Part 10 Ground Operations

Leaflet 10-1 Aircraft Handling

1 Introduction

This Leaflet describes the ground handling tasks which may be necessary during the normal day-to-day operation of an aircraft and details the procedures and precautions which are generally specified. These tasks vary considerably according to the size and type of aircraft concerned and the layout of the aircraft systems; this Leaflet should, therefore, be read in conjunction with the appropriate Maintenance Manual, where information relating to the particular aircraft will be found.

2 General

The tasks which may be required to be carried out on an aircraft between flights, apart from routine maintenance, cover a variety of subjects and these are dealt with separately in paragraphs 3 to 8 of this Leaflet. Special ground equipment is often required to enable these tasks to be carried out satisfactorily; in the case of light-aircraft operations this equipment may be of a very rudimentary nature, but when dealing with large transport aircraft more sophisticated equipment may be necessary.

2.1 Preparations for the reception of an aircraft should be made in advance of its arrival. The positioning of aircraft in the reception area should be arranged so that access paths to the aircraft are available for all replenishing vehicles and for the loading and unloading of passengers or cargo as applicable. All equipment likely to be required for the servicing of an aircraft should be readily available and should be in a fully serviceable condition.

2.2 When an aircraft has to be moved into a hangar in order to allow servicing operations or maintenance to be carried out, it should be positioned so as to avoid obstructing access to other working space or necessitating disturbance before the work is complete. Account should also be taken of the location of all necessary facilities such as weighing platforms, electric and pneumatic power sources, lighting and of the necessity for providing docks or platforms to enable the work to be carried out.

3 Towing

It is often necessary to move an aircraft without starting the engines, in order to position it for servicing or to enable passengers or cargo to be loaded, if this operation is not carried out properly, severe damage can be caused to the aircraft. Should it be necessary to call upon the assistance of untrained or inexperienced persons to move the aircraft, the person taking charge should instruct them adequately before starting and ensure that they fully appreciate what they are required to do. Paragraphs 3.1 and 3.2 contain general information on the towing of aircraft and the precautions to be observed, but detailed information relating to the movement of a particular aircraft will be found in the manufacturer's Maintenance Manual for the aircraft concerned.

3.1 Light Aircraft

Great care should be exercised when manhandling light aircraft, particularly those manufactured from wood and fabric.

3.1.1 On aircraft having a nose-wheel landing gear, a steering arm should be fitted to the nose wheel to guide the aircraft and force should be applied only to those parts of the structure which are designed to accept it. Force should not be applied to trailing edges of wings or control surfaces, to streamlined wires, or to areas which are marked to prohibit the application of force; an engine should always be regarded as 'live', therefore, a propeller should not be used to push or pull the aircraft.

3.1.2 Generally it is better to push an aircraft backwards rather than forwards, since the leading edges of the wings and tailplane are stronger than the trailing edges, but the struts and undercarriages on some aircraft are suitable for pushing the aircraft forwards. The flat of the hands should be used when pushing, so as to spread the load over the largest area, in addition when pushing on struts or undercarriages the force should be applied as near to the end fittings as possible.

3.1.3 On aircraft with a steerable nose wheel connected to the rudder pedals, care must be taken not to exceed the turning limits, which are normally marked on the nose undercarriage leg. On this type of aircraft it is also important that the rudder controls are not locked during towing operations.

3.1.4 On aircraft which are fitted with a tail skid instead of a tail wheel, it is customary to raise the tail by lifting on the tailplane struts near to the fuselage fittings, so that the aircraft is balanced at the main wheels; the aircraft may then be pushed backwards as required. On some aircraft it may also be advisable to place the propeller in a horizontal position, to prevent it striking the ground when the tail is lifted.

3.1.5 When towing a light aircraft by means of a tractor, the correct tow-bar should be connected between the towing attachment at the base of the nose undercarriage leg and the tractor; a person familiar with the aircraft brake system should be seated in the cockpit/cabin to operate the brakes in an emergency; the brakes should not normally be applied unless the aircraft is stationary. Once the tow-bar is connected, the brakes and, where fitted, the rudder lock, may be released and the aircraft towed forwards at a safe speed, depending on conditions in the vicinity. A close watch should be kept on the wing tips and tail, particularly in confined spaces, to ensure that they do not come into contact with other stationary or moving objects. Care should be taken when negotiating bends, to prevent the limits of nose-wheel movement being exceeded.

3.1.6 In circumstances where the ground over which the aircraft has to be towed is either boggy or very uneven, the strain imposed on the nose undercarriage may be excessive and it may be necessary to tow the aircraft by means of bridles attached to each main undercarriage. If towing attachments are not provided on the main undercarriage legs, ropes should be passed carefully around the legs as near to the top as possible, avoiding fouling on adjacent pipes or structure. A separate tractor should be connected to each main undercarriage and steering should be carried out by means of a steering arm attached to the nose wheel rather than by differential movement of the tractors.

3.2 Large Aircraft

Large multi-engined aircraft are usually moved by towing with a tow-bar attached to the nose undercarriage leg, a special tug often being required to provide sufficient tractive effort. The tow-bar is fitted with a shear-pin or bolt, which will shear at a

predetermined load to prevent excessive force being applied to the nose undercarriage.

3.2.1 The centre-of-gravity (C of G) of the aircraft must be determined before towing, to ensure that there is sufficient weight on the nose wheel. Adverse fuel distribution and the aircraft being in a non-standard condition (e.g. with an engine removed), could affect the C of G position and a maximum aft limit is generally specified in the relevant Maintenance Manual. Ballast may sometimes be required to achieve a safe C of G position, but the maximum towing weight must not be exceeded.

