CHAPTER 11

GROUND HANDLING, SAFETY, AND SUPPORT EQUIPMENT

INTRODUCTION

Aircraft maintenance technicians devote a portion of their aviation career working with ground support equipment and ground handling of aircraft. The complexity of support equipment and the hazards involved in ground handling of expensive aircraft require that maintenance technicians possess a detailed knowledge of safe procedures used in aircraft servicing, taxiing, runup, and in the use of ground support equipment. The information provided in this chapter is intended as a general guide for working on all types of aircraft.

GENERAL

The following instructions cover the starting procedures for reciprocating, turboprop, and turbojet engines. These procedures are presented only as a general guide for familiarization with typical procedures and methods. Detailed instructions for starting a specific type of engine can be found in the manufacturer's instruction book.

Before starting an aircraft engine:

1. Position the aircraft to head into the prevailing wind to insure adequate air flow over the engine for cooling purposes.

2. Make sure that no property damage or personal injury will occur from the propeller or propeller blast.

3. If external electrical power is used for starting, make sure that it can be removed safely.

4. During any and all starting procedures a "fire guard" equipped with a suitable fire extinguisher shall be stationed in an appropriate place. ("Fire guard"—someone familiar with aircraft starting procedures. "Fire extinguisher"—a CO_2 extinguisher at least of 5-lb. capacity. "Appropriate place"—adjacent to the outboard side of the engine, in view of the pilot, and also where he can observe the engine/aircraft for indication of starting problems.)

5. If the aircraft is jet engine powered, the area in front of the jet inlet must be kept clear of personnel, property and/or debris. Also, the exhaust area must be kept clear.

6. These "before starting" procedures apply to all reciprocating, turbo-propeller and turbo-jet powerplants.

STARTING ENGINES

Reciprocating Engines

The following procedures are typical of those used to start reciprocating engines. There are, however, wide variations in the procedures for the many reciprocating engines. *No attempt should be made to use the methods presented here for actually starting an engine.* Instead, always refer to the procedures contained in the applicable manufacturer's instructions.

Reciprocating engines are capable of starting in fairly low temperatures without the use of engine heating or oil dilution, depending on the grade of oil used.

The various covers (wing, tail, cockpit, wheel, etc.) protecting the aircraft must be removed before attempting to turn the engine. External sources of electrical power should be used when starting engines equipped with electric starters. This eliminates an excessive burden on the aircraft battery. All unnecessary electrical equipment should be left off until the generators are furnishing electrical power to the aircraft power bus.

Before starting a radial engine that has been shut down for more than 30 minutes, check the ignition switch for off; turn the propeller three or four complete revolutions with the starter, or it may be pulled through by hand to detect a hydraulic lock if one is present.

Any liquid present in a cylinder is indicated by the abnormal effort required to rotate the propeller, or by the propeller stopping abruptly during rotation. Never use force to turn the propeller when a hydraulic lock is detected.

Sufficient force can be exerted on the crankshaft to bend or break a connecting rod if a lock is present.

To eliminate a lock, remove either the front or rear spark plug from the lower cylinders and pull the propeller through. Never attempt to clear the hydraulic lock by pulling the propeller through in the opposite direction to normal rotation. This tends to inject the liquid from the cylinder into the intake pipe. The liquid will be drawn back into the cylinder with the possibility of complete or partial lock occurring on the subsequent start.

To start the engine, proceed as follows:

1. Turn the auxiliary fuel pump on, if aircraft is so equipped.
2. Place the mixture control to the position recommended for the engine and carburetor combination being started. As a general rule, the mixture control should be in the "idle cutoff" position for pressure type carburetors and in the "full rich" position for float type carburetors.

   Many light aircraft are equipped with a mixture control pull rod which has no detented intermediate positions. When such controls are pushed in flush with the instrument panel, the mixture is set in the "full rich" position. Conversely, when the control rod is pulled all the way out, the carburetor is in the "idle cutoff" or "full lean" position. Unmarked intermediate positions between these two extremes can be selected by the operator to achieve any desired mixture setting.
3. Open the throttle to a position that will provide 1,000 to 1,200 r.p.m. (approximately 1/8 to 1/2 inch from the "closed" position).
4. Leave the preheat or alternate air (carburetor air) control in the "cold" position to prevent damage and fire in case of backfire. These auxiliary heating devices should be used after the engine warms up. They improve fuel vaporization, prevent fouling of the spark plugs, ice formation, and eliminate icing in the induction system.
5. Energize the starter after the propeller has made at least two complete revolutions, and turn the ignition switch on. On engines equipped with an induction vibrator, turn switch to the "both" position. When starting an engine that uses an impulse coupling magneto, turn the ignition switch to the "left" position. Place the ignition switch to "start" when the magneto incorporates a retard breaker assembly. Do not crank the engine continuously with the starter for more than 1 minute. Allow a 3- to 5-minute period for cooling the starter between successive attempts. Otherwise the starter may be burned out due to overheating.
6. Move the primer switch to "on" intermittently, or prime with one to three strokes of priming pump, depending on how the aircraft is equipped. When the engine begins to fire, hold the primer on while gradually opening throttle to obtain smooth operation.

   After the engine is operating smoothly on the primer, move the mixture control to the "full rich" position. Release the primer as soon as a drop in r.p.m. indicates the engine is receiving additional fuel from the carburetor.

Hand Cranking

If the aircraft has no self-starter, the engine must be started by swinging the propeller. The person who is turning the propeller calls, "fuel on, switch off, throttle closed, brakes on." The person operating the engine will check these items and repeat the phrase. The switch and throttle must not be touched again until the person swinging the prop calls "contact." The operator will repeat "contact" and then turn on the switch. Never turn on the switch and then call "contact."

When swinging the prop, a few simple precautions will help to avoid accidents. When touching a propeller, always assume that the ignition is on. The switches which control the magnetos operate on the principle of short-circuiting the current to turn the ignition off. If the switch is faulty, it can be in the "off" position and still permit current to flow in the magneto primary circuit.

Be sure the ground is firm. Slippery grass, mud, grease, or loose gravel can lead to a fall into or under the propeller. Never allow any portion of your body to get in the way of the propeller. This applies even though the engine is not being cranked.

Stand close enough to the propeller to be able to step away as it is pulled down. Stepping away after cranking is a safeguard in case the brakes fail. Do not stand in a position that requires leaning toward the propeller to reach it. This throws the body off balance and could cause you to fall into the blades when the engine starts.

In swinging the prop, always move the blade downward by pushing with the palms of the hand. Do not grip the blade with the fingers curled over the edge, since "kickback" may break them or draw your body in the blade path.

Excessive throttle opening and intermittent priming after the engine has fired are the principal causes of backfiring during starting. Gradual opening of the throttle while priming continuously will reduce the initial "over rich" mixture to a smooth running, best power mixture as the engine picks up speed. An engine operating on an "over rich" mixture is sluggish but will not backfire.

