailed information is outside the scope of this Leaflet. It is important that the masks used are suitable for the particular oxygen system concerned.

4.10.2 In general, crew masks can be fitted to the wearer’s face with minimum leakage and may be of the self-contained re-breather type. Crew masks also contain a microphone cord and jackplug for connection into the aircraft communications system. In some instances there is a requirement for pressurised aircraft to carry oxygen masks designed for the protection of crew members in a smoke- or fume-laden atmosphere. These masks are of the full-face type consisting of a transparent visor, oxygen supply hose and adjustable head straps, or of the 'sweep-on' type with pre-set head straps and/or elasticated sides. A demand regulator may also be fitted to some masks to control the flow. The hose connections are of the plug-in type designed for insertion into the supply sockets of a ring main system or, alternatively, a portable cylinder.

4.10.3 The masks provided in automatic drop-out systems for passengers are normally simple cup-shaped rubber mouldings sufficiently flexible to obviate individual fitting. They may be held in position by a simple elastic head strap, or may require holding to the face by the passenger. In non-automatic systems, the masks are usually plastic fitted with a simple elastic head strap.

4.11 **Flow Indicators**

Oxygen flow is often indicated by a direct type of flow indicator, e.g. a float inside the transparent hose of a mask, or by a pressure-operated blinker type of instrument.

4.12 **Thermal Compensators**

4.12.1 Thermal compensator assemblies are installed in the charging lines of some oxygen systems for the purpose of minimising temperature build-up when oxygen, at charging pressure, flows through. A compensator consists of a brush-like wire element approximately 5 inches long, inserted into a stainless steel tube provided with connectors at each end.

4.12.2 There are two types of thermal compensators in use, one for connection to oxygen cylinders and the other for connection to shut-off valves or regulators. Those fitted to oxygen cylinders have a coupling nut fitting that attaches direct to a cylinder and the downstream end has a flareless tube connection. The second type of compensator is attached to the component by means of a corrosion-resistant steel union through which the wire element extends. A flareless tube connection is fitted to the upstream end.

4.13 Discharge Indicators

In some aircraft, discharge indicators are mounted flush to the fuselage skin in an area adjacent to the oxygen system servicing panels. They are connected to the pressure relief lines from the oxygen cylinders and consist of a green plastic disc which is normally retained within its holder by a circlip. In the event of an excess pressure within a cylinder the safety valve opens and escaping oxygen will blow out the indicator disc, thereby providing a visual indication that discharge has occurred.

4.14 Ground Charging Valves

4.14.1 Oxygen systems are provided with valves to permit 'in-situ' charging of the cylinders from special ground servicing units. The charging connections to the valves are normally sealed off by blanking cap nuts. A short length of chain between a cap nut and an adjacent part of the structure, ensures retention of the nut at the charging point location when removed for charging purposes.

4.14.2 In some systems, the charging valve incorporates manual temperature and pressure compensation adjustments which allow the system cylinder to be charged to optimum pressure at the ambient temperature in the vicinity of the cylinder. The charging rate is automatically controlled by the valve to a safe value thereby minimising the hazard of heat build-up. A pressure/temperature correction chart is normally displayed near the charging valve for reference purposes.

NOTE: An air temperature indicator is sometimes fitted at the location of aircraft cylinders to record ambient temperature conditions.

5 Installation and Maintenance Practices

5.1 To ensure that oxygen systems serve their purpose of supplying hygienically clean oxygen under emergency conditions in an efficient and safe manner, strict observance of servicing instructions and the necessary safety precautions, is essential during the installation and maintenance of components. Failure to observe such precautions could result in fire and explosions and consequent serious injury to personnel and severe damage to an aircraft. The emphasis is, at all times, on cleanliness and on the standards of the work to be carried out at the appropriate stages of installation and maintenance.

5.2 The information given in the following paragraphs is intended to serve as a guide to practices and precautions applicable to systems in general. Details relevant to specific types of aircraft systems are contained in the approved Maintenance Manuals and the schedules drawn up by an aircraft operator and reference must always be made to these documents.

5.3 **Servicing Personnel**

Servicing personnel must fully understand the operation of an aircraft system, the relevant ground charging equipment and its connection to charging points and must have a full knowledge of any appropriate engineering and maintenance regulations in force. Personnel should also be alert to emergency situations which could arise during oxygen system servicing.

5.4 **Oxygen Fires or Explosions**

5.4.1 An oxygen fire or explosion depends on a combination of oxygen, a combustible material and heat. The danger of ignition is in direct ratio to the concentration of oxygen, the combustible nature of the material exposed to the oxygen and the temperature of either the oxygen or the material, or both.

5.4.2 Oxygen itself does not burn but it supports and vigorously intensifies a fire with any combustible material. The term 'combustible material' is used in its widest sense, denoting not only flammable materials but also such materials as steel, normally considered to be non-combustible, but which is in fact combustible at high temperatures in the presence of oxygen under pressure.

5.4.3 Any oxygen system leak can lead to a build-up of near-pure oxygen in unventilated zones, particularly in aircraft that remain idle. A concentration of oxygen in such a zone, e.g. behind upholstery, or thermal/acoustic lagging, or in control panels, could result in a fire or explosion by contact with grease, oil or electrical hot spots. Any indication of pressure loss or leaks must, therefore, be treated as hazardous and must be traced and eliminated before further flight (see also Leaflet 11–22 Appendix 35–1).

5.4.4 Heat can be generated in an oxygen system by sudden compression or by resonance of oxygen under relatively low pressure impinging into a dead-end cavity. It can also be caused by the vibration of a seal, 'O' ring, or other non-metallic material which is exposed to oxygen under pressure. A small high pressure leak could cause ignition of the material through which it is leaking due to heat generated by friction.

5.4.5 Many materials such as oils, grease, fuel, paint, flammable solvents and metal swarf (e.g. from a damaged thread or a pipe coupling) are liable to ignite or explode spontaneously when exposed to oxygen under pressure. Similarly, extraneous matter such as dust, lint from a cleaning rag or natural oil from the hands getting into the system or into a component could cause ignition or explosion. It is essential therefore to keep these materials and other extraneous matter away from exposed parts of oxygen systems to prevent contamination. Clean areas should be used for dismantling and assembly of all oxygen system components.

5.5 **Safety Precautions**

5.5.1 Before carrying out any work on an oxygen system, the following precautions against fire should be taken:

a) Provide adequate and properly manned fire-fighting equipment.

b) Display 'No Smoking' and other appropriate warning placards outside the aircraft.

c) If artificial lighting is required, use explosion-proof lamps and hand torches (e.g. equipment complying with BS 4683 and BS 889).

d) Testing of aircraft radio or electrical systems should be avoided.

e) Ensure that the aircraft is properly earthed.

f) Ensure that charging or servicing units, appropriate to oxygen systems are used and that they and all other necessary tools, are serviceable and free of dirt, oil, grease or any other contaminants.

g) Where work on an oxygen system is to be performed in a confined space within the aircraft, adequate ventilation must be provided to prevent a high concentration of oxygen.

h) Pipe and component connections should be wiped clean and dry if contamination is present.

i) One of the most serious hazards with oxygen is the penetration of the gas into clothing which can take place when a person has been exposed to an oxygen-rich atmosphere. In this state an infinitesimal particle of hot ash from a pipe or cigarette, can ignite the clothing which will immediately burst into a fierce flame. Clothing which has been saturated by oxygen should be kept away from naked lights or any other source of heat until a period of a quarter of an hour has elapsed, or until thorough ventilation with air has been effected.

j) A clean area, with bench surfaces and tools free of dirt and grease, should be used whenever it is necessary to carry out work on oxygen system components.

5.5.2 The following general procedures and precautions should be followed when handling, testing and cleaning any part of an oxygen system:

a) Clean, white, lint-free cotton gloves should be worn by servicing personnel.

b) Before installing a component it must have been cleaned in accordance with the cleaning instructions laid down in relevant manuals (see also paragraph 5.11). In order to avoid contamination, protective/blanking caps should not be removed until immediately before the installation of the component. When the caps are subsequently removed, the fittings of the component should be checked to ensure they are clean and free of contaminants, e.g. flaked particles from protective caps.

c) Shut-off valves should always be opened slowly to minimise the possibility of heat being generated by sudden compression of high pressure oxygen within the confined spaces of valves or regulators. Particular attention must also be paid to any torque values specified for valve operation.

d) Before uncoupling a connection the oxygen supply must be turned off. Connections should be unscrewed slowly to allow any residual pressure in the line or component to escape.

NOTE: If a cylinder valve is not completely closed, or is leaking and there is a time lag after bleeding a line, sufficient oxygen pressure could build up in the line to become potentially dangerous.

e) Certain components are stored in polythene bags which should not be opened until immediately prior to installation. If a bag containing a component has been torn or unsealed during storage, the component should be re-cleaned.

f) All open pipe ends or component apertures should be kept capped or plugged at all times, except during installation or removal of components. Only protection caps or plugs designed for the purpose should be used (see also paragraph 5.6.4 h)).

g) On replacement of a component requiring electrical bonding or power supply connections, e.g. an electrical pressure transducer, the circuit should be tested (see also Leaflet 9–1).

h) For leak testing, only those solutions specified in the relevant manuals must be used. Care must be taken to prevent a solution from entering any connection, valve or component. All tested parts must be wiped clean and dried immediately (see also paragraph 5.8).

i) For the testing of components, clean dry filtered air or nitrogen may be used instead of oxygen. On completion of the tests, components should be purged with breathing oxygen.

NOTE: Guidance on the requirements for gases to be used for testing is given in Appendix 'C' to British Standard N100.

5.6 **Components**

5.6.1 The following paragraphs detail some of the procedures and precautions generally applicable to the installation and maintenance of the principal components comprising oxygen systems. Reference should always be made to the approved Maintenance Manual relevant to a specific aircraft and system for full details.