3.2.2 Before towing is commenced the undercarriage ground locks should be installed, the steering should, if applicable, be disconnected or disabled (usually by removing a steering disconnection pin, by inserting a lock-out pin, or by tripping the associated circuit breaker) and the nose undercarriage shock absorber should be checked for normal extension. In addition, the brake pressure should be checked and, if necessary, built up to the minimum safe pressure (this is often accomplished by operation of an electrically-driven hydraulic pump, which must be used sparingly to prevent the motor overheating). If it is likely to be necessary to turn the nose wheel through a greater angle than the prescribed steering limits, the nose wheel is usually freed by removing the apex pin from the torque links, thus allowing the nose wheel complete freedom of movement, but particular attention must be paid to any limits imposed on aircraft having bogie undercarriages.

3.2.3 When towing the aircraft, two qualified pilots or suitably trained and authorised members of the towing crew should be stationed in the cabin, to operate the brakes and any of the other aircraft systems which may be required and to keep a look-out and monitor progress. These persons should be in telephonic communication with the outside ground crew and with the tractor driver. Ground crew should be located at the wing tips and tail to guide the aircraft past any obstructions. One person should be in overall control of the operation.

3.2.4 The aircraft brakes should be released before the tractor moves off and towing-speed should be kept down to a safe speed. The radii of turns should be kept as large as possible, to minimise tyre scrubbing and twisting loads on the main undercarriage legs. Care should be taken not to exceed any towing-force limits which may be specified in the relevant Maintenance Manual for various nose-wheel steering angles. Before stopping, the aircraft should be towed in a straight line for a short distance in order to remove any tyre stresses imposed by turning. Once stationary the aircraft brakes may be re-applied, the tractor and tow-bar may be removed and the nose-wheel steering links refitted and safety locked.

3.2.5 In circumstances where the towing load exceeds the nose-wheel limitations, towing bridles should be attached to the main undercarriage legs and the aircraft should be towed using two tractors, one connected to each main undercarriage leg. A steering arm attached to the nose wheel should be used for steering purposes. Where no special towing attachments are provided, it will often be necessary to remove the fixed doors from the main undercarriage legs to permit attachment of the towing bridles.

3.2.6 In an emergency it may be necessary to move an aircraft from a runway while it has one or more deflated tyres. Provided that there is one sound tyre on an axle the aircraft may be towed to the maintenance area, but sharp turns should be avoided, towing speed should be kept to an absolute minimum and brakes should be applied very carefully. If an axle is not supported by a sound tyre, however, the aircraft may only be moved the shortest distance necessary to clear the active runway and the wheels with deflated tyres must be removed and serviceable components fitted before towing is continued. After any tyre failure the associated wheel must be

inspected (see Leaflet 5–8) and it may also be necessary to inspect the wheels and tyres which have not failed if the aircraft has landed or been towed with a deflated tyre.

4 Parking and Picketing

When an aircraft is out of service and in the open, it should be secured against inadvertent movement and protected against adverse weather conditions. The operations which are recommended in the relevant Maintenance Manual depend on the type of aircraft, the length of time it will be out of service and the prevailing or forecast weather conditions.

4.1 Between flights it is usually sufficient to apply the parking brakes, lock the control surfaces and chock the wheels, but in a strong wind light aircraft should be headed into wind. Light aircraft without wheel brakes should be headed into wind and their wheels should be chocked front and rear.

4.1.1 Flying controls on many aircraft are locked by movement of a lever in the cockpit/cabin, which is connected to locking pins at convenient positions in the control runs or at the control surfaces. When this type of lock is not fitted, locking attachments may have to be fitted to the control column and rudder pedals, but a more positive method which is frequently used on older or elementary aircraft, is the fitting of external control surface locks, which prevent control surface movement and thus prevent strain on the control system. All external locks should have suitable streamers attached, to make it visually obvious that the locks are fitted.

4.2 If an aircraft has to be parked overnight or for longer periods in the open, then additional precautions should be taken to guard against the effects of adverse weather. The undercarriage ground locks should be fitted, all openings such as static vents, engine intakes and cooling air intakes should be blanked to prevent the ingress of dirt, birds, insects and precipitation and all fittings such as pitot heads and incidence indicators should be covered. When severe weather is expected it is recommended that cockpit/cabin covers and wheel covers are also fitted. Blanks and covers for all these components are specially designed for the particular aircraft and if not visually obvious, are fitted with streamers to guard against their being left in position when the aircraft is prepared for service; servicing instructions should, however, include a pre-flight check to ensure that all covers and locks have been removed.

4.3 Light aircraft should normally be tied down when parked overnight or longer, but this is not usually necessary with large aircraft unless particularly strong winds are expected.

4.3.1 Light aircraft are fitted with picketing rings (or positions for the attachment of picketing rings) at the wings and tail and, on some aircraft, adjacent to the main undercarriage legs. The aircraft should be parked into wind and secured from the picketing points to suitable anchorage points on the ground (heavy concrete blocks or screw pickets). Cable or nylon rope of adequate strength should be used if possible, but if rope made from natural fibres is used, sufficient slack must be left to allow for shrinkage in damp conditions. Additional picketing from the undercarriage legs may be recommended in strong wind conditions and, if so, care should be taken not to damage any pipelines or equipment attached to the legs or wheels.

4.3.2 Large aircraft only require picketing in very strong wind conditions. The aircraft should be headed into wind, the parking brakes should be applied (unless pre-loaded main-wheel chocks are recommended) and cables should be attached from the aircraft

picketing points to prepared anchorages. In some cases the picketing cables are special components and include a tension meter which is used when applying a pre-load to the cable.

4.4 For helicopters, in addition to the actions outlined in paragraphs 4.1 to 4.3, the rotor blades should be tethered whenever possible, since even light gusting winds can cause damage to blades which are free to flap. The collective pitch lever should normally be locked in the fully fine position and the rotor brake applied. Rotor head and blade covers should also be fitted if the helicopter is parked overnight, if high winds are expected it should be hangared or the rotor blades should be folded.

4.4.1 On many helicopters the main rotor blades are tethered by aligning one blade along the tail cone, locking the collective pitch lever in fine pitch and applying the tip covers to each blade, pulling them against the damper stops. Each blade may then be lashed to its respective picketing point, but care must be taken not to pull the blades down excessively; the relevant Maintenance Manual will generally stipulate a maximum distance from the normal drooped position which must not be exceeded. The tail rotor is generally tethered by fitting the blade covers and securing them to the associated picketing point or tail skid.