When starting an engine using a priming pump, move the mixture control into "full rich" position, if not previously placed there, when the engine begins to fire. If the engine fails to start immediately, return the mixture control to "idle cutoff" position. Failure to do so will create an excessive amount of fuel in the carburetor air scoop, constituting a fire hazard.

Avoid priming the engine before it is turned over by the starter. This can result in fires, scored or scuffed cylinders and pistons, and, in some cases, engine failures due to hydraulic lock. If the engine is inadvertently flooded or overprimed, turn the ignition switch off and move the throttle to the "full open" position. To rid the engine of the excess fuel, turn it over by hand or by the starter. If excessive force is needed to turn over the engine, stop immediately. Do not force rotation of the engine. If in doubt, remove the lower cylinder spark plugs. If very serious overloading has occurred, it may be necessary to remove the lower cylinder intake pipes. To reduce the likelihood of damage to the engine due to overpriming on some medium and large aircraft, the engine blower drain valves should be checked frequently for fouling or sticking.

Immediately after the engine starts, check the oil pressure indicator. If oil pressure does not show within 30 seconds, stop the engine and determine the trouble. If oil pressure is indicated, adjust the throttle to the aircraft manufacturer's specified r.p.m. for engine warm-up. Warm-up r.p.m. will usually be in the 1,000 to 1,300 r.p.m. range.

Most aircraft reciprocating engines are air cooled and depend on the forward speed of the aircraft to maintain proper cooling. Therefore, particular care is necessary when operating these engines on the ground.

During all ground running, operate the engine with the propeller in full low pitch and headed into the wind with the cowling installed to provide the best degree of engine cooling. The engine instruments should be monitored closely at all times. Do not close the cowl flaps for engine warm-up; closing of the cowl flaps may cause the ignition harness to overheat. When warming up the engine, make sure that personnel, ground installations, equipment that may be damaged, or other aircraft are not in the propeller wash.

Extinguishing Engine Fires

In all cases a fireguard should stand by with a CO_2 fire extinguisher while the aircraft engine is being started. This is a necessary precaution against fire during the starting procedure. He should be familiar with the induction system of the engine so that in case of fire he can direct the CO_2 into the air intake of the engine to extinguish it. A fire could also occur in the exhaust system of the engine from liquid fuel being ignited in the cylinder and expelled during the normal rotation of the engine.

If an engine fire develops during the starting procedure, continue cranking to start the engine and blow out the fire. If the engine does not start and the fire continues to burn, discontinue the start attempt. The fireguard should extinguish the fire using the available equipment. The fireguard must observe all safety practices at all times while standing by during the starting procedure.

TURBOPROP ENGINES

Prestart Procedures

The various covers protecting the aircraft must be removed. Engine tailpipes should be carefully inspected for the presence of fuel or oil. A close visual inspection of all accessible parts of the engines and engine controls should be made, followed by an inspection of all nacelle areas to determine that all inspection and access plates are secured. Sumps should be checked for water. Air inlet areas should be inspected for general condition and foreign material. The compressor should be checked for free rotation, when the installation permits, by reaching in and turning the blades by hand.

The following procedures are typical of those used to start turboprop engines. There are, however, wide variations in the procedures applicable to the many turboprop engines, and no attempt should be made to use these procedures in the actual starting of a turboprop engine. These procedures are presented only as a general guide for familiarization with typical procedures and methods. For starting of all turboprop engines, refer to the detailed procedures contained in the applicable manufacturer's instructions or their approved equivalent.

The first step in starting a turbine engine is to provide an adequate source of power for the starter. Where an air turbine starter is used, the starting air supply may be obtained from a gas-turbine compressor(GTC), an external source, or an engine cross-bleed operation. To start the first engine, use a GTC or low-pressure, large-volume tank. Start the remaining engine(s) using bleed air from the running engine.

While starting an engine, always observe the following:

1. Never energize the starter while the engine is rotating.
2. Do not move the power lever of any engine while it is being bled for cross-bleed starting.
3. Do not perform a ground start if turbine inlet temperature is above that specified by the manufacturer.
4. Do not use bleed air from an engine that is accelerating.

Starting Procedures

To start an engine on the ground, perform the following operations:

1. Place the start selector switch to the desired engine and the start-arming switch (if so equipped) to the "start" position.
2. Turn the aircraft boost pumps on.
3. Place the fuel and ignition switch on.
4. Position the low-r.p.m. switch in low or normal (high).
5. Make sure that the power lever is in the "start" position. If the propeller is not at the "start" position, difficulty may be encountered in making a start.
6. Depress the start switch and, if priming is necessary, depress the primer button.
7. Make sure the fuel pump parallel light comes on at, or above, 2,200 r.p.m. and remains on up to 9,000 r.p.m.
8. Check the oil pressure and temperature. Maintain the power lever at the "start" position until the specified minimum oil temperature is reached.
9. Disconnect the ground power supply.

If any of the following conditions occur during the starting sequence, turn off the fuel and ignition switch, discontinue the start immediately, make an investigation and record the findings.

1. Turbine inlet temperature exceeds the specified maximum. Record the observed peak temperature.
2. Acceleration time from start of propeller rotation to stabilized r.p.m. exceeds the specified time.
3. There is no oil pressure indication at 5,000 r.p.m. for either the reduction gear or the power unit.
4. Torching (visible burning in the exhaust nozzle other than normal enrichment) or excessive smoke is observed during initial fire-up.
5. The engine fails to ignite by 4,500 r.p.m. or maximum motoring r.p.m. (whichever is first), and r.p.m. stagnates or begins to decay.
6. Abnormal vibration is noted or compressor surge occurs (indicated by backfiring).
7. There is fuel spewing from the nacelle drain, indicating that the drip valve did not close.
8. Fire warning bell rings. (This may be due to either an engine fire or failure of an anti-icing shutoff valve to close.)

TURBOJET ENGINES

Preflight Operations

Unlike reciprocating engine aircraft, the turbojet-powered aircraft does not require a preflight runup unless it is necessary to investigate a suspected malfunction.

Before starting, all protective covers and air-inlet duct covers should be removed. If possible, the aircraft should be headed into the wind to obtain better cooling, faster starting, and smoother engine performance. It is especially important that the aircraft be headed into the wind if the engine is to be trimmed.

The runup area around the aircraft should be cleared of both personnel and loose equipment.