5.6.2 **Cylinders**

The handling and transportation of cylinders requires that extreme care be exercised at all times. They must not be allowed to fall over, or be knocked or jarred against hard or sharp objects, or against each other. On no account must they be rolled from a truck or trolley directly onto the ground.

a) Rapid opening of valves to allow a sudden release of oxygen under pressure from the outlet connections should be avoided. This applies particularly to cylinders which do not incorporate a pressure reducing valve. Apart from the fire risk, the reaction from the pressure discharge can cause an insecurely held cylinder to become a dangerous uncontrollable object.

b) Cylinders must be checked to ensure that the date of the last pressure test (see paragraph 5.9) has not expired and that the storage pressure is not below the minimum specified in the relevant manual. A pressure of 14·07 to 21·1 kg/cm^2 (200 to 300 lb/in^2) is typical.

c) Where specified, it is necessary to carry out tests to ensure that there is no leakage of oxygen from the seats and spindle glands of cylinder valves.

d) Control valves and, where appropriate, pressure regulators and gauges, are fitted by the cylinder manufacturers and no attempt should be made to remove them during service.

e) The exterior of cylinders should be checked for signs of corrosion and damage such as dents, cuts, gouging, or marking by metal stamps other than that prescribed by the manufacturer on defined areas of the body. If the acceptability of a cylinder is in question after making these checks it must be withdrawn for more detailed inspection and overhaul.

f) Checks on threads of connections should be carried out to ensure they are clean and free from damage. Thread lubricants should not be used (see also paragraph 5.7). Protective caps should remain on the connections until a cylinder is ready for installation and should be replaced immediately a cylinder is removed.

g) During installation of cylinders a check must be made that they are properly aligned with their respective pipe lines before finally tightening cylinder clamps and pipe connecting unions.

h) After installation, cylinder valves should be slowly opened to pressurise the high pressure lines and a leak test carried out at the cylinder connections and any other connections which may have been opened. On satisfactory completion of a leak test, cylinder pressures should be checked and recharging to normal system pressure carried out where necessary (see also paragraph 5.12) and valves should be wire locked in the open position.

i) If cylinders are inadvertently discharged below the minimum specified pressure, condensation will occur. Cylinders in this condition should be identified for special action when recharging (see also paragraph 5.13.3 g)).

5.6.3 **Chemical Oxygen Generators**

Unexpended generators should be handled with extreme care to prevent inadvertent removal of the firing pin. A blanking cap is normally fitted over the pin and this should remain in position until the generator is finally installed and the lanyard is tied to the disconnect ring of the mask. If a generator should become activated it should be immediately placed on a non-combustible surface.

a) A minimum clearance of $^{5}/_{8}$ inch must exist between a generator and its heat shield to allow proper cooling when the generator is activated.

b) Oil or grease must not be used to lubricate the hinges or latch mechanism of a service panel door.

c) When closing the door of a service panel it should be checked that the hoses between the generator and masks will fold without kinking or twisting.

d) Generators which have passed their expiration date or which have been used are **forbidden** for air transport. New or unused generators intended for air transport must be prepared for carriage in accordance with the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air, Doc 9284-AN/905 and are **forbidden** on passenger aircraft.

5.6.4 **Pipes and Fittings**

Pipes and fittings should be inspected for damage, cleanliness and signs of corrosion. If a pipe is damaged or deformed it should be removed and a new pipe fitted. The security of pipe attachments such as 'P' clips, support brackets, etc. and the conditions of electrical bonding connections should be checked.

a) Only pipes and fittings designated for use with oxygen and cleaned by an approved method must be installed (see also paragraph 5.11).

b) Clearances between pipes and aircraft structure should be in agreement with those specified in the relevant aircraft manuals and installation drawings, otherwise damage may be caused by vibration. Particular care is necessary to ensure clearance between pipes and moving parts such as aircraft control rods and levers.

c) Before making a connection it is important to verify that any loose parts which may form part of the connection such as nipples and filters, are properly positioned and that any identification (e.g. filter notice or direction of flow) relating to the connection is clearly shown.

d) Pipes and fittings should align with each other; with components such as cylinders, valves, etc. be assembled without using undue force and no gap should exist between the fittings.

e) Pipes should, in the first instance, be positioned and only partially coupled (i.e. turning union nuts through one or two threads) to each other or components as the case may be. The alignment of the tubes should then be adjusted for optimum clearance and the tubes partially secured to the structure by the appropriate attachment method. Commencing at either end of the pipe run, the union nuts should be backed off and a check made on the seating of the fittings. If satisfactory, union nuts should be re-fitted and tightened and the pipe attachments finally secured.

f) Torque values specified for a particular oxygen system should be strictly observed when tightening the fittings. A fitting should never be overtightened to effect a seal or to establish a proper electrical bond; loosen the fitting and retorque it several times, if necessary, until the seal or bond has been established.

g) When tightening or disconnecting a pipe coupling, a second spanner should be used as a back-up to prevent rotation of the fitting to which the pipe union is attached.

h) If a section of the pipeline system is left open or disconnected during installation or removal, clean blanking caps must be fitted to open lines, fittings or parts to prevent contamination of the system. In connection with the application of blanking caps, the following points should be particularly noted:

   i) Plastic caps should only be used on plain sections of pipes, e.g. flareless pipes. Plastic caps should not be re-used.

   ii) Where caps are to be fitted to threaded unions or fittings they should be of the metal type.

   iii) Plugs which can be jammed into pipes should not be used.

   iv) Metal caps may be re-used after cleaning in accordance with an approved method.

   v) Blanking caps should be sealed in polythene bags and should not be opened until ready for use. After opening, the bags should be re-sealed immediately to prevent contamination of unused caps.

i) During installation and removal of thermal compensators care must be taken not to separate the connector couplings and nuts. The elements should not be rotated within unions since damage to the wire bristles and jamming of the element may result.

j) Flexible hoses should not be twisted, kinked or collapsed during installation. In some aircraft, flexible hose assemblies are used in both the high and low pressure systems and these can be connected to standard pipe connectors. Care must, therefore, be taken to ensure that the hoses are not interchanged.

k) On completing the installation of pipes a leak test must be carried out on all relevant connections and fittings (see also paragraph 5.8). If a connection leaks, a check should be made that the specified torque values were used in tightening. If the leak persists, using the specified torque value, the connection should be re-opened and inspected to find the cause. Defective pipes or fittings should be replaced by serviceable items.

5.6.5 **Masks**

The procedure for the installation of masks depends largely on whether they are of the plug-in type or automatic drop-out type and full details should, therefore, be obtained from relevant manuals. In general, the following points should be observed during installation and maintenance:

a) Masks should be properly stored without kinking or twisting of the hoses.

b) Masks and hoses should be free from cracks, breaks and other damage or deterioration. Plug-in couplings should be checked for proper insertion and removal.

c) Stowage compartments should be inspected for cleanliness and general condition.

d) Reservoir bags, where used in service panels, must be correctly positioned and folded to ensure efficient drop-out.

e) Masks should be cleaned and disinfected before installation and also whenever the oxygen system has been used and at the periods specified in approved Maintenance Schedules (see also paragraph 5.11.2 g)).

5.7 **Thread Lubrication**

With the exception of teflon sealing tape to specification MIL–T–27730, it is recommended that the application of any other lubricants or anti-seize compounds to the threads of pipe or component connections be avoided. The tape, which contains a lubricating compound, should be applied to all except the first two threads of male fittings and not more than three wraps of tape should be used. The tape should be wrapped in a direction opposite to the running thread; any excess should be trimmed off.

NOTE: All traces of previous tape should be removed from threads and extreme care must be taken to prevent debris from entering the oxygen system.

5.8 **Leak Testing**

5.8.1 Whenever a system component e.g. cylinder, pipe or regulator, etc., has been removed, re-installed, or the system has in any way been disconnected, tests for leakage should be carried out. The system pressure should be at its normal maximum value.

5.8.2 Leaks should be located using a leak detecting solution free from any combustible substances unless, of course, particular leaks are large enough to be heard or felt. Solutions recommended for this purpose are those conforming to specifications MIL-L-25567 'B' and MIL–L–25567 'C' Type 1.

5.8.3 The solution should be applied with a soft brush and the suspected connections checked for signs of frothing or bubble formation. After testing, all traces of solution must be removed by a thorough rinsing with clean water and drying with a soft lint-free cloth.

5.8.4 Where it may be necessary to check a leak-rate (e.g. through a valve) a leak-rate tester should be used. A simple tester consists of a flexible tube into which has been inserted a length of $^1/_4$ inch bore glass tube. To check a leak-rate, the free end of the flexible tubing is fitted over the outlet to be tested whilst the glass tube is immersed one inch below the surface of water in a glass jar. The leak-rate can then be calculated from the number of bubbles passing through the water. Eight bubbles are considered equal to 1 c.c. therefore eight bubbles per minute would show a leak-rate of 60 c.c. per hour.

NOTE: Where very accurate leak-rate measurement is necessary, special leak-rate testing instruments are available and should be used as appropriate.

5.9 **Pressure Tests**

Pressure testing of oxygen cylinders is required at stated periods (e.g. every four years) normally indicated in the relevant manuals and schedules. The date of pressure test is usually stamped on the neck ring of a cylinder or painted on the top hemispherical portion.

NOTE: The dates of any previous pressure tests should not be over-stamped or obliterated.

5.10 **Flow Testing**

Where the testing of flow rates is required at various points in a system (e.g. at mask socket connections) special oxygen flowmeters should be used in accordance with the manufacturer's instructions. These flowmeters generally consist of a float inside a glass cylinder graduated for the appropriate flow ranges in litres per minute.

5.11 **Cleaning**

5.11.1 Cleanliness is of the utmost importance in the installation and maintenance of an oxygen system since contamination can provide noxious or toxic fumes to the user, prevent system components from operating properly, or cause fires and explosion. Contamination of the exterior surfaces of components may also cause fires in the presence of leaking oxygen and possible sources of ignition (e.g. electrical equipment). In addition to observing the handling precautions noted earlier in this Leaflet, it is necessary for cleaning operations to be performed at certain stages of installation and maintenance procedures.

