s) the jacking operation must be carried out in a controlled and steady movement; and

t) install landing gear down-lock pins in any landing gear that is serviceable .

6.2.8 When the aircraft is lifted to the required height, the jacks must be left in place as a safety precaution in the following circumstances:

a) when attempting to extend any landing gear that is capable of supporting the aircraft's weight;

b) when work on the landing gear is carried out; and

c) when repairs or replacement of any damaged landing gear is undertaken.

If it is not possible to make the landing gear serviceable, removal trailers or trucks will be required to move the aircraft.

Other jacking requirements

6.2.9 Initial lifting of the aircraft may be necessary to gain clearance for positioning aircraft removal jacks or to make room for positioning lifting bags or lifting straps. In cases where the landing gear is collapsed, missing or retracted, or engines are missing, the aircraft will provide very little clearance for positioning lifting devices. In this case, wheel change axle jacks or bottle jacks can be used to lift the aircraft to a sufficient height. Again, all loads must be properly calculated and complied with (see Chapter 3).

6.2.10 In the event the aircraft comes to rest with landing gear extended but with multiple tire failures, special lifting requirements will be necessary. With more than one tire failure on the same axle, it will be difficult to place normal axle jacks due to the limited clearance. However, there are a number of special purpose jacks, jacking adapters and ramps available for this purpose. The specific ARM will provide details on this subject.

6.3 PNEUMATIC LIFTING DEVICES

6.3.1 Different designs of pneumatic lifting devices are available to achieve the desired lift during aircraft removal operations. Depending on the design, different methods are used to control lateral stability and arc movement during the lift.

6.3.2 The most common pneumatic lifting devices use bags with a multi-element or multi-compartment design for aircraft removal operations. Multi-element pneumatic lifting bags are designed to restrict the expansion of the individual element providing a flat slab shape of uniform thickness. Some degree of lateral instability is inherent in the design, although there are features that allow upper elements to more easily conform to the wing profile.

Pneumatic lifting device capacity

6.3.3 Pneumatic lifting bags are generally rated in terms of lifting capacity in tons and metric tonnes. Lifting bags are usually manufactured in approximate standard capacities of 15, 25 and 40 tons. Some manufacturers have developed pneumatic lifting devices with a higher capacity for the NLA.

Pneumatic lifting device placement

6.3.4 Pneumatic lifting bags and other pneumatic lifting devices are normally placed under the wings, the forward fuselage and the aft fuselage. The ARM will provide specific details on where the lifting bags should be placed and the maximum allowable skin pressure in these areas.

6.3.5 When pneumatic lifting bags are used to lift aircraft from unprepared surfaces, the area that the lifting bags rest on must be properly stabilized and able to support the anticipated loads. As with jacks, this may include requirements to excavate the area and prepare it with a gravel base and/or steel plates and plywood. The base should also be large enough to allow for repositioning of the lifting bags and in some cases the repositioning of any constructed cribbing platforms.

6.3.6 It is important not to place lifting bags under any damaged area of the fuselage or wings. Where damage exists, lifting bags generally should be placed a minimum of one fuselage frame or wing rib away from the damaged area. On some aircraft the wing dihedral in the area of air bag placement is considerable, and caution must be taken to prevent the bags from sliding outboard under the wing.

Calculating lift capacity

6.3.7 A major limitation with the use of lifting bags is their rated lifting capacity. For example, a lifting bag rated at 25 tons may not lift this load in all recovery events. The actual lifting load is dependent on the following few key factors:

a) the specified lifting capacity of the bag;

b) the maximum acceptable skin pressure in the area the lifting bag will be inflated; and

c) the measured surface area of the wing or fuselage that the lifting bag is actually in contact with.

6.3.8 If the lifting capacity required is greater than the capacity of the bag lifting, a different method of lifting will be required, or the weight of the aircraft will have to be reduced. In some cases, additional lifting capacity can be gained by pressurizing the aircraft cabin. Any increase in cabin pressure will, in most cases, add to the allowable fuselage skin pressure, thereby increasing the lifting capacity.