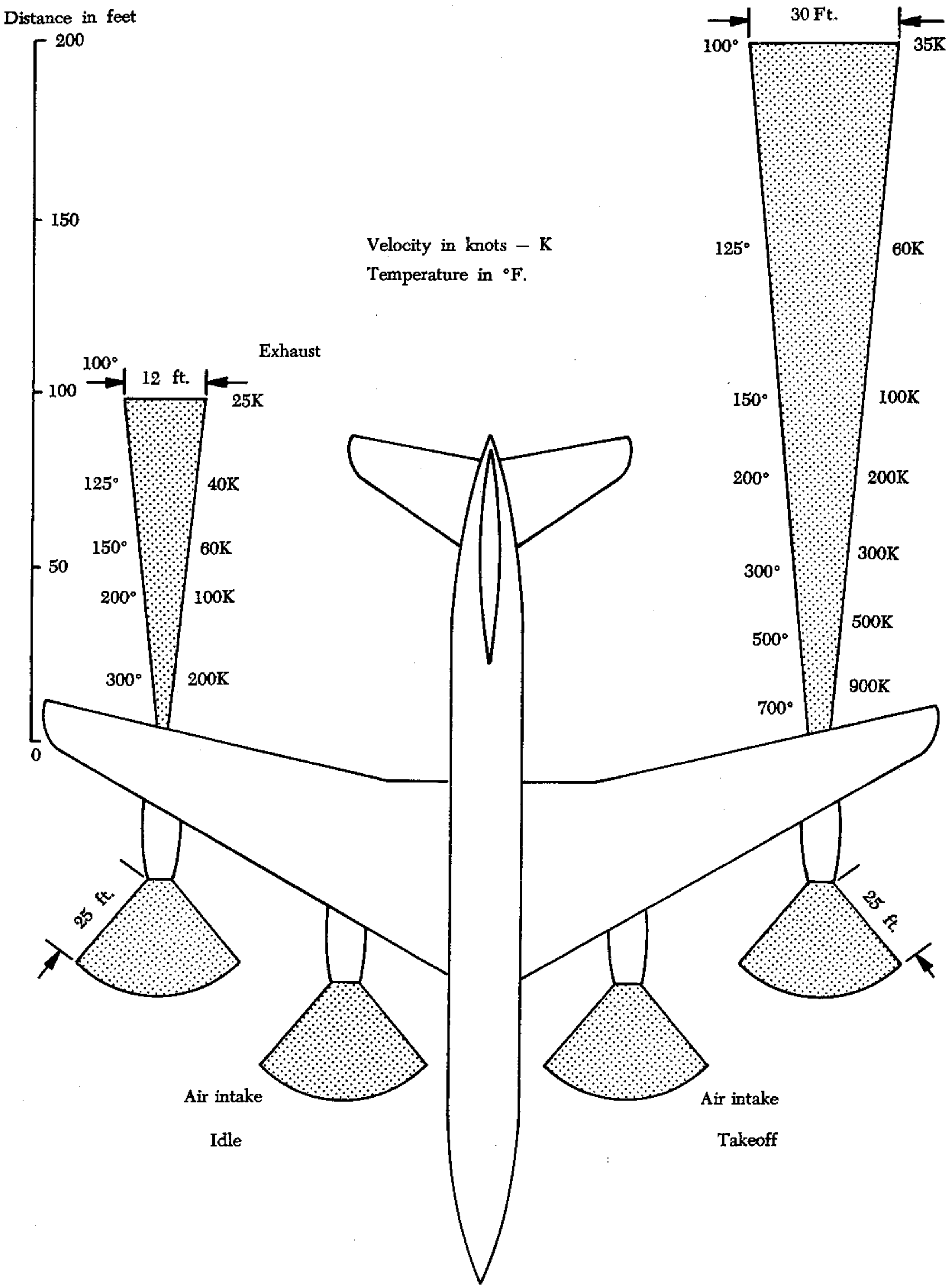


FIGURE 11–1. Engine intake and exhaust hazard areas.

The turbojet engine intake and exhaust hazard areas are illustrated in figure 11–1. Care should also be taken to ensure that the runup area is clear of all items such as nuts, bolts, rocks, rags, or other loose debris.

A great number of very serious accidents occur involving personnel in the vicinity of turbojet engine air inlets. Extreme caution should be exercised when starting turbojet aircraft.

The aircraft fuel sumps should be checked for water or ice, and the engine air inlet should be inspected for general condition and the presence of foreign objects. The forward compressor blades and the compressor inlet guide vanes should be visually inspected for nicks and other damage.

If possible, the compressor should be checked for free rotation by turning the compressor blades by hand.

All engine controls should be operated, and engine instruments and warning lights should be checked for proper operation.

Starting a Turbojet Engine

The following procedures are typical of those used to start many turbojet engines. There are, however, wide variations in the starting procedures used for turbojet engines, and no attempt should be made to use these procedures in the actual starting of an engine. These procedures are presented only as a general guide for familiarization with typical procedures and methods. In the starting of all turbojet engines, refer to the detailed procedures contained in the applicable manufacturer's instructions or their approved equivalent.

Most turbojet engines can be started by either air turbine or combustion-type starters. Air-turbine starters use compressed air from an external source. This source may be a ground cart unit or air bled from another engine on the aircraft that is in operation. Combustion starters are small gas turbine engines that obtain power from expanding gases generated in the starter's combustion chamber. These hot gases are produced by the burning of fuel and air or, in some cases, a slow-burning solid or liquid monopropellant specially compounded for such starter units.

Fuel is turned on either by moving the power-lever to "idle" position or by opening a fuel shutoff valve. If an air-turbine starter is used, the engine should start or "light up" within approximately 20 seconds after the fuel is turned on. This is an arbitrarily chosen time interval that, if exceeded, indicates a malfunction has occurred and the start should be discontinued. After the cause of the trouble has been removed, another start may be made. If a combustion starter is used, the 20-second interval need not be observed, since starter operation will discontinue automatically after a predetermined time interval. The following procedures are useful only as a general guide, and are included to show the sequence of events in starting a turbojet engine.

1. Move power lever to "off" position unless the engine is equipped with thrust reverser. If the engine is so equipped, place the power lever in the "idle" position.
2. Turn on electrical power to engine.
3. Turn fuel system shutoff switch to "fuel on" position.
4. Turn fuel boost pump switch on.
5. A fuel inlet pressure indicator reading of 5 p.s.i. ensures fuel is being delivered to engine fuel pump inlet.
6. Turn engine starter switch on; when engine begins to rotate, check for oil pressure rise.
7. Turn ignition switch on after engine begins to rotate.
8. Move throttle to idle (if engine is not equipped with thrust reverser).
9. Engine start (light up) is indicated by a rise in exhaust gas temperature.
10. After engine stabilizes at idle, ensure that none of the engine limits are exceeded.
11. Turn engine starter switch off after start.
12. Turn ignition switch off.

Unsatisfactory Turbojet Starts

1. *Hot Starts.*
   A hot start occurs when the engine starts, but the exhaust gas temperature exceeds specified limits. This is usually caused by an excessively rich fuel/air mixture entering the combustion chamber. The fuel to the engine should be shut off immediately.
2. *False or Hung Start.*
   False or hung starts occur when the engine starts normally but the r.p.m. remains at some low value rather than increasing to the normal starting r.p.m. This is often the result of insufficient power to the starter, or the starter cutting off before the engine starts self-accelerating. In this case, the engine should be shut down.