5.11.2 Details of the methods to be adopted, the solvents to be used and periods at which cleaning is to be carried out are given in relevant manuals, drawings and schedules and reference should always be made to these documents. The following paragraphs detail certain important aspects applicable to cleaning operations generally.

a) For external cleaning of components and pipelines after testing and installation and at specified inspection periods, a clean, lint-free cotton cloth should be used moistened, if necessary, with the approved solvent.

b) Pipes and fittings should be cleaned by a vapour degreasing process. After cleaning, pipes must be washed through with boiling water followed by a thorough flushing with demineralised water and finally purged and dried (see paragraph 5.11.2 d)).

c) Thermal compensator assemblies where required, should be cleaned by either an ultrasonic or vapour degreasing process.

d) After cleaning, pipes, fittings or components should be purged and dried with clean dry nitrogen, clean, dry, water-pumped air, or breathing oxygen. Particular attention should be paid to the evaporation of degreasing fluid from reverse or 'U' bends in pipes. When thoroughly dry, all openings should be blanked by the appropriate type of blanking caps (see also paragraph 5.6.4 h)).

e) Air which has been compressed by an oil-lubricated compressor must not be used unless it has passed through an oil separator, dehydration unit or filter system specifically designed to ensure clean air for use with oxygen components. Compressed air can be checked for freedom from oil or water by allowing the air to impinge onto a clean mirror held at about 45° to the air stream. The mirror should remain clean and dry. If a deposit does appear, warming the face mirror will evaporate the water and any oil will remain on the surface.

f) If components or fittings are not to be used immediately after cleaning they should be individually sealed in polythene bags. The bags should be identified as to their contents and also contain the date on which the parts were cleaned and sealed.

g) Oxygen masks should be cleaned by a mild solution of soap, or other detergent product and warm water. The solution should be applied to facepieces with an absorbent cheesecloth or sponge applicator. After cleaning, all traces of solution should be removed with clean warm water and the masks dried with cloth or allowed to air-dry. An approved disinfectant should then be applied from an antiseptic spray or an aerosol can.

NOTE: When cleaning crew masks, microphones should be removed to prevent contact with cleaning solutions.

5.12 **Functional Testing**

The functional testing of systems 'in-situ' should be carried out at the periods specified in approved Maintenance Schedules and whenever a component has been changed. The methods of conducting tests and the equipment required, vary between types of systems and reference should always be made to the relevant manuals for full details. In general, the methods include tests for leakage (see also paragraph 5.8), flow checks at mask connections and, where appropriate, the simulation of the automatic drop-out action of masks.

5.13 **Charging of Oxygen Systems**

5.13.1 For the charging of oxygen system cylinders, breathing oxygen to British Standard N3 must be used. Oxygen produced for other applications, e.g. welding, may contain excess water which could freeze in and obstruct pipelines, regulators and valves of the oxygen system.

5.13.2 To facilitate the charging procedure, the oxygen is supplied in large transport cylinders at a pressure of 3600 lb/in^2, several of which are interconnected and mounted in a special oxygen servicing trolley. The pressure is reduced to between 126.64 to 133.68 kg/cm^2 (1800 and 1900lb/in^2) for charging purposes by a regulator consisting basically of a manually adjustable reducing valve and a shut-off valve. The regulator is mounted in the servicing trolley together with pressure gauges which indicate the transport cylinder pressure and the charging pressure. A special oxygen high pressure hose for connecting the trolley to the aircraft's charging point completes the basic equipment.

NOTE: An oxygen servicing trolley must never be used for the charging or testing of systems and components designed for operation by compressed air or other gases.

5.13.3 Before charging a system, reference should be made to the relevant aircraft Maintenance Manual to determine any special procedures to be adopted for the particular system and also to the operating instructions appropriate to the type of servicing trolley. In addition to the safety precautions referred to in paragraph 5.5 of this Leaflet, the following points which apply generally to charging should be observed:

a) The servicing trolley and aircraft should be properly bonded.

b) The operation of ground power units should not be permitted in the vicinity during charging operations.

c) The aircraft and servicing trolley hose charging adaptors and servicing panels, where appropriate, should be scrupulously clean both internally and externally.

d) Before coupling to the aircraft, the charging hose should be purged by slowly opening the trolley shut-off valve to produce a low pressure flow of oxygen in the hose.

e) Care should be taken when coupling the hose and aircraft coupling adaptors since, in many instances, the adaptors have a left-hand thread.

f) Charging valves and cylinder valves must be opened slowly and pressures allowed to stabilise. Servicing trolley and aircraft system pressure gauges should be continuously monitored to ensure that excessive pressures are not applied and to prevent high cylinder temperatures.

   i) Charging graphs are located at the servicing points of many types of aircraft and the maximum permissible charging pressure should be determined from the graphs, after having checked the ambient temperature in the vicinity of the aircraft cylinders.

ii) In charging a system that incorporates manual temperature and pressure compensation adjustments, the dials should be set to the most restrictive setting, i.e. that corresponding to the lower pressure of the system and to the lower value of ambient temperatures in the vicinity of the aircraft cylinders. This will ensure that a conservative rate of charging is applied and that the maximum pressure is not exceeded.

g) If a cylinder has been emptied, contamination resulting from moisture can develop (see paragraph 6). In such cases, the cylinder should be blanked off either by closing its shut-off valve or by using blanking caps. it should be removed and suitably identified as requiring purging before recharging.

NOTE: Depending on the degree of exposure to moisture, it may be advisable to examine a cylinder for internal corrosion.

h) On completion of charging, the trolley shut-off valve and aircraft charging valve should be closed and the pressure in the aircraft system allowed to stabilise. A check should then be made on the cylinder pressure gauges and other system gauges if fitted, to ensure that the cylinders are fully charged.

i) Trolley hose adaptors should always be removed slowly from the aircraft charging adaptor to dissipate any trapped pressure.

ii) Aircraft charging adaptor blanking caps must be checked to ensure that they are scrupulously clean before re-fitting.

6 Oxygen Contamination

6.1 At specified periods, or if for any reason the system is thought to be contaminated, the oxygen should be tested and if necessary the system purged. Purging should always be carried out if it is known that a system is empty.

6.2 The main cause of contamination is moisture in the system and this may be due to damp charging equipment, charging of cylinders when their pressure is below a certain minimum value and the small amount of moisture contained in breathing oxygen may, due to repeated charging especially in very cold weather, also cause contamination.

NOTE: In some cases it has been known for the system to freeze due to the presence of moisture, thus restricting the flow of oxygen.

6.3 Although the introduction of moisture into the aircraft oxygen system can be considerably reduced by using the correct charging procedure, cumulative condensation in the system cannot be entirely avoided. There have been instances where oxygen systems, unused for long periods, have developed an unpleasant odour which necessitated purging to clear the system of moisture.

6.4 Oxygen Moisture Tests

6.4.1 To test the moisture content of oxygen in the aircraft system a hygrometer, based on the dew-point principle, is normally used.

6.4.2 By determining the dew-point (i.e. the temperature at which the gas becomes saturated) of the oxygen and referring this to a conversion chart the moisture content of the oxygen can be established.

6.4.3 The type of apparatus normally used depends on a flow of oxygen (at a constant rate and pressure) impinging on the surface of a mirror, the temperature of which is gradually lowered (e.g. by means of carbon dioxide) until a film of moisture is formed on the mirror thus determining the dew-point.

NOTE: Breathing oxygen dew-point is –40C at 21·1 kg/cm^2 (300 lb/in^2) with a flow rate of 15 litres per minute. This corresponds to a moisture content of 0·0056 grammes per cubic metre at Standard Temperature and Pressure.

7 Soldering

If soft soldering or silver soldering is required on any part of an oxygen system it is important that only specified materials are used, particularly in the case of fluxes. After soldering, or silver soldering operations have been completed, it is of the utmost importance to ensure that all traces of flux or scale are completely removed by thorough cleaning. A trace of flux or a minute piece of scale inside a pipe or component could cause an explosion when in contact with high pressure oxygen. Resin-based soldering fluxes should never be used for soldering nipples, connections, etc., on oxygen system pipes.

Leaflet 5-10 High Pressure Pneumatic System

1 Introduction

1.1 This Leaflet gives guidance on the operation and maintenance of high-pressure pneumatic systems in aircraft, and no attempt is made to describe any particular system in detail. Any maintenance work on an aircraft or system should be carried out in accordance with the procedures defined by the manufacturer, and the Leaflet should, therefore, be read in conjunction with the relevant manuals for the aircraft concerned.

1.2 Information on associated subjects will be found in Leaflets 05-6 - Installation and Maintenance of Rigid Pipes, 02-11 - Torque Loading, 11-22 Appendix 20-4 - Maintenance and Re-Installation of Pipes and Cable Looms, and 05-8 - Wheels and Brakes.

2 General

The use of a compressed-air system to operate an aircraft's services usually represents a saving in weight compared to a hydraulic system, since the operating medium is freely available, no return lines are necessary, and pipes can be of smaller diameter. Systems having operating pressures of up to 24 MN/ml (3,500 lbf/in^2) are in use, and provide for the rapid operation of services when this is required. However, compressed air is generally not suitable for the operation of large capacity components, leaks can be difficult to trace, and the results of pipeline or component failure can be very serious.

2.1 Extensive high-pressure pneumatic systems powered by engine-driven compressors are generally fitted on the older types of piston-engined aircraft and are used to operate services such as the landing gear, wing flaps, wheel brakes, radiator shutters and, at reduced pressure, de-icing shoes. There are some modern aircraft which also use a high-pressure pneumatic system and there are many aircraft which use pneumatic power for the emergency operation of essential services; the latter type of system is usually designed for ground-charging only.

2.2 Low-pressure pneumatic systems used on most turbine-engined aircraft for engine starting, de-icing, and cabin pressurization, are supplied with compressed air tapped from the engine compressor and are not dealt with in this Leaflet.

3 Typical System

This paragraph describes both a typical high-pressure pneumatic system, and the types of components which could be used.

3.1 The system illustrated in Figure 1 contains two separate power circuits, each of which is supplied by a four-stage compressor driven from the gearbox of one main engine, and a common delivery pipe to the high-pressure storage bottles and system services. A multi-stage cooler attached to each compressor cools the air between each of the compression stages, and a means is provided for off-loading the compressor when the system is not being used.