4.4.2 The method of folding the main rotor blades depends on the method of attachment to the rotor head and on the position of each blade; the procedure for a particular helicopter should, therefore, be obtained from the relevant Maintenance Manual. In the folded position the blade tips are generally secured by means of support cradles, which are attached to the tail cone structure.

5 Jacking

An aircraft may have to be jacked up for a variety of reasons, including servicing, weighing, changing wheels and retraction tests and care is necessary to avoid damaging the aircraft. Jacking points are provided in the wings and fuselage to enable the whole aircraft to be lifted, and usually, at the nose and main undercarriages to enable individual wheels to be changed. Some aircraft require a jacking pad to be fitted to each jacking point in the wings and fuselage and adapters to be fitted to the jacks, while in other cases special stirrups or beams may be required to lift individual axles.

5.1 Because of the position of the jacking points, the centre-of-gravity of some aircraft may, although satisfactory for flight, fall behind the main jacking points and thus be unsatisfactory for jacking purposes. In these cases it may be necessary to add ballast forward of the main jacking points to bring the centre-of-gravity within limits specified in the relevant Maintenance Manual. In addition, each jacking or steadying point may have a load limit which, if exceeded, could result in structural damage. To avoid exceeding the limiting load at the jacking points it is sometimes necessary to fit hydraulic or electrical load cells (see Leaflet 1–4) to the jacks, while ballast may have to be used to avoid exceeding the loading limit at a steadying point.

5.2 Micro-switches fitted to the undercarriage legs and operated by the extension or contraction of the shock absorbers, are used to arm or disarm various electrical circuits on an aircraft. If the aircraft is jacked up these circuits will operate as required during flight, this may not be desirable. Therefore, these circuits should be isolated by tripping the appropriate circuit-breakers or by removing the associated fuses, as necessary.

5.3 As a safety precaution, light aircraft should normally be jacked inside a hangar, but large aircraft may be jacked in the open provided that they are headed into wind and

that the surface is level and strong enough to support the weight of the aircraft at the jacking points. A maximum safe windspeed for jacking is generally specified in the relevant Maintenance Manual.

5.4 The following procedure will generally ensure the satisfactory jacking of most aircraft, but account should also be taken of any additional precautions or actions specified in the Maintenance Manual for a particular aircraft. One person should be located at each jacking position and a co-ordinator should supervise the operation. On large aircraft the levelling station (paragraph 6) should also be manned and all ground crew concerned should be in communication with the co-ordinator, headphones being used when necessary.

a) Check that the aircraft weight, fuel state and centre-of-gravity are within the limits specified in the aircraft Maintenance Manual.

b) Head the aircraft into wind if it is to be jacked in the open, chock the main wheels front and rear and release the brakes.

c) If jacking an aircraft in a restricted space, ensure that there is adequate clearance above every part of the aircraft to allow for its being raised and adequate access and lifting space for cranes or other equipment which may be required.

d) Connect earthing cables to the earthing points on the aircraft.

e) Install the undercarriage ground locks.

f) Fit jacking pads to the aircraft jacking points and adapters to the jacks as required. Load cells should also be fitted to the jacks at positions where a maximum jacking load is specified.

NOTE: The capacity and extension of the jacks should be adequate for the aircraft size and weight. The minimum requirements will normally be stated in the relevant Maintenance Manual.

g) Position the jacks at each jacking point and raise them until the adapters are located centrally in the jacking pads. Care must be taken to ensure that the jacks are vertical and that the weight is evenly distributed over the legs of each jack.

h) Remove the wheel chocks and slowly raise the aircraft, maintaining it in a horizontal attitude as nearly as possible, until the undercarriage legs are fully extended and the wheels are a few inches off the ground. As a safety measure the locking nuts on the jack rams should be kept in close proximity to the jack shoulders as the jacks are raised.

i) Tighten the jack ram locking nuts and place supports under the outer wings and rear fuselage as indicated in the Maintenance Manual. The positioning of these supports is most important, as they are usually shaped to fit the undersurface of the wing or fuselage and must be located at a strong point such as a rib or frame; they are not intended to support the weight of an aircraft.

5.5 A 'bottle' jack and an adapter or special fitting are often used when raising a single undercarriage or part of a bogie beam for the purpose of changing a wheel. The remaining wheels should be chocked front and rear to prevent aircraft movement, it may also be specified that a tail support is located at the rear fuselage jacking point when raising a nose undercarriage. The jack should be raised only sufficiently to lift the unserviceable wheel a few inches clear of the ground (lowering the tail support, when applicable, as the jack is raised). Any applicable safety precautions outlined in paragraph 5.4 should be observed.

5.6 Before lowering an aircraft to the ground, all ground equipment, work stands, supports, etc., should be moved clear of the aircraft structure to prevent inadvertent

damage, the wheels should also be rotated by hand to check that the brakes are free. The jacks should be lowered slowly in unison, by opening their pressure release valves, and, to guard against failure of a jack, the locking nuts on the jack rams should be unscrewed while the jacks are lowered and kept within 50 mm (2 in) of the jack heads. The jacks should be fully lowered after the aircraft is resting on its wheels and the pressure release valves should be closed. Chocks should then be placed in position, the jacks, jacking pads and adapters should be removed from the aircraft and any electrical circuits which were disarmed as a safety measure should be reinstated.

NOTE: Undercarriage shock absorbers occasionally stick in the extended position, care should, therefore, be taken not to leave any equipment in a position beneath the aircraft where it could cause damage, until it is certain that the shock absorbers have compressed.

6 Levelling

For some purposes, such as rigging or weighing, an aircraft must be levelled laterally and longitudinally and a number of different methods may be employed.