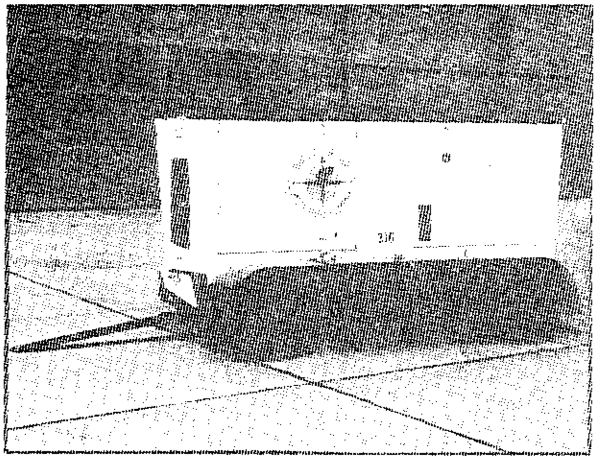


FIGURE 11-2. Mobile ground power unit (towed).

3. *Engine Will Not Start.*
The engine will not start within the prescribed time limit. It can be caused by lack of fuel to the engine, insufficient or no electrical power, or malfunctions in the ignition system. If the engine fails to start within the prescribed time, it should be shut down.

In all cases of unsatisfactory starts the fuel and ignition should be turned off. Continue rotating the compressor for approximately 15 seconds to remove accumulated fuel from the engine. If unable to motor (rotate) the engine, allow a 30-second fuel draining period before attempting another start.

ELECTRICAL POWER

Ground support electrical power units vary widely in size and type. Generally, they can be classified as either towed or self-propelled items of equipment.

The towed power units vary in size and range of available power. The smallest units are simply high-capacity batteries used to start light aircraft. These units are normally mounted on wheels or skids and are equipped with an extra-long electrical line terminated in a suitable plug-in adapter. Larger units (figure 11-2) are equipped with generators. These units provide a wider range of output power.

Such power units are normally designed to supply constant-current, variable-voltage d.c. electrical power for starting jet aircraft engines, and constant-voltage direct current for starting reciprocating aircraft engines. This type of vehicle is normally somewhat top-heavy and possesses a large inertia; consequently, it should be towed at restricted speeds, and sharp turns should be avoided.

Self-propelled power units are normally more expensive than the towed units and in most instances supply a wider range of output voltages and frequencies. For example, the self-propelled power unit shown in figure 11-3 is capable of supplying d.c. power in varying amounts, as well as 115/200-volt, 3-phase, 400-cycle a.c. power continuously for 5 minutes.

When using ground electrical power units, it is important to position the unit carefully. It must be positioned to prevent collision with the aircraft being serviced, or others nearby in the event the brakes on the unit fail. It should be parked a full service cable length away from the aircraft being serviced.

All electrical safety precautions should be observed when servicing an aircraft, and a power unit should never be moved when service cables are attached to an aircraft or when the generator system is engaged.

HYDRAULIC POWER

Portable hydraulic test stands are manufactured in many sizes and cost ranges. Some have a limited range of operation, while others can be used to perform all the system tests that fixed shop test stands are designed to perform. For example, one particular type of portable test unit can perform the following functions:

1. Drain the aircraft hydraulic system.
2. Filter the aircraft system hydraulic fluid.

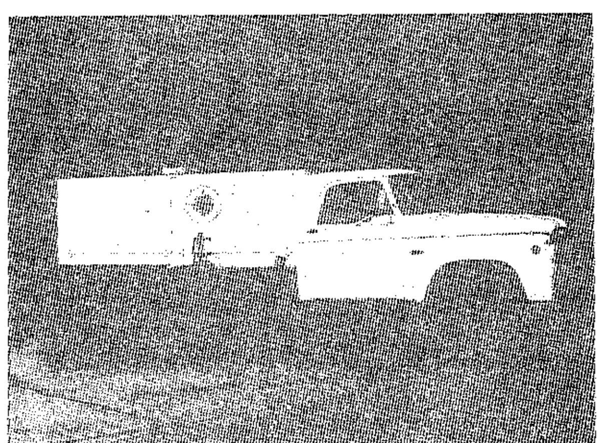


FIGURE 11-3. Self-propelled ground power unit.

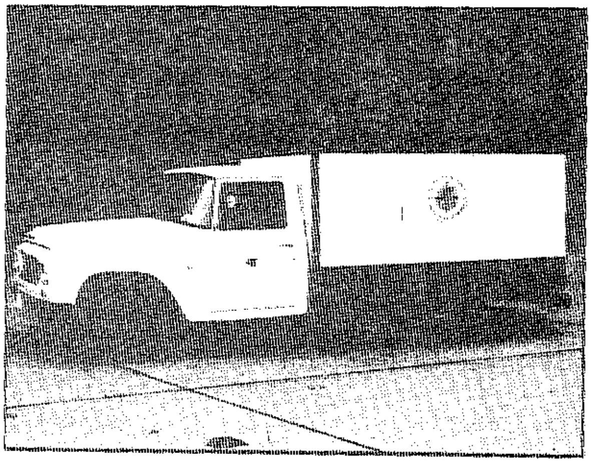


FIGURE 11–4. Air conditioner and heater unit.

3. Refill the aircraft system with clean, micronically filtered hydraulic fluid.
4. Check performance of aircraft systems and subsystems.
5. Check the aircraft hydraulic systems for internal and external leakage.

This type of portable hydraulic test unit is usually an electrically powered unit. It uses a hydraulic system capable of delivering a variable volume of fluid from zero to approximately 24 gallons per minute at variable pressures up to 3,000 p.s.i.g. The test unit and its components are mounted on a metal base enclosed by a removable top cover. The base is usually mounted on four pneumatic rubber tire wheels. It may be self-propelled or provided with a tow bar for towing by hand or vehicle.

AIR-CONDITIONING AND HEATING UNITS

Mobile air-conditioning and heating units are ground support equipment designed to supply conditioned air to heat or cool aircraft. Such units are capable of delivering a large airflow against static pressure at the end of a flexible duct or into an aircraft. Compared to the air-conditioning capability, the heating capability is normally considered an optional accessory, but in some climates the heating capability is often as useful as the cooling.

Figure 11–4 shows a typical mobile air conditioner and heating unit. This unit is capable of delivering up to 3,500 cu. ft. of cooling air per minute. It is capable of dropping the interior temperature of a large aircraft from 115° F. to approximately 76° F. Its heating capability provides an output of up to 400,000 B.t.u. per hour. A single engine supplies power to the truck and the air-conditioning equipment. This is accomplished by means of power-takeoffs mounted on an auxiliary transmission. By simple shifting of gear handles in various combinations of positions, an operator can drive the truck, operate the blower only, or operate the blower and the refrigeration equipment. All controls and switches for operation are in the cab.

GROUND SUPPORT AIR START UNITS

Air start units provide a supply of compressed air to operate pneumatic starters on turboprop and gas-turbine engines. Air start units may be mounted on trailer units to be towed to the aircraft, or they may be self-propelled units similar to that shown in figure 11–5.