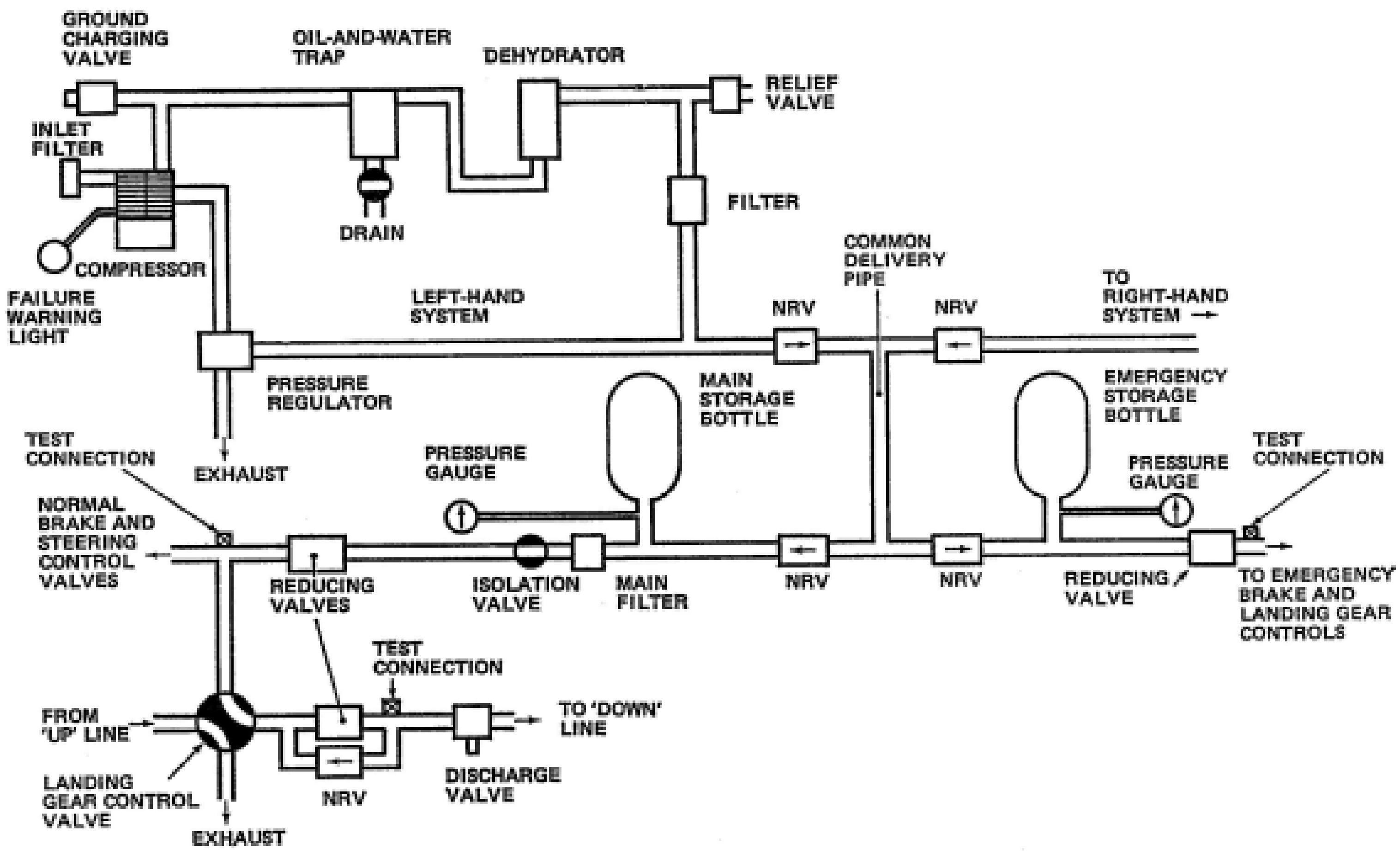

Figure 1 Typical High-Pressure Pneumatic System

3.2 Air is drawn through an inlet filter into each compressor, and is discharged through an oil-and-water trap, a chemical dehydrator, a filter and a non-return valve, to the main storage bottle and system. Overall control of main system pressure is provided by means of a pressure regulator, but pressure relief valves are included to prevent excessive pressures in the system, which may be caused by regulator failure or by an increase in temperature in the pipelines and components. Pressure reducing valves are used to reduce the pressure supplied to some components.

3.3 A storage bottle for the emergency system is pressurized through a non-return valve from the main system supply, and maintains an adequate supply of compressed air to enable the landing gear and flaps to be lowered, and the brakes to be applied a sufficient number of times to ensure a safe landing.

3.4 Isolation valves are fitted to enable servicing and maintenance to be carried out without the need to release all air from the system, and pressure gauges are provided to indicate the air pressure in the main and emergency storage bottles.

4 Components

The types of components used in a high-pressure pneumatic system will vary considerably between aircraft, but the examples considered in this paragraph are typical of the components which may be found in current use.

4.1 **Compressors.** A positive-displacement pump is necessary to raise the air pressure sufficiently for the operation of a pneumatic system, and a piston-type pump is generally used. Some older types of aircraft are fitted with a single-cylinder piston pump, which provides two stages of compression and raises the working pressure to approximately 3 MN/ml (450 lbf/in^2). To obtain higher working pressures further compression stages are required. The compressor described in paragraphs 4.1.1 to 4.1.3 is capable of raising air pressure in four compression stages to 24 MN/ml (3,500 lbf/in^2).

4.1.1 The compressor illustrated in Figure 2 has two stepped cylinders, each of which houses a stepped piston; a plunger attached to the head of No. 2 piston operates in a small cylinder bored in the head of No. 2 cylinder. The reciprocating motion of the main pistons is provided by individual cranks and connecting rods, the cranks being rotated by a common drive gear, and rotating in the same direction. Air passing between each compression stage is routed through an integral cooler, and lubrication is provided by an oil feed connection from the main engine lubrication system.

4.1.2 Compression depends on the volume of each successive stroke being smaller than the stroke preceding it; the induction strokes for each cylinder and the four compression strokes are accomplished during each revolution of the cranks. Operation of the compressor is as follows:

a) On the downward stroke of No. 1 piston, air is drawn into the cylinder head through a filter and Non-Return Valve (NRV).

b) On the upward stroke of No. 1 piston, air is compressed in the cylinder, opens a NRV in the cylinder head, and passes to the annular space formed between the steps of the cylinder and piston.

c) The next downward stroke of No. 1 piston compresses air in the annular space in this cylinder and forces it through a NRV into the annular space formed between the steps of No. 2 cylinder and piston. No. 2 piston is approximately 90° in advance of No. I piston, and is moving upwards as No. I piston approaches the bottom of its stroke.

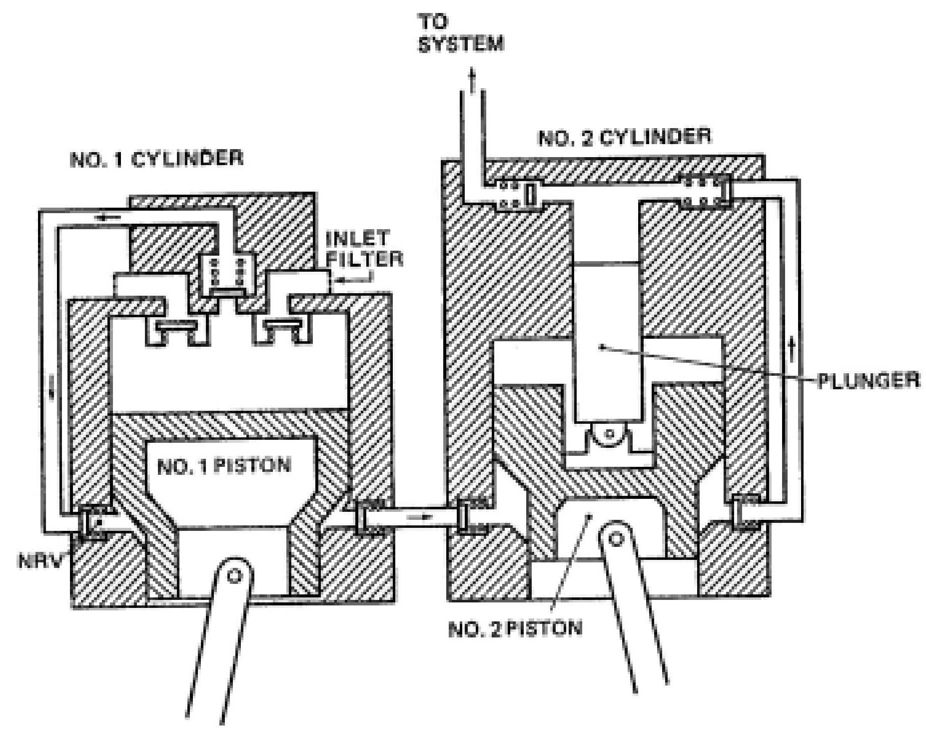

Figure 2 Air Compressor

d) On the downward stroke of No. 2 piston, air is compressed in the annular space at the bottom of the cylinder, and passes through a NRV into the small cylinder formed in No. 2 cylinder head.

e) On the upward stroke of No. 2 piston, the plunger attached to it also moves upwards, further compressing the air in the small cylinder and passing it through a NRV to the system.

4.1.3 A pressure warning transmitter is fitted at the second-stage outlet, and third-stage pressure is connected to the pressure regulator (paragraph 4.2).

4.2 **Pressure Regulator.** The pressure regulator is fitted to control the maximum pressure in the system and to off-load the compressor when the system is idle. With the regulator illustrated in Figure 3, system pressure is fed to the top connection and acts on a piston, the lower end of which is in contact with the ball of a spring-loaded ball valve. At the predetermined maximum system pressure, the air pressure on the piston overcomes spring pressure and the ball valve is opened, releasing third-stage compressor pressure to atmosphere and allowing the pump to operate at second-stage pressure only. If any pneumatic services are operated, or a leak exists in the system, the air pressure trapped in the storage bottle and pipelines will drop, and the ball valve in the pressure regulator will close. The compressor will thus be brought back on line until the maximum system pressure is restored.

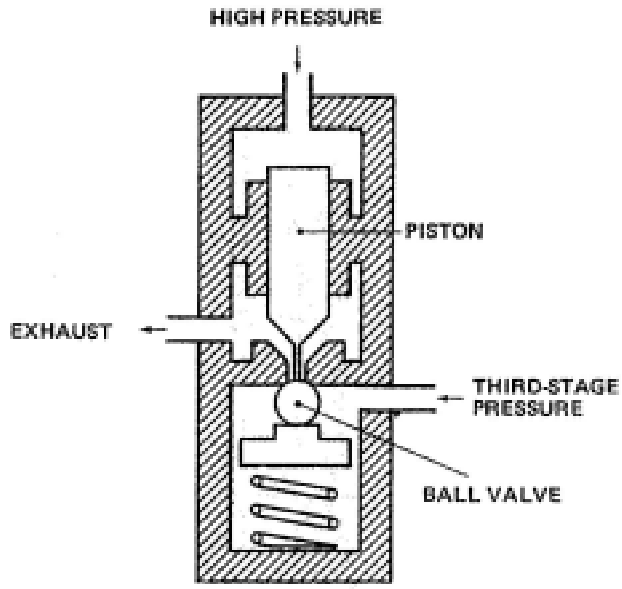

Figure 3 Pressure Regulator

4.3 **Oil-and-Water Trap.** The oil-and-water trap is designed to remove any oil or water which may be suspended in the air delivered by the compressor. It consists of a casing with inlet and outlet connections at the top and a drain valve in the bottom. Air entering the trap does so through a stack pipe, which includes a restriction and a baffle to prevent the air flow stirring up any liquid or sediment in the bottom of the container. Air leaving the trap also passes through a stack pipe, to prevent liquid or sediment entering the system during aircraft manoeuvres.