Platform cribbing

6.3.9 The inflated height of the lifting bag may not be sufficient to lift the aircraft to the required height. In this case a platform can be built to increase the height of the lift, however, this is a very time-consuming and labor-intensive job. The platform it must be made large enough to adapt to any minor position changes of the lifting bags, otherwise it will be necessary to dismantle it and rebuild it in a more accurate position.

6.3.10 There are alternatives to a wood platform or wood cribbing available from various companies in the form of inflatable cribbing and cribbing manufactured from composite and other man-made materials.

Lifting with pneumatic devices

6.3.11 Before the lifting process can begin, the aircraft must be levelled. The levelling process must always start laterally then longitudinally from the lowest point.

6.3.12 As with other lifting devices, there are general preparations and precautions to take prior to any lifting operations with pneumatic devices such as:

a) ensure that all safety instructions are complied with;

b) monitor and ensure that wind speeds are not exceeded;

c) ensure that the aircraft is tethered if required;

d) ensure that all weights and loads have been calculated;

e) ensure that all the manufacturer's operating instructions are complied with;

f) ensure that landing gear down-lock pins are installed in any serviceable landing gear;

g) determine the necessary lifting capacity and the number of bags required;

h) confirm the placement of the lifting bags on the ground and provide protection from sharp objects with rubber mats or tarpaulins, keeping in mind that ground preparation may be required;

i) protect the lower wing or fuselage from minor protrusions using rubber mats; however, it may be necessary to completely remove antennas and drain masts;

j) ensure that the area around the wing jack point is not encroached upon, as failure to provide an area for the jacks may require the aircraft to be shored once the lifting process is complete, to allow for the removal of the lifting devices and positioning of wing jacks;

k) place the lifting bags with the inflation fittings facing the inflation console if possible;

l) position the inflation console with a good view of the lifting bags;

m) discuss with the console operators and other personnel what may occur as the aircraft is raised and what is expected of each operator;

n) ensure adequate communication is available between the console operators, the recovery manager and the lift coordinator;

o) ensure that unnecessary personnel are not in the safety zone;

p) ensure that the compressor and console have adequate moisture traps;

q) unroll the inflation hoses and connect them to the console;

r) after purging, connect the hoses to the appropriate lifting bag inflation fitting and confirm the correct hose sequence;

s) attach plumb bobs to various fuselage and wing locations to assist in monitoring the relative attitude of the aircraft as it is lifted;

t) if tethers are being used, ensure that personnel are available to monitor and adjust the tension loads as the aircraft is lifted;

u) provide tail tip protection; and

v) follow the aircraft manufacturer's recommendations as to whether the parking brakes are to be set, wheel chocks installed and whether it is necessary to deflate the landing gear shock struts.

6.3.13 It may be necessary to lift the aircraft in stages if the lifting equipment being used is not capable of lifting to the required height in a single step. This will require the aircraft to be supported on some form of shoring or cradles while the lifting equipment is being repositioned, replaced or while a platform is being built to provide additional lift. If an adequate area is left available, jacks could be installed at this point.

Note.— During any shoring operations, allowable shoring loads must be calculated and monitored.

6.3.14 When the aircraft is lifted to the required height, jacks must be installed or shoring fabricated as a safety precaution under the following circumstances:

a) when attempting to extend any landing gear that is capable of supporting the aircraft's weight;

b) when work on the landing gear is carried out; and

c) when repairs or replacement of any damaged landing gear is undertaken.

If it is not possible to make the landing gear serviceable, removal trailers or trucks will be required to move the aircraft.

Inspections

6.3.15 Generally inspections include a visual inspection in the area the lifting bags made contact with the aircraft to ensure that there are no deep scratches or gouges caused by debris, stones or sand trapped between the lifting bag and the aircraft.