6.1 Spirit Level

Many aircraft are levelled by use of a spirit level, which is placed at jigged positions on the airframe structure. On light aircraft the longitudinally level position is generally obtained by placing the spirit level on two pegs or on the heads of two partially withdrawn screws on the side of the fuselage and adjusting the jacks (or the shock absorber extension or tyre pressures, if the aircraft is resting on its wheels) until the spirit level is centred. The laterally level position is obtained by placing the spirit level on the centre-section spar boom (or other nominated position) and again adjusting the jacks or tyre pressures until the level is centred. With some large aircraft a spirit level may be used in conjunction with special fittings, which are secured by locations in the centre fuselage or in one of the wheel bays; these fittings must be removed before flight and should have warning streamers attached. If adjustments have been necessary to level an aircraft laterally, the longitudinal level should be re-checked.

NOTE: In cases where tyre pressures are adjusted to level the aircraft, care must be taken not to over-inflate or to completely deflate a tyre.

6.2 Plumb Bob

On many aircraft a plumb bob is used in conjunction with a levelling plate. The plumb bob is suspended from a fixed position in the cabin roof or upper part of a wheel bay and hangs over a levelling plate, which may be a permanent fixture or a separate fitting accurately located on the cabin floor or lower part of the wheel bay. The levelling plate is marked with a zero position and scales indicating the adjustments required about the lateral and longitudinal axes to centre the plumb bob.

6.3 Engineers Transit

The most accurate means of levelling an aircraft is by the use of an engineers transit (theodolite) in conjunction with range poles or scales located on the aircraft's lateral and longitudinal axes. The transit is set up below the aircraft centreline and between the lateral levelling points and levelled horizontally. Range poles or scales are then located at the four marked levelling points on the lower surfaces of the fuselage and wings. Sightings are first taken on the lateral range poles or scales and the main jacks are adjusted until identical readings are obtained. Sightings are then taken on the longitudinal range poles or scales and the nose jack is adjusted until identical readings are again obtained. The aircraft is then considered level and the transit can be removed.

NOTE: The transit method is also employed when checking alignment of the aircraft structure, graduations on the range poles being used to check dihedral and incidence.

7 Servicing

Servicing may often be carried out in a crowded environment and must be properly organised to ensure that the necessary operations are carried out, to provide adequate safety to passengers and ground crew and to protect the aircraft from damage. The procedures and precautions generally applicable to the routine servicing of aircraft are dealt with in the following paragraphs.

NOTE: For the purposes of this Leaflet, the term 'servicing' means those operations which are required to check and replenish an aircraft's systems and to maintain an aircraft in an operational condition. In cases where an aircraft Maintenance Manual is produced in accordance with ATA Specification 100, detailed information on servicing operations will be found in Chapter 12.

7.1 General

The maintenance of a satisfactory surface contour and finish on an aircraft is most important and care is necessary to prevent damage to outer surfaces, access panels and fasteners. Walkways are provided on the wings of many aircraft for access to the cockpit/cabin or for servicing purposes and areas which must not be trodden upon, pushed or pulled, are clearly marked. Mats and suitable rubber footwear must be used when it is necessary to walk on the wings and every precaution should be taken to prevent damage by tools or servicing equipment. It is also advisable to wear clothing without buttons or buckles which could scratch the wing surface, and, without pockets in which loose tools could be carried, since they could fall out and become a loose-article hazard.

7.2 Ground Equipment

Many types of ground equipment may be required during aircraft servicing and all must be compatible with the aircraft systems on which they are to be used. The ground equipment should be kept scrupulously clean and should be maintained in accordance with a schedule recommended by the manufacturer. Delivery pipes from all liquid and gas servicing trolleys should be blanked when not in use and their cleanliness and serviceability should be checked before connection to an aircraft. Fire extinguishers suitable for fuel and electrical fires should always be readily accessible wherever an aircraft is being serviced and should be subject to regular inspection.

7.3 Refuelling

Before refuelling it should be ensured that the refuelling vehicle contains the correct grade of fuel, as shown at the refuelling points on the aircraft.

7.3.1 Precautions should be taken to provide a path to earth for any static electricity which may be present or which may build up as a result of the fuel flow. The aircraft and the refuelling vehicle should be earthed to a point which is known to be satisfactory and the earthing wire on the refuelling pipe should be connected to the earth point provided on the aircraft before connecting the refuelling pipe or removing the tank filler cap. The earthing wire should remain in position until after the refuelling pipe is disconnected or the tank filler cap is replaced, as appropriate. When draining fuel into buckets, containers or tanks, these should also be bonded to the aircraft and/or the refuelling vehicle. No radio or radar equipment should be operated while refuelling or defuelling is taking place and only those electrical circuits essential to these operations should be switched on.

7.3.2 When pressure refuelling, a float switch or fuel level shut-off valve is often used to cut off fuel flow when the tanks are full, or have reached a pre-set level. Since pressure refuelling rates are very high, failure of these components could cause a rapid build-up in pressure and serious damage to the tanks. The tanks of some aircraft are fitted with pressure relief valves which can be checked manually prior to refuelling, but when this is not the case persons engaged in refuelling operations should be prepared to shut off the supply instantly, should the automatic cut-off system fail to operate.

NOTE: When refuelling, the wheel chocks should be moved a short distance away from the tyres, to prevent them being trapped when the tyres absorb the additional weight.

7.3.3 Particular care should be taken when refuelling high-winged light aircraft, since the upper wing surface will not normally be safe to walk on and the filler cap may not be within easy reach. A step ladder or stand should be used to gain access to the filler cap and assist in preventing damage to the wing surface. Use of the steps will also facilitate correct locking of the filler cap.

7.3.4 When a spillage of fuel has occurred, care should be taken to ensure that all traces of fuel and vapour are removed. Any residual fuel should be mopped up and any fuel-soaked lagging or fabric should be removed and cleaned. The effects of the fuel on other parts such as cables, seals, bearings and windows should also be considered and the appropriate action should be taken.