4.4 **Dehydrator.** To protect pneumatic systems from malfunctioning due to moisture freezing in the components and pipelines, the compressed air may be dehydrated by a substance such as activated alumina, or it may be inhibited by a small quantity of methanol vapour. The handling of methanol presents some difficulties, however, and because of its corrosive nature systems must be specially designed for its use; activated alumina is, therefore, more generally used.

4.4.1 Activated alumina is housed in a container through which the compressed air passes after leaving the oil-and-water trap, and which generally contains a filter at the outlet end. The charge of alumina in the container will gradually become saturated with moisture, and should be changed at the specified intervals. The number of flying hours at which the alumina charge is changed is normally determined by the aircraft manufacturer through practical experience.

4.5 **Storage Bottles.** In a pneumatic system the storage bottles provide the reservoir of compressed air which operates all services, the compressors being used to build up system pressure when it falls below the normal level. The volume of the actuators and pipelines determines the size of the bottles required for the normal and emergency operation of the pneumatic services.

4.5.1 Storage bottles are generally made of steel, and may be of wire-wound manufacture for maximum strength. Bottles are generally mounted in an upright position, and a fitting screwed into the bottom end contains the supply connection and, usually, a connection to an associated pressure gauge, together with a drain valve by means of which any moisture or sediment may be removed. Stack pipes are provided at the supply and gauge connections in the fitting, to prevent contamination passing to the system or pressure gauge. Pressure testing of high-pressure storage bottles is required at specified periods, and the date of testing is usually stamped on the neck of the bottle.

4.6 **Pressure Reducing Valves.** Some services operate at pressures lower than the pressure available in the air bottle, and are supplied through a pressure reducing valve. This low pressure is, in some instances, further reduced for the operation of, for example, the wheel brakes, by the fitting of a second pressure reducing valve.

4.6.1 Figure 4 illustrates the operation of a pressure reducing valve. When pressure in the low-pressure system is below the valve setting, the compression spring extends and, by the action of the bell-crank mechanism, moves the inlet valve plunger to admit air from the high-pressure system. As pressure in the low-pressure system increases, the bellows compresses the spring and returns the inlet valve plunger to the closed position. The inside of the bellows is vented to atmosphere, and the valve thus maintains a constant difference in pressure between the low-pressure system and atmospheric pressure.

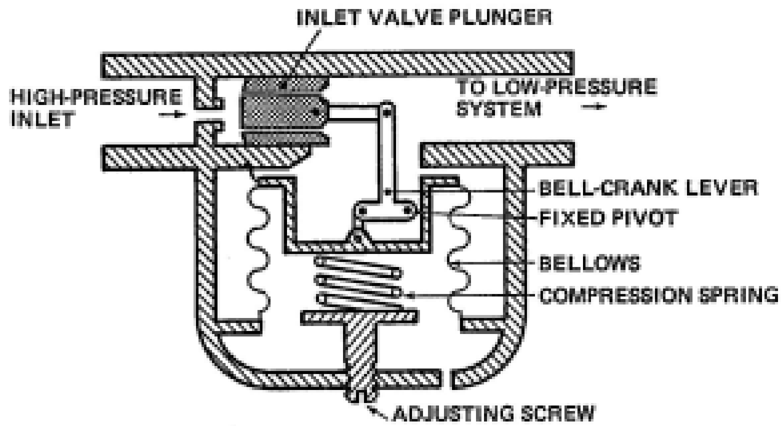

Figure 4 Pressure Reducing Valve

4.7 **Pressure Maintaining Valve.** A pressure maintaining valve is designed to conserve air pressure for the operation of essential services (e.g. gear extension and wheel brake operation), in the event of the pneumatic system pressure falling below a pre-determined value.

4.7.1 Figure 5 illustrates the operation of a typical pressure maintaining valve. Under normal circumstances air pressure is sufficient to open the valve against spring pressure and allow air to flow to the non-essential services. Should the pressure in the storage bottle fall below a value pre-set by the valve spring, however, the valve will close (as shown) and prevent air passing to the non-essential services.

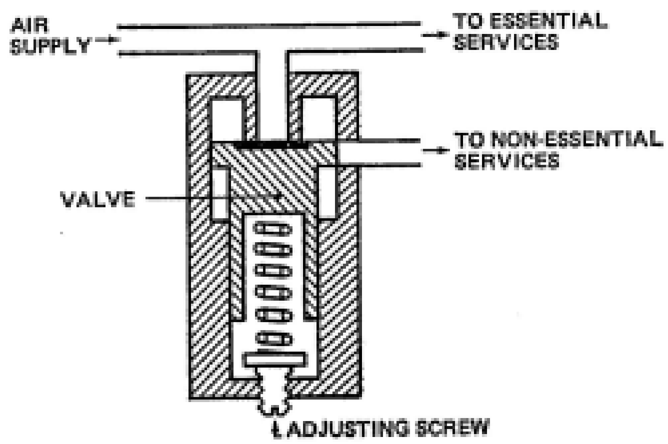

Figure 5 Pressure Maintaining Valve

4.8 **Control Valves.** Compressed air stored in the bottle is distributed to the various pneumatic services, and directed to the various types of actuators by means of control valves, which may be manually or electrically operated. Examples of several types of control valves are described in paragraphs 4.8.1 to 4.8.3.

4.8.1 **Electrically-operated Control Valve.** The electrically-operated control valve for a pneumatic landing gear retraction system is illustrated in Figure 6. Selection of the landing gear position is made by either of two push-buttons (marked 'up' and 'down') which are mechanically interconnected to prevent operation of both buttons at the same time. These buttons, when depressed, supply electrical power to the 'up' or 'down' solenoid as appropriate. Actuation of this solenoid lifts an attached pilot valve, supplying compressed air to the cylinder at the bottom of the associated valve; the piston moves downwards, and the valve guide attached to it opens the inlet valve, admitting compressed air to the appropriate side of the landing gear actuators. At the same time the beam attached to the extension of this piston transfers movement to the valve guide in the opposite valve, allowing air from the opposite side of the actuators to exhaust to atmosphere.

4.8.2 **Manually-operated Control Valve.** The valve illustrated in Figure 7 is a simple two-position valve, and may be used as an isolation valve in some systems. The sleeve valve is operated by a cam, and is spring-loaded to the 'opposition; linkage from the cam spindle connects the valve to an operating lever. When used as an isolation valve the operating lever would normally be wire-locked in the 'on' position, and would only be used to permit servicing operations to be carried out.