A typical air start unit consists of the following components: A GTC, a high-capacity storage battery, and the necessary fuel, oil and electrical systems, controls, and compressed air lines.

The typical GTC is basically a two-stage centrifugal compressor assembly directly coupled to a radial inward-flow turbine. In addition to compressed bleed air, the compressor supplies compressed air for combustion to drive the turbine wheel. The combustion gas is passed through the combustion chamber to the turbine nozzle assembly. The power extracted by the turbine wheel is transmitted to the compressor, accessory section, and control system components.

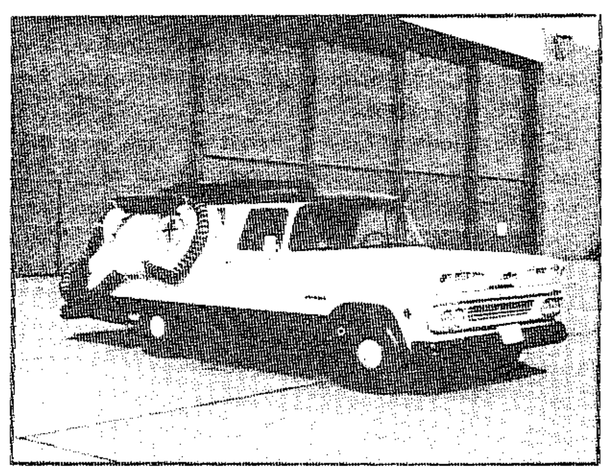


FIGURE 11–5. Air start unit.

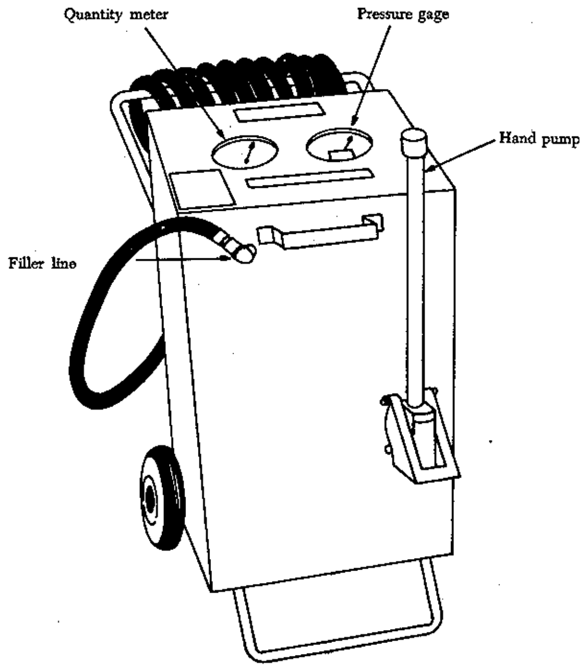


FIGURE 11–6. Pressure oil unit.

PREOILING EQUIPMENT

Preoiling reciprocating aircraft engines is usually necessary before starting a new or preserved engine, or one which has been idle for a period of time.

Using a preoiler (see figure 11–6) for reciprocating aircraft engines simplifies the job of preoiling. Such units supply preheated oil under pressure to the engine to ensure adequate lubrication before starting.

The conditions for preoiling turbine engines are essentially the same as those for reciprocating engines. In addition, if a lubricating oil line fitting has been disconnected on a turbine engine, the engine must be preoiled before starting again. The portable preoiler tank supplies low-pressure oil to the lubrication system of the turbine engine.

AIRCRAFT FUELING

Strict fire precautions must be adhered to during the fueling process. Smoking is not permitted in or around an aircraft during fueling. Also, open flames such as oil lanterns, candles, or matches are prohibited. Exposed electric switches, sliprings or commutators, dynamos or motors, spark-producing electrical equipment, or any burning material must not be permitted within 100 feet of an aircraft being fueled or defueled. No lights other than approved explosion-proof lights are permitted within 100 feet of these operations, and no light of any sort may be placed where it can come in contact with spilled fuel. Warning signs should be posted as a precautionary measure.

All aircraft fuels or other combustible liquids accidentally spilled should be immediately removed by washing with water or covered with a foam blanket to prevent ignition, or neutralized by other means. The proper fire authorities must be notified if necessary.

If indications of underground leakage of combustible liquids are discovered, areas must be guarded by appropriate means, and the proper fire authorities must be notified immediately.

It is recommended that aircraft fuel tanks be filled before storing aircraft in hangars, since this leaves no space for explosive vapors to form. This practice is also recommended after each flight to prevent water condensation in fuel tanks.

The fuel tanks should not be filled completely to the top when aircraft are stored in hangars, especially if the outside temperature is cooler than the inside temperature. If it is warmer inside the hangar than outside, fuel in the tanks expands and causes overflow through the fuel tank's venting system, creating a fire hazard.

Nonspark tools must be used when working on any part of a system or unit designed for storing or handling combustible liquids.

Use of leaky tanks or fuel lines is not permitted. Repairs must be made on discovery, with due regard to the hazard involved.

All fuel is filtered and passes through water-separating equipment at the tank farm when it is delivered to the mobile refueler; or in the case of island-type refueling stations, as it leaves the supply connections. The mobile refueler also passes the fuel through a system of filters and water-separating equipment before its delivery to the aircraft. These filters and separators are usually checked in the morning for evidence of dirt and water, and each time thereafter that the mobile refueler is reloaded. When the mobile refueler is loaded, it must sit at least 15 minutes and then have the sumps checked for water before any aircraft are refueled from it.

When using fuel which has been stored in cans or barrels, it must be run through a strainer-funnel before being put into aircraft. This practice is necessary as condensation and rust develop inside cans and barrels.

If a chamois is used to filter the fuel, an increase in the static electricity hazard results from the passage of gasoline through the material. The chamois must be grounded and remain grounded until all gasoline has drained through the filter. This can be done by contact with a supporting metal screen which is positively grounded. Never use a plastic funnel, bucket, or similar nonconductive container when servicing from storage cans or barrels.

Aircraft should be fueled in a safe place. Do not fuel or defuel an aircraft in a hangar or other enclosed space except in case of an emergency. Aircraft should be free from fire hazards, and have engine switches off and chocks placed under the wheels prior to fueling or defueling.

A person who functions as a fireguard with a CO_2 extinguisher or other firefighting equipment should possess a thorough knowledge of all fuel-servicing hazards. He should guard against breathing hydrocarbon vapors, which may cause sickness or dizziness, or may even be fatal. Adequate ventilating measures to prevent the accumulation of fumes should be provided.

Because of its high lead content, fuel should not be allowed to come in contact with clothes, skin, or eyes. Fuel-saturated clothing should be removed as soon as possible and the parts of the body exposed to the fuel washed thoroughly with soap and water. Wearing clothing saturated with fuel creates a dangerous fire hazard, and painful blisters (similar to those caused by fire burns) may result from direct contact with fuel. If fuel enters the eyes, medical attention should be sought immediately.