7.3.5 After refuelling an aircraft it is usually recommended that fuel is checked for contamination. Drain valves are provided in the tank sumps, pipelines and filters, by means of which a small quantity of fuel may be drained into a glass jar and checked for the presence of water, sediment and microbiological contamination. Because of the slow rate of settlement of water in turbine fuels it is usually recommended that the tanks are left as long as possible after refuelling before the sample is taken. With turbine-engined aircraft, samples may also be taken to determine the specific gravity of the fuel in the tanks.

7.4 Connection of Electrical Power

It is often necessary to connect an external electrical power supply to an aircraft, either for engine starting purposes or to permit operation of the aircraft systems and equipment. Certain precautions must be observed when connecting the external supply, to prevent damage to the aircraft electrical system.

7.4.1 Most light aircraft have direct current (d.c.) electrical systems and although alternating current (a.c.) is provided for the operation of certain equipment it is not usual for the aircraft to have provision for the connection of a.c. external power. The external power socket is, therefore, usually for the connection of a d.c. supply, which may be provided solely by batteries or from a generator and battery set. The following actions should be taken when connecting an external d.c. supply to a typical light aircraft:

a) Check the voltage and polarity of the ground supply.

b) Check that the external power plug and socket are clean, dry and undamaged.

c) Check that the external supply and the aircraft battery master switch are off and connect the external supply, ensuring that the plug is fully home in the socket.

d) Switch on the external supply and the aircraft battery master switch and carry out the servicing operations for which the external power was required.

e) To disconnect the external supply, switch off the battery master switch, switch off the external supply, disconnect the external power plug and, if the aircraft electrical

system is to be used (e.g. after engine starting), switch the battery master switch on again.

7.4.2 Most large aircraft are provided with multi-pin plugs or sockets, by means of which external d.c. or a.c. power may be connected into the aircraft electrical system. The external supply is usually provided by a towed or self-propelled unit, which has its own power-driven generator and can provide d.c. power at various voltages and a.c. power at a particular voltage, frequency and phase rotation. Aircraft electrical systems vary considerably and the checks which are necessary after connecting the external power will vary between aircraft, but the following procedure is applicable in most cases:

a) Check that the external supply is compatible with the aircraft system (i.e. it has the same voltage, frequency and phase rotation as the aircraft system) and is switched off.

b) Check that the external plug and socket are clean, dry and undamaged.

c) Connect the external plug/socket, ensuring that it is fully mated and secure and switch on the external power supply.

d) Check the voltage and frequency of the external supply on the aircraft electrical system instruments and perform the operations specified in the relevant Maintenance Manual to engage the external supply with the aircraft a.c. system.

e) To disconnect the external supply, disengage it from the aircraft a.c. system, switch off the external power at source and remove the external power plug/ socket.

7.5 Connection of Compressed Gases

Any component containing compressed gas must be handled and serviced carefully, because the sudden release of gas under pressure could have disastrous consequences. Oxygen systems present an additional hazard in that oil and grease are prone to spontaneous combustion in the presence of undiluted oxygen.

7.5.1 The gas pressure required in some components varies according to the ambient temperature and in order to ensure that the correct working pressure is maintained, the relationship between temperature and pressure is generally presented in the form of a graph, both in the Maintenance Manual and on a placard adjacent to the charging point. In the case of tyres and shock absorbers on large aircraft the required gas pressures may vary according to the aircraft weight and centre-of-gravity position, the requirements for a particular aircraft should be obtained from the relevant Maintenance Manual.

7.5.2 Since the rapid compression of a gas produces heat it will affect the gas pressure in a component; heat will be minimised by charging slowly. The sudden release of a compressed gas will have the reverse effect, i.e. lowering its temperature and this is particularly important when deflating a tyre (see Leaflet 5–7), as ice may form and block the valve, giving the impression that the tyre is fully deflated when in fact it is still partially inflated. Prior to working on any unit from which compressed gas has been exhausted, the charging valve or valve case should be completely removed.

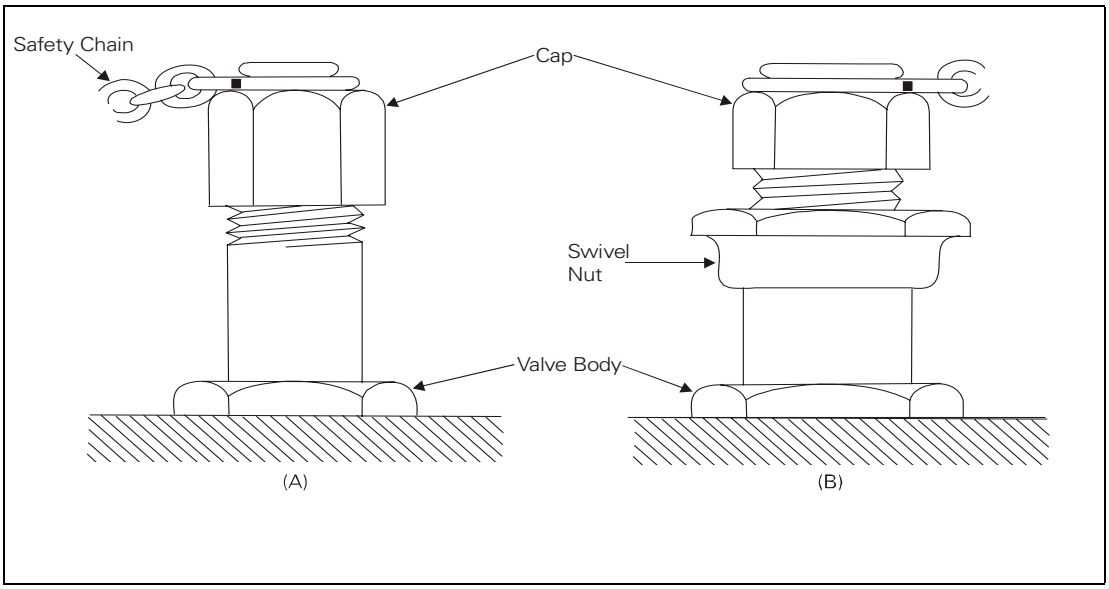

Figure 1 Charging Valves

7.5.3 Charging Valves

The valves fitted to components which are charged with gas may be of two types. One is a needle-type valve (Figure 1(A)) which opens and closes automatically, the other is a poppet-type valve on which the swivel-nut has to be unscrewed one full turn to release the valve stem (Figure 1(B)). A valve cap should always be fitted to prevent the entry of dirt and moisture and should be removed only when it is necessary to charge the component or to release gas pressure. On no account should the valve body be unscrewed while the component is pressurised, since this could result in the valve blowing out and causing damage or injury.