6.4 CRANES

6.4.1 Large mobile cranes, used in combination with various sling assemblies can be used in the recovery of disabled aircraft and are possibly the easiest way to lift the forward fuselage, for example, after a nose gear collapse. Whether to use cranes in the recovery operation depends on their availability. In some areas cranes are available with many choices in lifting capacity. In other areas cranes can be in short supply with limited lifting capacity, unknown serviceability and incomplete or non-existent records of safety inspections. When it is necessary to use equipment that are suspect, extreme caution must be exercised.

6.4.2 Prior to any crane operation, a reassessment of the initial aircraft survey must take place to confirm details of any structural damage. Careful examination of any damaged areas must be made prior to placing any lifting straps. Normally the strongest locations for placing lifting straps are near jack points, fuselage frames, bulkheads, fuselage production joints and doorframes. The ARM will identify these locations.

Note.— Tethering is important in any crane lift operation as even slight winds can cause large swinging forces.

Crane types

6.4.3 The types of cranes that can be used are:

a) *Mobile cranes.* Mobile cranes require a prepared surface called a pad to operate from. Depending on the size and lifting capacity of the crane, the requirements for the pad and access road can be substantial.

b) *All terrain cranes.* All terrain cranes with high flotation tires provide good site access with less of a requirement for prepared surfaces, although lifting capacity is limited.

c) *Crawler cranes.* Crawler cranes are available with substantial lifting capacities but require a prepared pad to operate from. The major problem with crawler cranes is the time required for transport and set-up.

Slings

6.4.4 A sling assembly is comprised of cables, hooks, fittings, spreader bars and straps. Some sling assemblies can be quite complicated featuring elaborate pulley systems to distribute the load evenly through a number of straps as the aircraft is raised from an unusual attitude. Other slings can be quite simple consisting of a single strap and spreader bar.

6.4.5 The number of lifting straps needed is dependent on the anticipated loads. It is recommended that the strap width be not less than 200 mm and fabricated from nylon or some form of carbon fiber weave. The ARM will identify placement of the straps around specific frames of the fuselage. Straps must not be placed near a damaged frame, stringer or damaged area of skin. Generally straps are placed a minimum of one frame away from any damage. Lifting straps must be used with an appropriate spreader bar, or secondary damage may result from the crushing action of the straps. One alternative is the use of a crane on each side of the fuselage, each lifting one end of the strap vertically.

Note.— All straps must be inspected prior to use and should have the load rating and inspection date tags attached.

Crane-lifting combinations

6.4.6 Cranes can be used as an integral part of the aircraft recovery operation assuming the crane has adequate lifting capacity. Generally, cranes of greater capacity than required offer much more flexibility in their positioning. Larger capacity cranes can be placed further away allowing for a greater operating radius around the aircraft. Jibs or jib extensions provide increased lifting height but do not increase the operating radius. As the boom angle of the crane decreases, the load capacity of the crane also decreases.

6.4.7 The required lifting height must be calculated to ensure sufficient lift height and boom travel range is available. The length of the lifting straps used must be determined to ensure that the maximum crane hook height is not reached before the required lift height of the aircraft is reached.

6.4.8 Following a nose gear collapse, the forward fuselage of most aircraft can easily be lifted with a proper sling and straps. In some cases, the nose landing gear is still serviceable, and once extended, the aircraft can be towed away.

6.4.9 Some aircraft are capable of being lifted from the main landing gear support beam, landing gear trunnion or some form of lifting adapter attached to the landing gear. Access is gained through removable panels on the upper surface of the wing above the landing gear attachments. Most aircraft without removable upper wing panels are incapable of being lifted with cranes from the main landing gear.

6.4.10 In some cases, cranes are able to lift the entire aircraft when it is possible to lift from the main landing gear. In this case, the aircraft can be lifted using the landing gear attachments and straps placed around either the forward or aft fuselage. To accomplish this three-point lift, several cranes may be used. Three-point single crane lifts may not be feasible for larger aircraft but are useful on smaller aircraft where cranes of adequate capacity are available.