Refueling Crew Duties

When an aircraft is to be overwing fueled by truck, it should be located on the apron or a dispersal site, and should not be in the vicinity of possible sources of fuel-vapor ignition. Consideration must be given to the direction of the wind so that fuel vapors are not carried toward a source of ignition.

The tank truck should be driven to a point as distant from the aircraft as the length of hose permits, and preferably to the windward (upwind) side of the aircraft. It must be parked parallel to or heading away from the wing, or in such a position that it may be driven away quickly in the event of fire (*A* of figure 11–7). As soon as the fueling operation has been completed, the truck should be removed from the aircraft's vicinity. The truck fuel tank covers should be kept closed except when a tank is actually being loaded.

Ideally, refueling crews for large aircraft would possibly involve four men. One person stands by with the firefighting equipment; another stays with the truck; the third man handles the fuel hose on the ground; and the fourth man handles the fueling hose at the aircraft and fills the tanks (*A* and *B* of figure 11–7).

Care should be taken to identify the aviation fuel and lubricating oil dispensed from each refueling unit before beginning the actual servicing. Aviation technicians should be familiar with the various grades and the aircraft's gasoline requirements so that the appropriate fuel is used. A check should also be made to see that all radio equipment and electrical switches not needed for the fueling operation are turned off, and nonessential outside electrical sources are not connected to the aircraft. A member of the crew then makes sure that both the aircraft and the truck are properly grounded to prevent sparks from static electricity.

Fueling Operations

In the overwing fueling of large aircraft, the man with the CO_2 bottle stands close to the aircraft to be refueled. The fuel hose handler on the truck unreels the hose and passes it up to the man on the aircraft who is to do the fueling. Care should be taken in bringing the hose nozzle up to the filler neck of the fuel tank to avoid excessive marring of the aircraft finish. Attached to the nozzle is a ground wire which is plugged into the receptacle adjacent to the fuel tank to be filled. Another type of ground wire commonly used terminates in an alligator clip connected to a grounding post. This connection is made before the fuel tank cap is removed from the filler neck. This serves as a continuous ground connection for the fuel nozzle (*C* of figure 11–7). The fuel truck has two ground wires; one is connected to a suitable ground on the apron (*A* of figure 11–7), and the other is connected to the aircraft (*A* and *B* figure 11–7). The aircraft should also be grounded to the apron.

This grounding arrangement may take other forms. In many cases, the fuel truck is grounded by a metal chain that is dragged behind the truck; the aircraft is grounded by a carbon strip embedded in the tires; and the aircraft and fuel truck are held at a common electrical potential by a

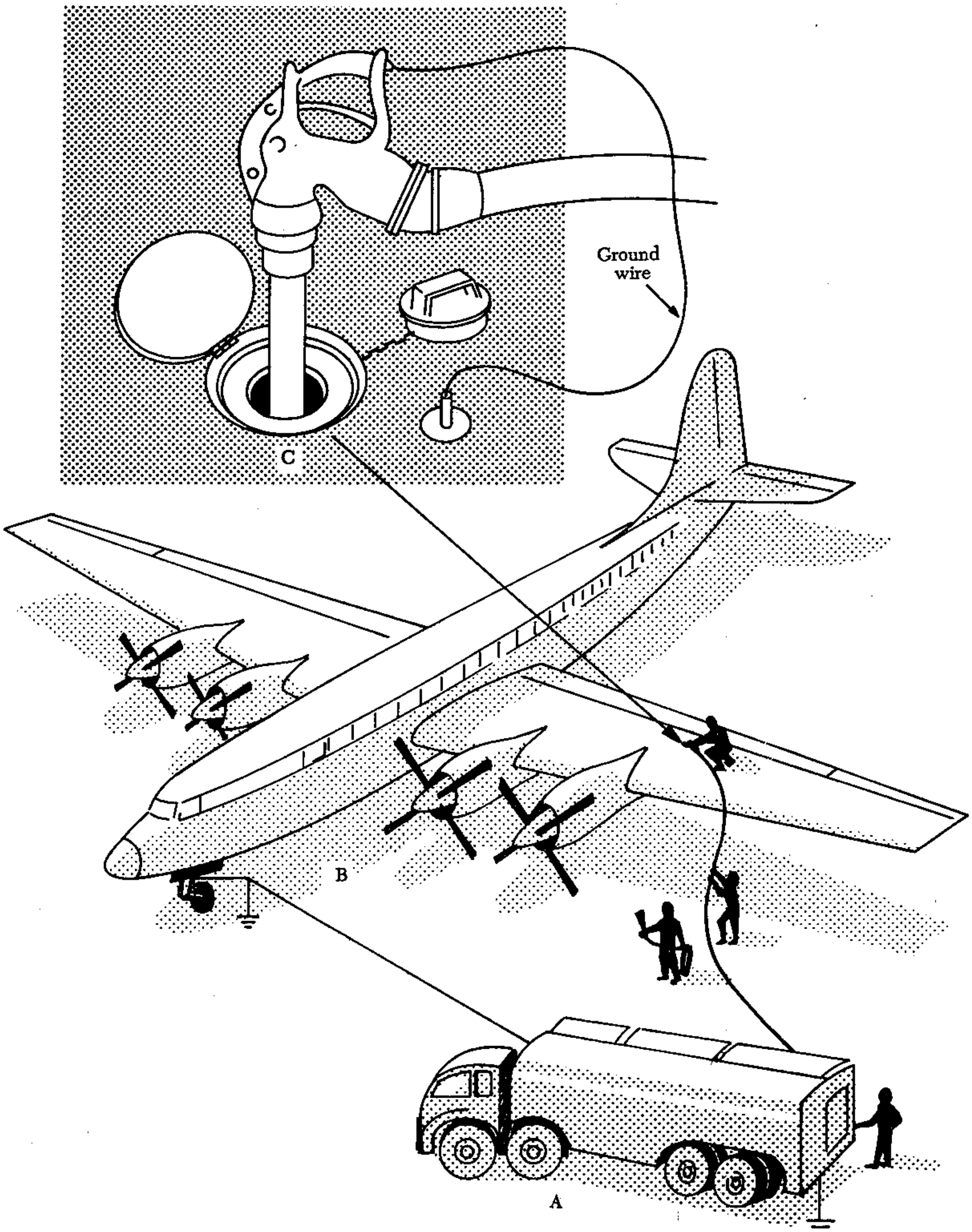


FIGURE 11–7. Refueling an aircraft.