7.5.4 Charging Rigs

A compressed-gas charging rig is generally a self-propelled or towed trolley, on which are mounted one or more high-pressure gas cylinders, a flexible supply hose, a supply shut-off valve and pressure gauges showing storage cylinder pressure and supply hose pressure. Some rigs are also fitted with a pressure regulator, by means of which the supply pressure may be limited to the maximum required in the component, this type of rig is used when the aircraft system does not have its own supply shut-off valve and pressure gauges.

7.5.5 Charging

Charging a component with compressed gas should be carried out carefully and the following precautions should be observed:

a) The pressure to which the component is to be charged should be checked according to the ambient temperature, or weight and centre-of-gravity of the aircraft, as appropriate.

b) The supply connection should be clean, dry and free from oil or grease; any contamination should be wiped off with a lint-free cloth moistened in a solvent such as methylated spirits.

c) The aircraft system should be charged very slowly, so as to minimise the rise in temperature.

d) When the required pressure is reached, the shut-off valve should be closed and the system pressure allowed to stabilise. The pressure should then be checked and adjusted as necessary.

e) The supply hose should not be disconnected unless the shut-off valve and the charging valves are closed, because of the dangers associated with rapid decompression. On some rigs provision is also made for relieving pressure from the supply hose before disconnection.

f) Blanking caps should be fitted to the charging valve and supply hose as soon as they are disconnected.

g) When charging oxygen systems, adequate and properly manned fire-fighting equipment should be positioned and, if illumination is required, explosion-proof lamps and hand torches should be used.

7.6 Replenishment of Liquids

On modern aircraft, replenishment of engine oil, hydraulic fluid, de-icing fluid, water and other systems containing liquids, is achieved by the use of servicing trolleys which are specially designed for the task and are connected into the system by quick-release couplings; alternatively, and with older aircraft, these systems may be replenished by removing the tank filler cap and pouring in the required liquid. Whichever method is used, the utmost care should be taken to ensure that only the approved liquids are used and that no foreign matter is allowed to enter the system. Servicing trolleys should be inspected regularly for cleanliness and their delivery pipes should be capped when not in use; all utensils should be kept scrupulously clean and should, preferably, be retained for use with one particular liquid.

7.6.1 The quantity of liquid in a system may be indicated by a sight glass, by use of a dip-stick, by its visible level in a filter fitted in the filler opening, or, in some cases, by means of a contents gauge, the transmitter unit for which is mounted in the tank. When required, the system should be replenished to the 'full' level; no system should be overfilled, as this could affect system operation.

7.6.2 Precautions applicable to the replenishment of systems containing liquid are outlined in paragraphs a) to d) below:

a) Some systems are pressurised in normal use and this pressure should be released before replenishing with liquid.

b) When replenishing a hydraulic system, it may be necessary to pre-set the hydraulic services to specified positions to prevent overfilling.

c) Some liquids, such as methanol, synthetic lubricating oils and hydraulic fluid, may be harmful or even toxic if their vapours are breathed in or if they come into contact with the skin or eyes.

Particular note should be taken of any warnings of dangers to health which may be contained in the relevant Maintenance Manuals and the recommended procedures for the handling of these liquids should be observed.

d) The liquids mentioned in paragraph c) may also have an adverse effect on paintwork, adhesives and sealant and thus inhibit corrosion prevention schemes. Care should be taken not to spill any of these liquids, but if a spillage does occur, immediate steps should be taken to mop it up and clean the affected area.

7.7 Lubrication

Lubrication should be carried out in accordance with a schedule approved for the particular aircraft, the intervals normally being related to flying hours, with certain

positions requiring additional lubrication after ground de-icing operations (see CAP 512) and after cleaning the aircraft.

7.7.1 The lubricant to be used, and the method of application, are usually annotated on a diagram of the aircraft in the appropriate chapter of the aircraft Maintenance Manual. The method of annotation is often by the use of mimic diagrams (e.g. an oil can for oiling or a grease gun for greasing) and the type of lubricant is indicated by a symbol.

7.7.2 The utensils used for lubrication purposes should be kept scrupulously clean and should only be filled with new lubricant. Each utensil or container should be clearly marked with the lubricant it contains and should be kept solely for that lubricant.

7.7.3 When lubricating a component, care should be taken to ensure that the quantity applied is adequate but not excessive; in some cases a particular quantity may be specified in the Maintenance Manual (e.g. 'apply 8 drops of oil...') but normally a quantity sufficient to cover the bearing surfaces, as evidenced by the exuding of new lubricant, should be applied. The lubricating point should be wiped clean and dry with a lint-free cloth before applying the oil or grease, any excess exuding from the component should be wiped off to prevent the accumulation of dirt or foreign matter.

7.8 Cleaning

Cleaning an aircraft improves its appearance and aerodynamic qualities, helps to prevent corrosion and facilitates the detection of fluid leakage. It is, therefore, often included in the servicing schedule.