6.4.11 When using a single crane, the three lifting points can be tied together with a combination of lateral and longitudinal spreader bars forming a single lift point. This same principle can be carried out using multiple cranes, where each crane lifts from a single lifting point. When using three separate cranes, a spreader bar is only required at the fuselage lifting point.

6.4.12 Whenever cranes are used, adequate roadways and crane pads must be constructed. The crane pad must be large enough to cope with repositioning of the crane. Lifting loads must be calculated to include the weight of the sling assembly and any associated shackles and cables. The lifting loads must continually be monitored and recorded. Most modern cranes are equipped with not only load indication devices but also systems that will stop crane movement if a preset crane load is exceeded.

Lifting with cranes

6.4.13 Before the lifting process can begin, the aircraft must be levelled. The levelling process must always start laterally then longitudinally from the lowest point.

6.4.14 As with other lifting devices, there are general preparations and precautions to take prior to any lifting operations with cranes, such as:

a) ensure that all safety instructions are complied with;

b) monitor and ensure that wind speeds are not exceeded;

c) ensure that the aircraft is tethered if required;

d) ensure that all weights and loads have been calculated;

e) ensure that landing gear down lock pins are installed in any serviceable landing gear;

f) determine the necessary lifting capacity and the number of sling straps required;

g) ensure that the prepared roadway and crane pad can support the anticipated loads;

h) ensure that cranes are placed as close to the aircraft as possible;

i) confirm the placement of lifting straps and provide protection from sharp objects with rubber mats;

j) protect the lower fuselage from minor protusions using rubber mats; however, it may be necessary to remove antennas and drain masts;

k) discuss with the crane operators and other personnel what will occur as the aircraft is raised and what is expected of each operator;

l) ensure adequate communication is available between the crane operators, the recovery manager and the lift coordinator;

m) ensure that unnecessary personnel are not in the safety zone;

n) attach plumb bobs to various fuselage and wing locations to assist in monitoring the relative attitude of the aircraft as it is lifted;

o) if tethers are being used, ensure that personnel are available to monitor and adjust the tension loads as the aircraft is lifted;

p) provide tail tip protection; and

q) follow the aircraft manufacturer's recommendations as to whether the parking brakes are to be set, wheel chocks installed and whether it is necessary to deflate the landing gear shock struts.

6.4.15 When the aircraft is lifted to the required height, jacks must be installed or shoring fabricated as a safety precaution under the following circumstances:

a) when attempting to extend any landing gear that is capable of supporting the aircraft's weight;

b) when work on the landing gear is carried out; and

c) when repairs or replacement of any damaged landing gear is undertaken.

If it is not possible to make the landing gear serviceable, removal trailers or trucks must be used to move the aircraft.

Crane operators

6.4.16 Crane operators, although skilled, may have little experience dealing with aircraft. Therefore, the removal manager must ensure that the crane operator is provided with as much information as possible, such as the basic weights and centre of gravity position of the aircraft, as well as any ideas on how the aircraft will respond as it is lifted. Crane operators usually work with at least one other assistant or rigger who is responsible for giving the crane operator instructions for crane movement and lifting directions. The removal manager must communicate with this assistant or rigger and not attempt to direct the crane operator himself.

Inspections

6.4.17 Generally this will include a visual inspection in the area the straps were placed to ensure that there are no deep scratches or gouges caused by debris, stones or sand trapped between the straps and the aircraft.

Chapter 7

MOVING THE AIRCRAFT

7.1 GENERAL

7.1.1 Once the aircraft has been stabilized, levelled and/or lifted, it will be necessary to move it back onto a hard surface and possibly to a repair facility. It is preferable to move a damaged aircraft supported on its own landing gear. If an aircraft has left the hard surface, a temporary roadway of some kind is usually required (see 7.2).