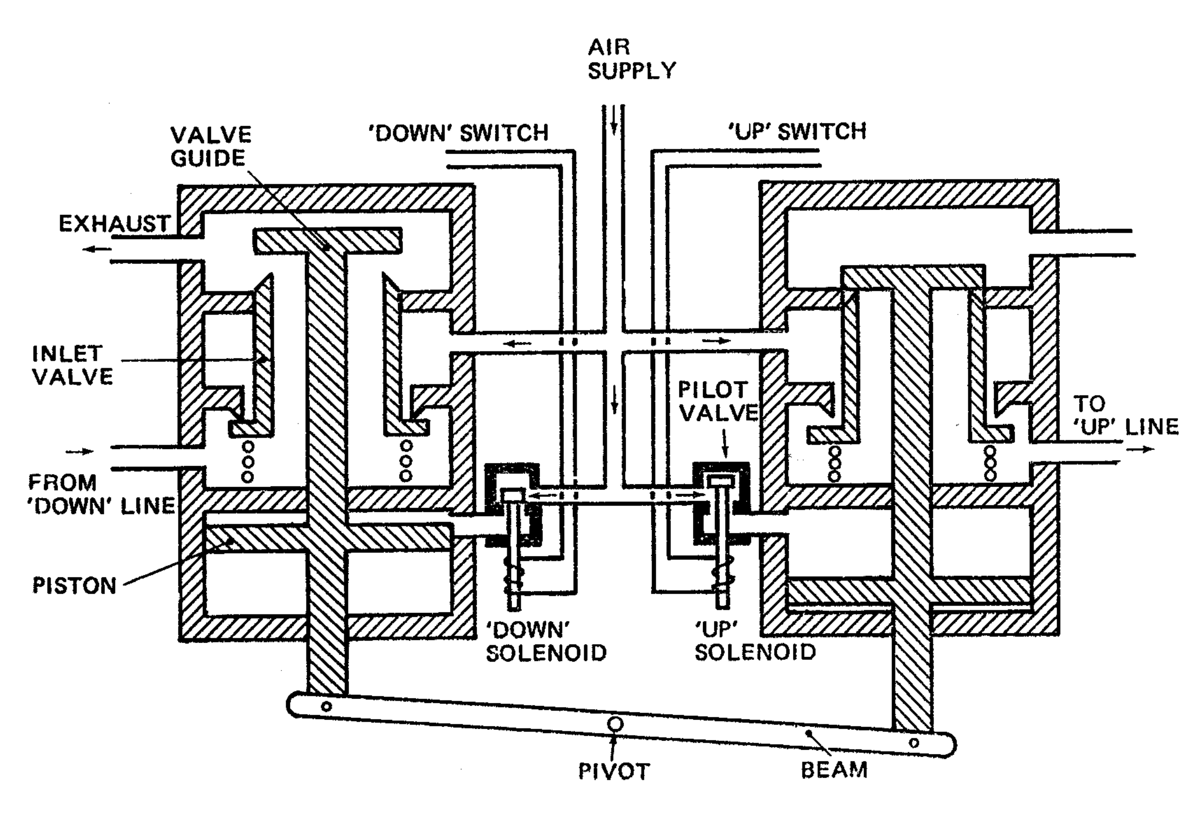

Figure 6 Electrically-Operated Control Valve

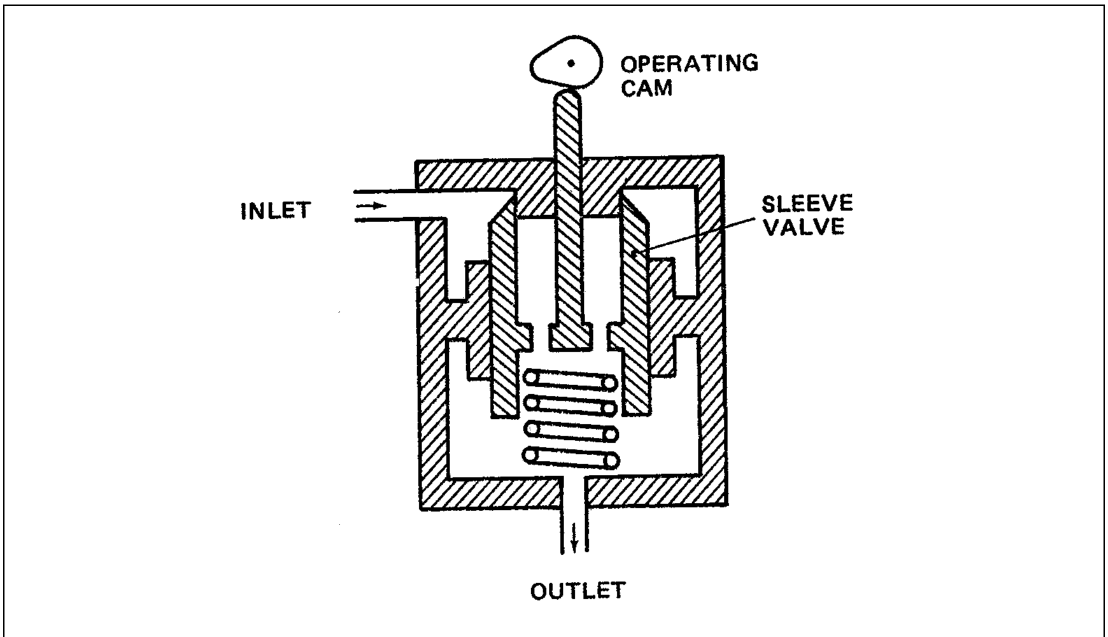

Figure 7 Manually-Operated Control Valve

4.8.3 **Brake Control Valve.** Some older types of aircraft may be fitted with a type of brake control valve (known as a dual-relay valve) by means of which total brake pressure is applied by the operation of a single hand-control, and distribution to either or both brakes is effected by means of a mechanical connection to the rudder bar. The type of brake control valve illustrated in Figure 8 is used on some modern aircraft, and is operated by linkage from brake pedals attached to the rudder bar; separate valves supply compressed air to the brake units on each wheel. Operation of the valve is as follows:

a) In the 'off' position (as illustrated) the inlet valve is closed and pressure in the brake line is connected to the exhaust port.

b) Pressure applied to the associated brake pedal is transmitted via the brake linkage to the valve sleeve, which moves up to close the exhaust valve. Further pressure applied through the valve sleeve and lower spring tends to open the inlet valve, and air pressure in the brake line combined with the force exerted by the upper and centre springs tends to close it. This produces a balanced condition in which any increase in the force applied to the valve sleeve results in a higher air pressure in the brake line, and a decrease in the force applied to the valve sleeve results in opening of the exhaust valve and a reduction in the air pressure in the brake line.

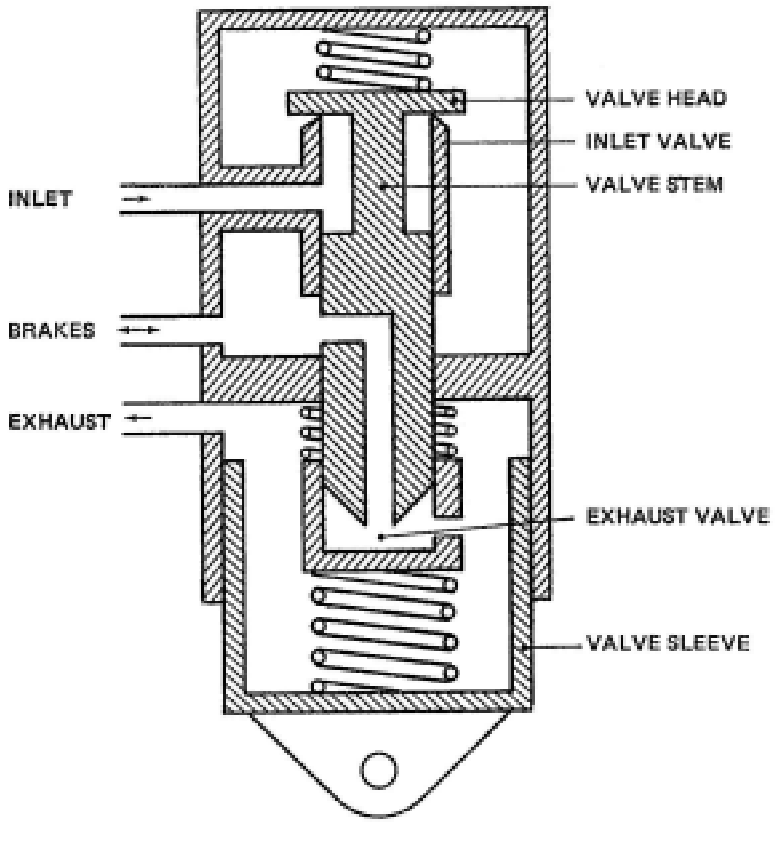

Figure 8 Brake Control Valve

4.9 **Actuators.** The purpose of an actuator is to transform the energy of the compressed air into linear or rotary motion. Actuators in pneumatic systems are normally of the linear type. Because of the nature of the operating medium, actuators in pneumatic systems are often damped to prevent violent operation of the services. A typical damped actuator is illustrated in Figure 9, the damping in this case being obtained by forcing grease through the annular space between the inner wall of the piston rod and a stationary damper piston; an orifice and plate valve in the damper piston provide less damping action when the piston rod retracts than when it extends. This type of actuator could be used, for example, to operate the landing gear and to restrict the rate of extension.

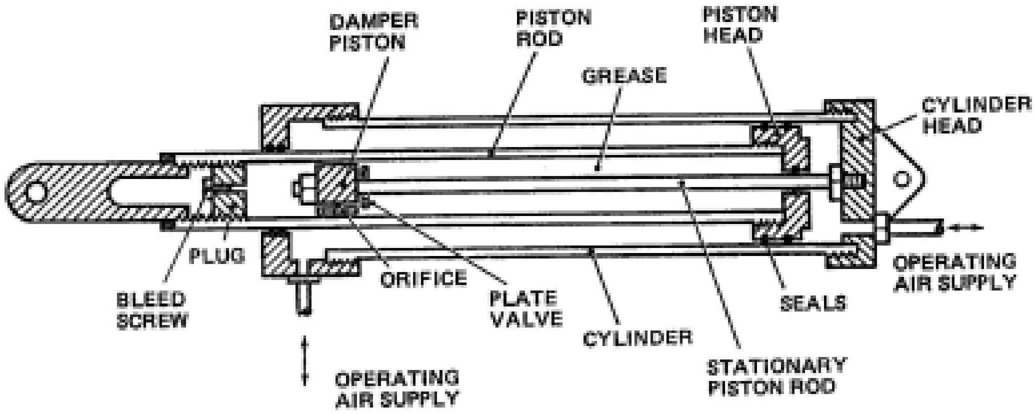

Figure 9 Damped Actuator

5 Removal and Installation

Aircraft pneumatic installations vary considerably, and reference should be made to the relevant Maintenance Manual before any work is carried out on a particular aircraft. Failure to observe any precautions detailed by the manufacturer could result in damage to the aircraft and, possibly, in physical injury. High pressures exist in parts of the system even when the aircraft engines are not running, and this pressure must be released before attempting to disconnect or remove any components or pipelines. Rapid operation of the system services is also a feature of pneumatic systems, and care must be taken during any tests to ensure that the services have complete freedom of movement and that the area is clear of personnel.

5.1 **Cleanliness.** The cleanliness of a pneumatic system is of the utmost importance to its correct operation. The filters fitted in the system will, if serviced at the appropriate intervals, protect the system components from contamination during normal use, but whenever a connection is broken or components are removed, the open pipes should be blanked immediately to prevent the entry of dirt and moisture; blanks should be left in position until the component is re-installed or the connection is re-made. Proper blanking caps should be fitted wherever possible, and on no account should rags or masking tape be used. Any external rig which is likely to be used to charge an aircraft system must be kept to the same standards of cleanliness, and the supply line should be blown through before being connected to the aircraft charging point.

5.2 **Removal of Components.**Before removing any components or disconnecting any pipelines, all pressure should be released from that part of the system. In some cases release of all pressure from the storage bottle will be specified by the manufacturer as being necessary; in the typical system shown in Figure l this is done by operating the discharge valve, but in other systems it may be necessary to unscrew a connection a quarter turn to release the air. Even those parts of the system protected from storage bottle pressure by a non-return valve or isolation valve may retain sufficient residual pressure to cause damage, and pipe connections should, therefore, be unscrewed slowly, pausing after the first quarter turn of the union nut to ensure that air pressure escapes slowly.

5.2.1 On aircraft which have a pneumatically-operated landing gear retraction system, ground locks should be fitted before releasing air from the 'down' lines in the system, and the landing gear control lever and emergency landing gear selector should be labelled to ensure that they are not operated.

5.2.2 On systems which have electrically-operated control valves it will usually be necessary to electrically isolate the part of the system being worked on, and this may be done by tripping the associated circuit-breakers or removing the associated fuses. Electrical isolation and placarding of controls is advisable in order to avoid any possible inadvertent selection, whether or not power is available at the time. Note should be taken of the disconnected circuits for reference when re-assembling.

5.2.3 Where a component, such as the compressor, has to be removed because of mechanical failure, other parts of the system may have become contaminated by metal particles. Filters downstream of the component which has failed should be checked for contamination, and if this is found, all components and pipes which may have been affected should be removed and cleaned or renewed as necessary.

5.2.4 Immediately after removing a component all openings should be blanked; flexible pipes should be secured to adjacent structure to prevent them from becoming damaged.