7.8.1 Exterior Surfaces

Before washing down the exterior surfaces of an aircraft, all doors and windows should be closed, all apertures such as air intakes, engine exhausts, fuel jettison pipes, static vents and vent pipes should be blanked, covers should be fitted to pitot heads and sensor vanes. Transparencies should be covered to prevent contamination by cleaning fluids. The structure should be washed down using a cleaning agent recommended by the aircraft manufacturer and mixed according to the instructions provided, caked mud or other foreign matter being removed with lint-free cloth soaked in the cleaning agent. The wash should be followed by swabbing with clean water and care should be taken to prevent cleaning fluid or water becoming trapped in parts of the structure where corrosion and seizure of mechanisms could result. The aircraft should be thoroughly dried after washing and rinsing. It is usually recommended that lubrication should be carried out, particularly if pressure hoses have been used.

a) If it is necessary to remove concentrations of oil or grease, a cloth moistened in solvent should be used, but chlorinated solvents should be avoided since they may be toxic. The minimum quantity of solvent should be applied, since prolonged saturation of parts may have an adverse effect upon adhesives and jointing compounds. When solvents are used, adequate fire-fighting equipment should be available.

7.8.2 Internal Structure

Internal structure is generally cleaned with a vacuum cleaner, but a cleaning agent and water may be used when necessary. Only a small area should be washed, rinsed and dried at a time, so as to prevent flooding of the structure and trapping of fluids in inaccessible places. Clean lint-free cloths should be used for all operations and the structure should be finally dried by circulating warm air.

7.8.3 Engines

An engine and its compartment should be cleaned by spraying or brushing with solvent or degreasing fluid, after first blanking all vents and apertures in such components as the magnetos and alternator. This solvent should be left on for five to ten minutes, then the engine should be washed with clean solvent and allowed to dry. All controls, hinges, etc., should be lubricated after cleaning and the engine should not be operated until all solvent has evaporated or otherwise been removed. The precautions stated in paragraph 7.8.1 a) regarding the use of solvents should be observed.

7.8.4 Upholstery

Soiled carpets and seats may usually be cleaned by means of a vacuum cleaner and an approved non-flammable air-drying type cleaner or foam-type upholstery cleaner. The manufacturer's instructions for the use of these materials should be carefully followed, soaking or harsh rubbing should be avoided.

7.9 Cold Weather Operations

Particular care is essential in the operation of aircraft when temperatures are likely to fall below freezing point at ground level. When snow or ice is present towing and taxying should be carried out with extreme caution and aircraft movements should be kept to a minimum; parking areas should, if possible, be cleared of snow and ice, so as to prevent aircraft tyres from freezing to the ground. If sand or grit is used to increase the tractive effort of tractors or assist the braking of aircraft, care should be taken to prevent these materials being drawn into operating engines; taxiways and hard standings should be swept to remove any sand or grit after the snow and ice have melted.

7.9.1 After Flight

When parking an aircraft, all covers, plugs and ground locks should be fitted as soon as possible. If the airframe is wet or affected by snow or ice, the surface under the covers should be given a light coating of anti-freeze liquid; anti-freeze liquid should not, however, be applied to the windows, since it has an adverse effect on plastics materials. Engine covers should be fitted as soon as the engine has cooled sufficiently, but in the case of turbine engines an inspection should be made for the presence of ice in the air intake, since this could melt while the engine is hot, drain to the lowest part of the compressor and subsequently re-freeze when the engine cools, locking the lower compressor blades in ice. If ice is present it should be allowed to melt, then removed before finally fitting the covers. Drain valves in the fuel and pitot/static systems should be opened to remove any accumulation of water. Domestic water, toilet systems and water injection tanks should be drained or treated with anti-freeze liquid as appropriate.

7.9.2 Before Flight

All external surfaces must be free of snow, frost or ice before an aircraft takes off and de-icing operations should be carried out as necessary (see CAP 512). Particular care is necessary when an aircraft has been removed from a heated hangar into falling snow since the snow will melt on the warm aircraft then re-freeze as it cools down, forming a thin layer of ice which may not be easily visible. Water systems should be filled with warm water and all covers should be kept in place until as near to departure time as possible.

8 Engine Starting and Running

An engine should not be ground run more often than is absolutely essential to ensure its serviceability. With a piston engine more wear takes place during cold starts than during normal operation and with a turbine engine the engine life may be directly related to the number of temperature cycles to which it is subjected. It is, however, frequently necessary to run an engine to check its performance; in these cases and when starting an engine prior to flight, certain precautions are necessary to ensure the safety of the aircraft, of surrounding aircraft and of personnel.

8.1 General Precautions

8.1.1 An aircraft should, whenever possible, be headed into wind before starting its engines. This is particularly important with light piston-engined aircraft as the wind direction will affect the engine speed obtained during checks and from certain directions could produce vibration and may adversely affect engine cooling. Turbine-engined aircraft are not usually affected so seriously by wind direction, but a strong tail wind could result in increased jet pipe temperatures during starting; care should also be taken not to engage the starter of a turbo-propeller engine if the propeller is being rotated backwards by the wind.

8.1.2 An aircraft should normally be parked with brakes on and chocks in front of the main wheels. The ground immediately in front of the propellers or intakes and beneath and behind the aircraft, should be checked for loose gravel or other foreign objects which could be drawn into the engine, cause damage to the propeller, or be blown against other aircraft, buildings and personnel. Jet blast can also have serious consequences and diagrams will be found in the Maintenance Manuals of turbine-powered aircraft showing the extent and velocity of the blast created at various power settings and the areas which should be kept clear of personnel and equipment. These diagrams also indicate the extent of the danger areas in front of the engines, which result from intake suction. When specified, intake guards should be fitted to turbine engines when they are run for maintenance purposes. A look-out man should be stationed in front of the aircraft and should be in visual and/or radio contact with the cockpit/cabin crew.

8.1.3 Whenever an aircraft engine is being started, adequate fire-fighting equipment should be readily available and manned.

8.2 Piston Engines

Piston engines are generally fitted with electric starter motors and an external power source should be connected to the aircraft whenever possible. When cold, engines should always be turned at least two revolutions before being started, to free the reciprocating and rotating parts and to determine whether a hydraulic lock (oil draining into the lower cylinders) has formed. The engine should normally be turned over by hand but when this is not possible the starter may be used. The magneto switches must be 'off' when turning the engine and the engine must always be treated as 'live', in case the switches are defective and not earthing the magneto primary circuits.