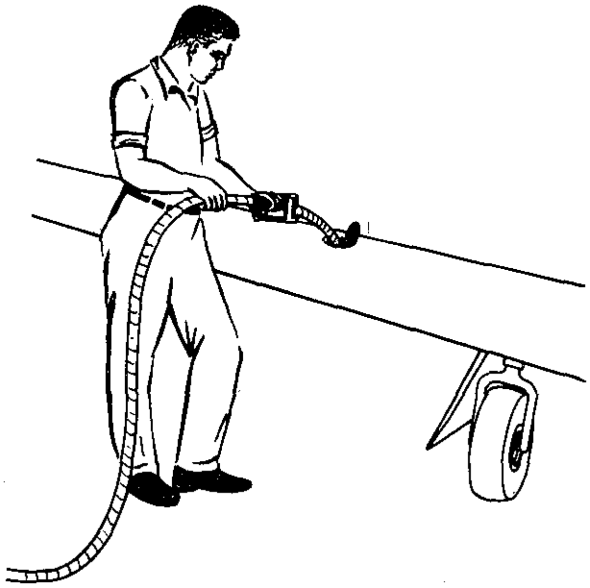


FIGURE 11–8. Fueling a small aircraft.

conducting wire encircling the fuel hose from nozzle to tank fitting. All this is to prevent a spark from static electricity that may be created as the fuel flows through the fuel hose into the aircraft's fuel tank.

The fueling of light aircraft involves fewer problems. While the fueler's responsibilities are still the same, it is usually a one- or two-man operation. The danger of marring the aircraft finish is minimized since the height and location of the fuel tanks usually permit easy accessibility to the filler neck. In addition, small aircraft can be easily pushed by hand to a fueling position near a fuel truck or a fueling island. Figure 11–8 shows a small aircraft being fueled.

When the fuel tank is nearly full, the rate of fuel flow should be reduced for topping off the tank; that is, the tank should be slowly filled to the top without spilling fuel on the wing or ground. The filler cap is replaced on that tank, the ground wire plug removed from its receptacle, and then the man handling the fuel nozzle takes the hose and moves on to the next tank to be filled. This procedure is followed at each tank until the aircraft is completely refueled. Then the ground wires are disconnected from the aircraft, and the hose is rewound onto the hose reel in the truck. During this operation the hose or nozzle should not be allowed to drop to the ground.

Pressure Fueling

Pressure fueling is used on many late-model aircraft. This fueling process, sometimes referred to as single-point or underwing fueling, greatly reduces the time required to service large aircraft. There are also other advantages in the pressure fueling process. It eliminates aircraft skin damage and hazards to personnel and reduces the chances for fuel contamination. Pressure fueling also reduces the chance of static electricity igniting fuel vapors.

Because of the limited fuel tank area, there are fewer advantages of a pressure fueling system in light aircraft. Thus, they are usually incorporated only in medium size executive jets and large military or commercial transport aircraft.

Most pressure fueling systems consist of a pressure fueling hose and a panel of controls and gages that permit one man to fuel or defuel any or all fuel tanks of an aircraft. A single-point fueling system is usually designed so that an in-the-wing fueling manifold is accessible near a wingtip or under the wing near the wing root. The valves connecting the various tanks to the main fueling manifold are usually actuated in response to fuel pressure signals.

Fueling and defueling procedures are normally placarded on the fueling control panel access door. The fueling operator should possess a thorough knowledge of the aircraft fuel system to recognize malfunction symptoms. Since the design of pressure fueling systems varies somewhat with each type of aircraft, the fueling operator should consult the manufacturer's instructions for detailed procedures.

Due to varying procedures in defueling aircraft, it is important to consult the applicable manufacturer's maintenance instructions.

FIRE

Types of Fire

The National Fire Protection Association has classified fires into three basic types:

a. Class A fires—as fires in ordinary combustible materials such as wood, cloth, paper, upholstery materials, etc.

b. Class B fires—as fires in flammable petroleum products or other flammable or combustible liquids, greases, solvents, paints, etc.

c. Class C fires—as fires involving energized electrical equipment where the electrical non-conductivity of the extinguishing media is of importance. In most cases where electrical equipment is deenergized, extinguishers suitable for use on Class A or B fires may be employed effectively.

A fourth class of fire, Class D fire, is defined as fire in flammable metal. Class D fires are not considered a basic type since they are generally caused by a Class A, B, or C fire. Usually these fires involve magnesium in the shop or in aircraft wheels and brakes.

Any one of these types of fires can occur during maintenance or operations. There is a particular type extinguisher which is most effective for each type of fire.

Fire Extinguishment

Three things are required for a fire. Fuel—something that will in the presence of heat combine with oxygen, thereby releasing more heat and as a result reduces itself to other chemical compounds. Heat—can be considered the catalyst which accelerates the combining of oxygen with fuel, in turn releasing more heat. Oxygen—element which combines chemically with another substance through the process of oxidation. Rapid oxidation, accompanied by a noticeable release of heat and light is called combustion or burning (figure 11-9). Remove any one of these things and the fire goes out.

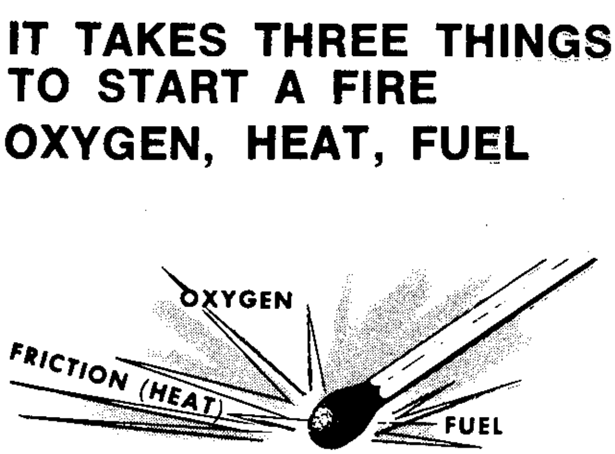


FIGURE 11-9. Three elements for fire.

Types of Fire vs. Extinguishing Agent

Class A fires respond best to water or water type extinguishers which cool the fuel below combustion temperatures. Class B and C extinguishers are effective but not equal to the wetting/cooling action of the Class A extinguisher.

Class B fires respond to carbon dioxide (CO_2), halogenated hydrocarbons (Halons) and dry chemicals, all of which displace the oxygen in the air thereby making combustion impossible. Foam is effective, especially when used in large quantities. Water is ineffective on class B fires and will cause the fire to spread.

Class C fires involving electrical wiring, equipment, or current respond best to carbon dioxide (CO_2) which displaces the oxygen in the atmosphere making combustion improbable. The CO_2 equipment must be equipped with a nonmetallic horn to be approved for use on electrical fires. Two reasons for this must be considered:

1. The discharge of CO_2 as through a metal horn can generate static electricity. The static discharge could reignite the fire.

2. The metal horn if in contact with the electrical current would transmit that current to the extinguisher operator.

Halogenated hydrocarbons are very effective on Class C fires. The vapor reacts chemically with the flame to extinguish the fire. Dry chemicals are effective but have the disadvantage of contaminating the local area with powder. Also, if used on wet and energized electrical equipment, it may aggravate current leakage.

Water, wet water or foam are not acceptable agents for use on electrical equipment fires.

Class D fires respond to application of dry powder, which prevents oxidation and the resulting flame. Application may be from an extinguisher or scoop or shovel. Special techniques are needed in combating fires involving metal. Manufacturers recommendations should be followed at all times. Areas which could be subjected to metal fires should have the proper protective equipment installed. Under no conditions use water on a metal fire. It will cause the fire to burn more violently and can cause explosions.