5.3 **Installation.** Before installing a new component, it should be inspected for any damage which may have occurred during storage, the part number and modification state should be checked, and it should be ensured that the storage life (paragraph 7) has not been exceeded. The thorough testing of components drawn from stores is not normally required (paragraph 5.4), but it should be ascertained that external moving parts function without binding, and operate in the correct sense. Components which have been removed from an aircraft and are to be re-installed must be thoroughly examined for cleanliness; pipes should be blown through with clean, dry air.

5.3.1 New gaskets should be fitted to all components which require their use, and other protective material such as may be used under straps or clamps, should be inspected for condition before being refitted.

5.3.2 Some components, such as non-return valves, must be fitted the correct way for the system to operate as intended, and are usually designed with different types of fittings at each connection to prevent incorrect installation. In some cases, however, the fittings may be identical, and the direction of flow marked on the component, should be checked.

5.3.3 The male threads on connections should be sparingly lubricated before assembly, as recommended by the manufacturer, and union nuts should be fitted by hand so as to check that the threads are not binding and to ensure that the connections are correctly aligned. AU union nuts should be tightened to the torque values specified in the relevant Maintenance Manual, and should be locked in the appropriate manner.

5.3.4 All blanks should be removed from pipes before installation, and it should be ensured that the pipes are correctly installed and free from acute bends and kinks or damaged protective covering, are correctly aligned with mating connections, have adequate clearance between adjacent pipes and structure, and have been correctly identified, locked and supported. Flexible pipes should be checked to ensure that they are not bent, twisted or stretched at the limits of movement of the component to which they are attached, and are adequately supported.

5.3.5 After the installation of a component, any mechanical or electrical connections should be made, and a full functioning test should be carried out.

a) Mechanical controls should be connected and adjusted so that control lever movement and valve operation are synchronized, and if stops are fitted to the valve the control should be adjusted to ensure that these stops are contacted; full details concerning the rigging and adjustment of the controls for a particular system should be obtained from the relevant Maintenance Manual. Controls should be free from binding over their full range of movement, and should have at least the minimum specified clearance from adjacent structure. After adjustment and checking, all linkage should be locked and lubricated as appropriate.

b) The circuits to electrically-operated control valves should be checked for correct installation and functioning. Micro-switches should be adjusted carefully to ensure that they operate positively without the plunger bottoming, and their mountings should be checked for rigidity and security.

c) Unless otherwise stated, an actuator should be adjusted so that its piston does not bottom in its cylinder at the ends of its travel, and it should be checked for smooth and correct operation. When required by the relevant Maintenance Manual, actuators should be filled with grease or other specified damping fluid before carrying out a functional check.

5.4 **Testing.** The overhaul and testing of individual components must be carried out in accordance with the manufacturer's Overhaul Manual and requires the use of specially designed test rigs to ensure their correct operation. Dismantling of components should not be undertaken unless suitable test facilities are available, and the aircraft system should not be considered to be an acceptable alternative. Once tested after manufacture or overhaul, components do not normally require further tests to be carried out prior to installation, provided that their storage life has not been exceeded and that there is no superficial damage. System tests should, however, be carried out on new installations, after any part of a system has been adjusted, dismantled, or renewed, and at the periods specified in the relevant Maintenance Schedule. The method of carrying out a test of the pneumatic system is detailed in the aircraft Maintenance Manual, and will normally include the operations outlined in paragraphs 5.4.1 to 5.4.5.

5.4.1 After a system has been exhausted of air pressure, or parts of a system have been isolated from the storage bottles to permit removal and installation of components, certain precautions must be taken to prevent damage to the aircraft or injury to personnel when the system is re-pressurized prior to testing. The electrical circuits to electrically-operated controls should be reinstated by resetting the appropriate circuit breakers or refitting the fuses, and the positions of all controls, including emergency controls, should be checked as corresponding to the positions of the actuators in the pneumatic services. Ground locks should be fitted to the landing gear (unless the aircraft is on jacks), and air pressure should be built up slowly in the relevant parts of the system, either through the charging connection or by opening the isolation valves, as appropriate.

5.4.2 When a compressor has been changed, or whenever a slow build-up in system pressure has been reported, the output of the compressors should be checked; this check is usually carried out by running the appropriate engine(s) on the ground. The engine power setting, initial pressure, and maximum time permitted to build up pressure by a specific amount, are usually quoted in tables provided in the relevant Maintenance Manual; separate tables are often provided for checking new and in-service compressors.

5.4.3 When checking the operation of the various control valves in the system, care should be taken to ensure that the associated services are free to function and that adequate clearance is provided between any moving part and adjacent structure, trestles, etc. The air exhausted from some large components may be capable of causing damage, and warning notices should be positioned before operating these particular services.

5.4.4 The adjustment and correct operation of all locks, actuators, selectors, control mechanisms and indicators should be checked, using the appropriate test connections where necessary, and the operating pressures of the regulators, pressure reducing valves, pressure maintaining valves, brake valves and relief valves should be verified. It should also be ascertained that there is no internal or external air leakage from the valves or connections.

5.4.5 AU services should be checked for correct operation, smoothness, and, when specified, speed of operation and system pressure drop. These tests should be carried out using both the normal and the emergency systems, and should be repeated a sufficient number of times to ensure consistency.

6 Maintenance

Maintenance of the pneumatic system should be carried out in accordance with the relevant Maintenance Manual and Schedule, and should include replenishment from an external source as necessary, routine inspections for condition, cleaning of filters, replacement of desiccants and checking for leaks.

6.1 **Chaffing.** A pneumatic system is fitted with one or more charging valves, by means of which the system may be fully pressurized from an external source. These valves also act as, or include, a non-return valve, and are fitted with a dust cap which must be removed when connecting an external supply. Any external supply, whether from high-pressure storage bottles or a mobile compressor, must be fitted with oil-and-water traps, and, preferably, a dehydrator, to ensure that the air supplied is clean and dry. The supply hose should be capped when not in use, and should be blown through with compressed air before being connected to the charging valve, to prevent the introduction of moisture or dirt into the aircraft system. Care should be taken to turn off the external supply and to release air pressure from the supply hose before disconnecting it from the aircraft.

6.2 **Routine Inspection.** The scheduled routine servicing of the pneumatic system should include the following operations:

6.2.1 **Filters.** Wire-gauze air and oil filters such as may be fitted to a compressor, should be removed for cleaning and inspection at frequent intervals; cleaning in solvent is usually recommended, and the filters should be dried thoroughly before being refitted. The main air filter usually has a paper or felt element, and this should be renewed at the specified periods. This filter should also be drained periodically in order to check for the presence of water or oil, and this is best carried out by un-screwing the drain plug a quarter turn and releasing the trapped air; if moisture is found, the filter housing should be thoroughly dried and the element renewed, and if oil is found the compressor and the oil-and-water trap should be examined. A porous metal filter may also be fitted in some systems, and this is usually cleaned by reverse-flushing with methylated spirits; the filter must be thoroughly dried before replacing it in the system.

6.2.2 **Physical Condition.** All components and pipelines in the system should be examined periodically, for corrosion, cracks, dents and other superficial damage. Minor damage may often be removed and the area re-protected, but some components (e.g. storage bottles) must be considered unserviceable if the damage extends beyond the protective, treatments. The components should also be checked for security and locking, and the pipelines for satisfactory clamping, protection and identification. Any leaks found should be treated as outlined in paragraph 6.3.

6.2.3 **Storage Bottles.** Storage bottles should be drained periodically to remove any sediment or moisture which may have accumulated. Draining is best carried out with pressure in the system, but the drain plug should not be unscrewed more than a quarter turn; without pressure in the bottle the drain plug may be completely removed, and it may be necessary to use a thin rod to clear any congealed sediment. After draining, the drain plug should be tightened to the specified torque and re-locked. The pressure testing of storage bottles should be carried out in accordance with, and at the times specified in, the relevant manuals.

6.2.4 **Oil-and-Water Trap.** The oil-and-water trap should be drained daily, or after each flight if freezing conditions exist, to prevent the freezing of water in the pipe from the compressor. Draining should be carried out as soon as possible after flight, and the procedures outlined in paragraph 6.2.3 for storage bottles should be used.

6.2.5 **Dehydrator.** The periods at which the alumina charge or other desiccant should be changed, depend on the weather conditions in general, and may vary considerably; the actual periods should be determined by experience, and should be such that the dehydrating agent never becomes saturated with moisture. In many cases it will be necessary to remove the dehydrator in order to recharge it, and the following procedure should be used:-

a) Remove residual pressure from the container by means of the drain plug on the oil-and-water trap.

b) Disconnect the pipe connection on the container, release the securing strap, and remove the container from the aircraft.

c) Unscrew the end cap from the container and remove the dehydrating agent.

d) Remove any moisture from the container by passing warm, dry air through it, and clean the outlet filter in methylated spirit. Check the container for corrosion.

e) Examine any seats for damage or deterioration, and renew as necessary.

f) Fill the container with a fresh charge of dehydrating agent, then refit and lock the end cap.

g) Refit the container in the aircraft, and tighten and lock the connections and securing strap.

NOTE: The dehydrating agent is normally delivered in air-tight tins, but if permitted by the manufacturer the old charge may be re-activated, in emergency, by heating to 250°C to 300°C for 4 to 5 hours.

6.2.6 **Lubrication.** Any linkage associated with the control levers and valves in the pneumatic system, should be lubricated in accordance with the relevant Maintenance Manual, at the periods specified in the Maintenance Schedule. Engine oil is generally satisfactory for use on the threads of fasteners and components, but silicone grease may be recommended for use on some, components (e.g. the dehydrator end cap), where it may come into contact with rubber seals.

6.2.7 **System Operation.** The operation of the complete system should be checked at the intervals specified in the Maintenance Schedule, whenever components are changed, and whenever faulty operation is reported. The method of testing a system is specified in the relevant Maintenance Manual, and the operations which are usually included are outlined in paragraph 5.4.

6.3 **Leakage.** In high-pressure pneumatic systems some leakage will inevitably occur, and manufacturers usually lay down a maximum permissible leakage rate for a particular aircraft system. Leakage will sometimes become apparent through the slow or incorrect operation of a service, or failure to maintain system pressure, but a small leakage may only be noticed by a drop in system pressure when the aircraft is out of use for a short period (e.g. overnight). The leakage rate is checked by fully pressurizing the system, then re-checking the pressure after a period of 12 hours (or other specified time). The initial and final pressures should be recorded, taking into account the ambient temperature at the time; if this drop exceeds the maximum permitted, a check for leaks should be carried out.