8.2.1 Piston-engine installations vary considerably and the method of starting recommended by the aircraft manufacturer should always be followed. Engine speed should be kept to a minimum until oil pressure has built up and the engine should be warmed up to minimum operating temperature before proceeding with the required tests. High power should only be used for sufficient duration to accomplish the necessary checks, since the engine may not be adequately cooled when the aircraft is stationary. After all checks have been carried out the engine should be cooled by running at the recommended speed for several minutes, the magneto switches

should be checked for operation and the engine should be stopped in the appropriate manner.

8.2.2 Extreme care is essential when starting piston engines by hand swinging. Many accidents have occurred in this way and both pilots and maintenance personnel should be given demonstrations and be checked out on this method of starting before being allowed to hand swing a propeller. The engine must always be treated as 'live' and no part of the arms, legs or body should be moved into the propeller disc at any time. No attempt should ever be made to start an engine without someone in the cockpit/cabin to operate the throttle or brakes as necessary, or without chocks placed in front of the wheels. A set sequence of calls and responses should be used to ensure that the ground crew and the pilot are fully aware of the actions being taken.

a) **Sucking-in.** To prime the engine cylinders, when necessary, the ground crew should stand away from the propeller, face the pilot and call 'Switches off, petrol on, throttle closed, suck in'. The pilot should repeat these words, carrying out the appropriate actions at the same time. The ground crew should then set the propeller to the beginning of a compression stroke and turn the engine through at least two revolutions. Starting at the position shown in Figure 2, the propeller should be swung by moving the arm (right in this case) smartly down and across the body, turning away from the propeller and stepping away in the direction of movement of the aircraft.

b) **Starting.** The ground crew should set the propeller at the start of a compression stroke (as in Figure 2), stand away from the propeller, face the pilot and call 'Contact'. The pilot should set the throttle for starting, switch on the magnetos and repeat 'Contact'. The ground crew should then swing the propeller as outlined in paragraph a). If the engine does not start, the ground crew should ensure that the magnetos are switched off before re-setting the propeller and switched on again before making another attempt to start the engine.

NOTE: The manufacturer's manual should be referred to for the operation, during starting, of magnetos which are fitted with impulse starters or retarded contact breakers.

c) **Blowing-out.** If the engine fails to start through over-richness, the ground crew should face the pilot and call 'Switches off, petrol off, throttle open, blow out'. The pilot should repeat these words, carrying out the appropriate actions at the same time. The ground crew should then turn the propeller several revolutions in the reverse direction of rotation to expel the mixture from the engine. This will usually entail swinging the propeller up from the 6 o'clock position (approximately), using the opposite hand. The throttle should then be closed, the petrol turned on and the operations outlined in paragraph b) continued.

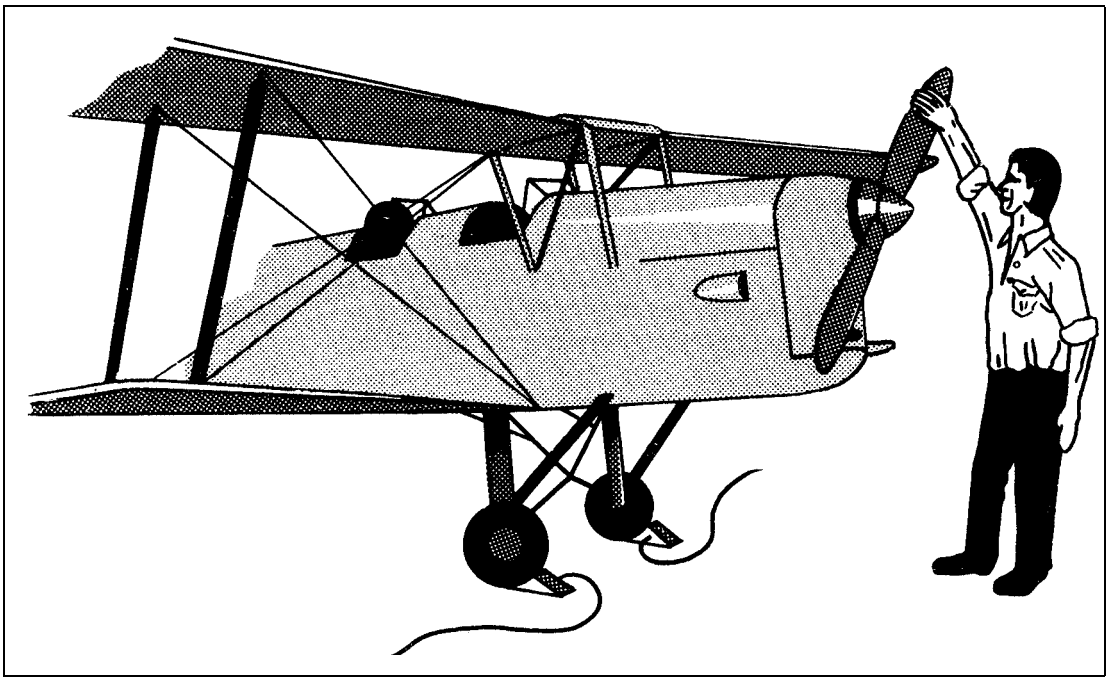

Figure 2 Hand Swinging

8.3 Turbine Engines

Turbine engines may be started by an electric motor or by an air turbine and may use either an internal power unit or an external power source to provide the necessary power. The danger areas in front of and behind the engines should be kept clear of vehicles and personnel and, if an auxiliary power unit is being used, from the vicinity of this exhaust also. Vehicles supplying electrical power or compressed air should be located in such a position that they can be moved away quickly in the event of an emergency. Qualified personnel should be located outside the aircraft and be in telephonic communication with the cabin crew, so as to be able to provide warning of situations not visible from the cabin and to prevent vehicles or personnel from entering the danger areas. Air intakes and exhaust pipes should be inspected for loose objects or debris before starting the engines.

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