7.1.2 Prior to any type of movement of the aircraft, the removal manager will need to determine:

a) whether the weight and centre of gravity location have changed due to shifting of fuel that was unable to be removed during the defuelling operation;

b) further weight reduction operations after the levelling process or the removal of any large components;

c) the serviceability of the landing gear by:

1) carrying out a detailed inspection of the landing gear to confirm its structural integrity;

2) ensuring that the landing gear is capable of supporting the weight of the aircraft during any winching or towing operations;

3) making certain the landing gear down-lock pins are installed in any serviceable gear;

4) completing a thorough investigation to determine why it is not possible to install down lock pins. Repairs must be carried out and the landing gear secured by other means prior to supporting the aircraft on that particular landing gear; and

d) the direction the aircraft will be moved, depending on:

1) the distance to a suitable hard surface;

2) any obstacles that are present in the direction of movement; and

e) the requirement for construction of a temporary roadway. This will depend on the outcome of the soil stability tests during the site survey. In most cases, a temporary roadway will be required whether the aircraft is damaged or not.

7.2 ROADWAY CONSTRUCTION

7.2.1 Local contractors or construction companies can provide assistance in roadway construction details. However, the basic requirements for a constructed roadway are that generally it must be capable of supporting the weight

of the aircraft and the recovery vehicles used to extract it. The roadway must also be wide enough to turn the aircraft if required. The interface between the constructed roadway and the hard surface is important, and the incline or ramp must consist of the smallest gradient possible.

7.2.2 In cases where the soil load-bearing capacity is high, and the ruts left by the aircraft tires are not deep, it may be possible to fill the ruts with gravel and move the aircraft backwards along these same tracks. Some ARMs provide charts that relate rut depth to aircraft weight and specify the depth of rut the aircraft can be moved in without preparing a roadway.

7.2.3 In cases where the soil is of a low load-bearing capacity, it will be necessary to excavate the unstable soil and prepare a proper base. The depth of the excavation will vary according to the soil stability. Large gravel is normally used to provide a sturdy base. Plywood sheets or steel plates can be placed over the gravel bed as a roadway. Where the soil is very soft, railroad ties can be placed laterally over the gravel and then covered with plywood or steel sheets, which must be overlapped in a shiplap manner. In situations where distances are long or if there is an insufficient amount of material to form a complete roadway, the plywood sheets or steel plates can be reused by constantly moving them ahead of the wheels in the direction of aircraft movement.

7.2.4 When large timbers or railroad ties are used in the construction of a roadway, they must be covered with a layer of sheet material, such as plywood or steel, to prevent the loads of individual aircraft wheels from pushing the timbers into the ground or against the wheel behind it and stopping movement.

7.2.5 In some cases only a prepared track and not a full width roadway will be required for each of the main landing gear. A roadway or track may not be necessary for the nose gear; however, this depends on soil stability, how the nose wheels will be steered and how the aircraft will be pulled or winched. If aircraft systems are serviceable, a qualified person can operate the nose wheel steering system, and, in this case, communication is mandatory. Tow bars can be attached to the nose gear and physically manoeuvred to provide steering. However, the level of difficulty for this type of operation increases with the size of the aircraft, soil type and depth of ruts. In cases where manual operation is not viable, a small tractor can be used with a prepared roadway or track.

7.2.6 Most aerodromes will have various types of crushed stone, gravel or broken up asphalt available that can also be used as a base for the roadway. In wet areas or inclement weather, drainage pumps may be required to remove standing water and to provide adequate drainage for the site. It is necessary to ensure that all materials used in the recovery operation are safe, able to cope with varying weather conditions and are capable of withstanding the loads imposed by the aircraft and the recovery equipment.

7.2.7 Aerodrome operators and/or major aircraft operators at each aerodrome must provide a “General Aircraft Removal Materials and Equipment” list that must include the location and availability of every item. (see Appendix 7 for a complete list).

7.3 COMMERCIAL TEMPORARY ROADWAY SYSTEMS

There are a number of commercially available temporary roadway systems on the market. Various types consist of aluminum or composite sections that can be fitted or bolted together. Fiberglass and carbon fiber matting are also available for this purpose.