6.3.1 **Checking for Leaks.** Large external leaks can often be traced aurally or by the application of a non-corrosive soapy water solution (bubbles will. appear at the position of a leak); all traces of soap solution must be removed after the test, using plenty of clean water, and the parts must be thoroughly dried. Smaller external leaks may not be detectable by these methods, but several types of electronic leak detectors are available which can be used to detect even the smallest leak. These detectors usually operate on ultrasonic principles, or by measurement of the positive ions emitted from the leak after a small quantity of carbon tetrachloride has been introduced into the system; operation of these detectors should be in accordance with the manufacturer's instructions. Internal leakage may be difficult to trace, and a knowledge of the particular system is essential. Leakage past seals and valves may often be found by checking the exhaust pipes, or by removing a connection and substituting a length of hose, the other end of which is held below the surface in a bucket of water; bubbles will indicate leakage from the component upstream of the disconnected pipe.

6.3.2 **Curing Leaks.** Leakage may be caused by a number of faults, such as deterioration of seals, loosening of nuts, splits in pipes, scoring of cylinder walls, or worn valve seats. Leakage from a pipe connection may sometimes be cured by tightening the union nut, but excessive force must not be used; if the leak persists after tightening, new parts should be fitted. Internal leakage from components will often require their removal for overhaul, but the replacement of seals and gaskets is sometimes permitted. Extreme care is necessary when refitting seals, and special tools may be required; any damage to the seal or component caused by careless handling could result in further leaks. When re-assembling components, absolute cleanliness is essential, and the tests specified in the relevant manual should be carried out before installing them in an aircraft.

7 Storage

Pneumatic components are normally packed in scaled containers or plastic bags, and should not be unpacked until required for use. They should be stored in conditions which are dry, and free from corrosive fumes. The storage life of assemblies is determined by the non-metallic parts, such as seals, that they contain, and upon storage conditions. The date of packing, record of tests carried out, and storage life of a component should be marked on the container, but storage life may also be checked by reference to the Maintenance Manual.

7.1 Pipes are usually blanked and wrapped for storage, but flexible pipes should always be stored in the shape in which they were manufactured or have assumed during use.

7.2 Components removed from storage for installation on an aircraft should be examined for external damage and corrosion, and the condition of all threads should be checked. Where applicable the components should be blown through with clean, dry compressed air, and every precaution should be taken to prevent the ingress of dirt or moisture.

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Leaflet 5-11 Emergency Floor Path Lighting System
(was previously AN No. 56 Issue 4, 17 March 1992)

1 Introduction

This Leaflet provides additional information on the installation of an Emergency Floor Path Lighting System required by the Air Navigation Order Schedule 4, scale Z(3).

2 Interpretation of Requirements

2.1 The following guidance information is provided with the objective of ensuring a consistent and uniform interpretation of the emergency floor path lighting system requirements.

2.2 The markings and illumination provided should enable the passenger to visually identify the escape path along the cabin aisle floor.

NOTE: It is not necessary to provide visual guidance to enable passengers to move from their seat to the cabin aisle.

2.3 The illumination should be of sufficient intensity to enable the passenger to identify features bounding the cabin aisle.

2.4 Where exits are to be found in one direction only, the system should not tend to lead the passenger toward the end of the cabin where there are no exits.

2.5 The escape path markings, coupled with exit markings, should be so arranged that a passenger will not tend to proceed along the cabin aisle past any available exits. It is recommended that conspicuous markers be placed at the point of access from the cabin aisle to the exit.

2.6 **Exit Identification**

2.6.1 Only those exits which are either 'designated' emergency exits or 'excess' emergency exits should be identified by the emergency floor path lighting system.

NOTE: 'Designated' emergency exits are the minimum required for the certificated passenger capacity. 'Excess' emergency exits are additional exits to the minimum required which satisfy the same arrangement, marking and lighting requirements as for designated exits and which are also readily accessible.

2.6.2 The exit should be positively identifiable to enable a passenger to proceed to it without hesitation in conditions where the exit is either open or closed. All exits likely to be available for use in an emergency should, therefore, have exit identifiers.

2.6.3 Exit identifiers of floor level exits need to be located so that they can be seen directly when adjacent to the last aisle marker, or in the case of a flood-lit system, within the flood-lit zone, and viewed on the vertical centre line of the aisle at a height no more than 4 feet above the cabin floor level. Additional cues to a passenger may, however, be provided as an alternative such as horizontally mounted exit identifiers located on an aft or forward bulkhead in the vestibule leading to an exit and within direct line of sight of a passenger when approaching the vestibules from the aisle.

2.6.4 Exit identifiers should, wherever practicable, be located at such a distance from the floor that they will not be obscured by any strewn hand baggage likely to be present in an emergency evacuation. It is, therefore, recommended that exit identifiers be located between 18 inches and 4 feet above the cabin floor level.

2.6.5 Where exit identifiers are mounted on cabin sidewalls and located close to passenger seats, they should be visible from the aisle with the seat next to the identifier occupied. This takes account of a passenger seated next to an exit being incapacitated. (A passenger slumped forward or sideways should also be considered.)

2.7 **Escape Path Markings along Cabin Aisle Floor**

2.7.1 Where single point incandescent type or electroluminescent strip type floor track markers are employed, the CAA recommends a distance between markers no greater than 20 inches (thus permitting a maximum distance between markers of 40 inches under typical Minimum Equipment List (MEL) conditions).

NOTE: Where incandescent lights are installed on the side of seats the distance between lights should not exceed 40 inches.

2.7.2 Floor track cabin aisle markers should be clearly visible when viewed from the aisle centre line at a height of 4 feet above the cabin floor.

2.7.3 At each end of a passenger cabin it is recommended that there are red/orange floor track cabin aisle markers (either, at least two closely spaced incandescent markers or, a short length of electroluminescent strip) to highlight clearly the ends of the aisle.

2.8 **Escape Path 'Flood Lighting' of Cabin Aisle**

2.8.1 Where a 'flood lighting' system is employed the maximum distance between light sources is to be agreed with the CAA and this will be dependant upon the intensity and distribution of light available.

2.9 **Aisle Cues for Overwing Exits**

2.9.1 Floor track marking system aisle cues for overwing exits are recommended to comprise three, with a minimum of two, closely spaced red/orange markers or a suitable length of red/orange strip-lighting, adjacent to the access route to overwing exits.

2.9.2 Where access to an overwing exit is achieved by a dual access route, the aisle cues should be located at the entrance to both access routes or be located so as not to bias one route when compared with the other.

2.9.3 Escape Path flood lighting systems do not normally provide adequate aisle cues for overwing exits and should be complemented by the provision of some discrete cues so located that they can be seen by a passenger at a maximum height of 4 feet above the cabin floor when moving down the aisle (strobe lights are not considered to be effective cues, especially when smoke is present).

2.10 **Cross Aisle Escape Path Markings**

A similar level of floor proximity escape path marking/illumination should be provided in cross aisles on multi-aisle aircraft to that provided for the cabin main aisles.

2.11 **The 25 Percent Rule**

2.11.1 Each escape path marking system is required to meet existing FAR/JAR/EASA CS 25.812 requirements. In particular, FAR/JAR/EASA CS 25.812(l)(1) requires that not more than 25 percent of the escape path marking system lights are rendered inoperative after any single transverse vertical separation.

2.11.2 For systems in which the lights are controlled by remote transmitters there must be sufficient transmitters installed to ensure that the FAR/JAR 25.812(l)(1) requirement can be met even though, in a crash, there may be a considerable distance between the two vertically separated parts of the fuselage.

3 Evaluations

3.1 The means provided in showing compliance with the requirement of the ANO shall be the subject of an evaluation by the CAA. In addition, all concepts not already approved shall be the subject of a demonstration to determine both the strengths and weaknesses of a particular system.

3.2 Engineering evaluations and demonstration tests should be conducted in conditions of darkness either at night or where conditions have been simulated by preventing daylight from entering through windows or through exits whether open or closed.

3.3 Where it is intended that an aircraft's MEL is to permit continued operation of the aircraft with some elements of the system unserviceable, the test subject demonstration should be conducted with the system configured so as to simulate the relevant MEL standard.

3.4 A demonstration should clearly show, to the satisfaction of the CAA, that test subjects, on leaving their seat in any part of the passenger compartment and entering the cabin aisle can using the visible signs and markings, immediately determine in which direction(s) exits are to be found using visual references only.

3.5 The demonstration is intended to establish that there are adequate visual references which will provide the necessary orientation of the passengers. It is not necessary to assess the passenger evacuation rate under these conditions. Obstructions created by loose cabin baggage, etc., need not, therefore, be simulated, except in so far as baggage might interfere with an illumination system.

3.6 In assessing the effectiveness of all visual cues, the existing emergency lighting system which provides illumination from locations more than 4 feet above the cabin aisle floor, must be switched off. It is not intended that the test should be performed in conditions of smoke but simply taking into account its blanketing effect. Therefore, care needs to be taken to ensure that, in the absence of an overlaying smoke, the floor proximity system is prevented from illuminating and hence reflecting light from parts of the cabin above the 4 foot level.

3.7 Test subjects should not have detailed knowledge of the aircraft other than that obtainable from a study of the normal Passenger Safety Leaflet. The total number of test subjects is not critical but they should be adults and should include both males and females over 60 years of age.

3.8 The precise details of5 any demonstration should be discussed and agreed with the CAA but should include consideration of the following:

In each demonstration, the test subject acting alone and without any assistance should be able:

a) to leave the seat or seat row and enter the cabin aisle;

b) standing or stooping in the aisle and making use of the visual reference to the floor proximity marking system, to identify and locate the first exit or pair of exits either forward or aft (where appropriate);

c) to proceed to the particular exit(s), without significant hesitation or evidence of confusion, making all exit identifications by reference only to visible features not more than 4 feet above the cabin floor.

After each test, the test subject should indicate to the observers the means by which the exit was located.

3.9 A sufficient number of tests should be performed to ensure that, at least, one exit of each type in the passenger cabin has been identified with the exit both open and closed using the associated marking systems. (Safety precautions should be taken particularly for any demonstration involving open exits).

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