Fire Extinguisher Periodic Check List

1. Appropriate extinguisher located in proper place.
2. Safety seals unbroken.
3. Remove all external dirt and rust.
4. Gage or indicator in operable range.
5. Check for proper weight.
6. No nozzle obstruction.

Fire Extinguishing Agents

A. Water and water based agents.

Water may be combined with antifreeze compounds or wetting agents (accelerate penetration of materials by water). Water is used on carbonaceous fires. It extinguishes fires by cooling the fuel below the combustion temperature.

1. Soda-acid and foam act on a fire the same as water by lowering the temperature. Foam

has some effect on a petroleum base fire by preventing oxygen from getting to the fire.

2. Loaded stream contains an antifreeze as well as a flame retardant.

B. Dry Chemical.

Four types of chemicals are used:

1. Sodium bicarbonate (Formula H). For ordinary risk class B and C fires.
2. Ammonium phosphate (Multipurpose). For multiple risk class B and C fires.
3. Potassium bicarbonate (Purple K). For high risk class B and C fires.
4. Multipurpose dry chemical (ABC). For use on Class A, B, and C fires. The dry chemicals extinguish a fire by smothering it, cutting off oxygen, and the blanket of dry chemicals prevents reflash fires. It also affords the operator some protection from the heat. All dry chemicals are nonconductors of electricity.

C. Gas.

1. Carbon dioxide (CO_2) has a toxicity rating (Underwriter's Laboratory) of 5A especially recommended for use on class B and C fires. Extinguishes flames by dissipating oxygen in the immediate area.
2. Halogenated hydrocarbons (commonly called freon by the industry), are numbered according to chemical formulas with Halon numbers.

Carbon tetrachloride (Halon 104). Chemical formula CCl_4. UL toxicity rating of 3. It is poisonous and toxic. Hydrochloric acid vapor, chlorine and phosgene gas are produced whenever carbon tetrachloride is used on ordinary fires. The amount of phosgene gas is increased whenever carbon tetrachloride is brought in direct contact with hot metal, certain chemicals, or continuing electrical arcs. It is no longer approved for any fire extinguishing use.

Methyl bromide (Halon 1001). Chemical formula CH_3Br—a liquified gas, UL toxicity rating of 2. Effective but very toxic and also is corrosive to aluminum alloys, magnesium and zinc. Not recommended for aircraft use.

Chlorobromomethane (Halon 1011). Chemical formula CH_2ClBr—a liquified gas, UL toxicity rating is 3. Not recommended for aircraft use.

Dibromodifluoromethane (Halon 1202). Chemical formula CBr_2F_2. UL toxicity rating of 4. Not recommended for aircraft use.

Bromochlorodifluoromethane (Halon 1211). Formula $CBrClF_2$—a liquified gas with a UL toxicity rating of 5. It is colorless, noncorrosive and evaporates rapidly leaving no residue whatever. It does not freeze or cause cold burns and will not harm fabrics, metals, or other materials it contacts. Halon 1211 acts rapidly on fires by producing a heavy blanketing mist that eliminates air from the fire source, but more importantly interferes chemically with the combustion process. It has outstanding properties in preventing reflash after the fire has been extinguished.

Group	Definition	Examples
6 (least toxic)	Gases or vapors which in concentrations up to at least 20% by volume for durations of exposure of the order of 2 hours do not appear to produce injury.	Bromotrifluoromethane (Halon 1301)
5a	Gases or vapors much less toxic than Group 4 but more toxic than Group 6.	Carbon dioxide
4	Gases or vapors which in concentrations of the order of 2 o 2½% for durations of exposure of the order of 2 hours are lethal or produce serious injury.	Dibromodifluoromethane (Halon 1202)
3	Gases or vapors which in concentrations of the order of 2 to 2½% for durations of exposure of the order of 1 hour are lethal or produce serious injury.	Bromochloromethane (Halon 1011), Carbon tetrachloride (Halon 104)
2	Gases or vapors which in concentrations of the order of 1/2 to 1% for durations of exposure of the order of 1/2 hour are lethal or produce serious injury.	Methyl bromide (Halon 1001)

FIGURE 11–10. Toxicity table.

Extinguishing Materials	Classes of fire				Self-generating	Self-expelling	Cartridge of N_2 cylinder	Stored oressure	Pump	Hand
	A	B	C	D						
Water and antifreeze	X						X	X	X	X
Soda-acid (water)	X				X					
Wetting agent	X						X			
Foam	X	X			X					
Loaded stream	X	X+					X	X		
Multipurpose dry chemical	X+	X	X				X	X		
Carbon dioxide		X+	X			X				
Dry chemical		X	X				X	X		
Bromotrifluoromethane — Halon 1301		X	X			X				
Bromochlorodifluoromethane — Halon 1211		X	X					X		
Dry powder (metal fires)				X			X			X

+Smaller sizes of these extinguishers are not recognized for use on these classes of fires.

FIGURE 11–11. Extinguisher operation and methods of expelling.

Bromotrifluoromethane (Halon 1301). Chemical formula CF_3Br is also a liquified gas with a UL toxicity rating of 6. It has all the characteristics of Halon 1211. The significant difference between the two is: Halon 1211 forms a spray similar to CO_2, while Halon 1301 has a vapor spray that is more difficult to direct.

D. Powder.

Dry powder for metal fires. Fires in metal require special handling. If water is used on a magnesium fire the burning is accelerated. Special dry powders are available for use wherever metal fires are possibilities. These are normally applied by scoop or shovel. Multipurpose (ABC) dry chemicals have a limited use on metal fires such as fires in wheel brakes or in magnesium fires.
(See figures 11–10 and 11–11).

RECOMMENDED MARKINGS TO INDICATE EXTINGUISHER SUITABILITY

(From NFPA Standard #10)

The following recommendations are given as a guide in marking extinguishers, and/or extinguisher locations, to indicate the suitability of the extinguisher for a particular class of fire.

Markings should be applied by decalcomanias, painting or similar methods having at least equivalent legibility and durability.

Where markings are applied to the extinguisher, they should be located on the front of the shell above or below the extinguisher nameplate. Markings should be of a size and form to give easy legibility at a distance of 3 feet.

Where markings are applied to wall panels, etc., in the vicinity of extinguishers, they should be of a size and form to give easy legibility at a distance of 25 feet. (See figures 11–12 and 11–13).

AIRCRAFT FIRE EXTINGUISHERS

Fire is one of the most dangerous threats to aircraft—either in flight or on the ground. Airborne fixed, powerplant and airframe, detection and extinguishing systems are designed and installed by the manufacturer in compliance with applicable FAR's. The requirement for portable fire extinguishers installed in the crew and passenger compartment says, the extinguisher must be approved, must be appropriate for the kind of fire likely to occur and must minimize the hazard of toxic gases.

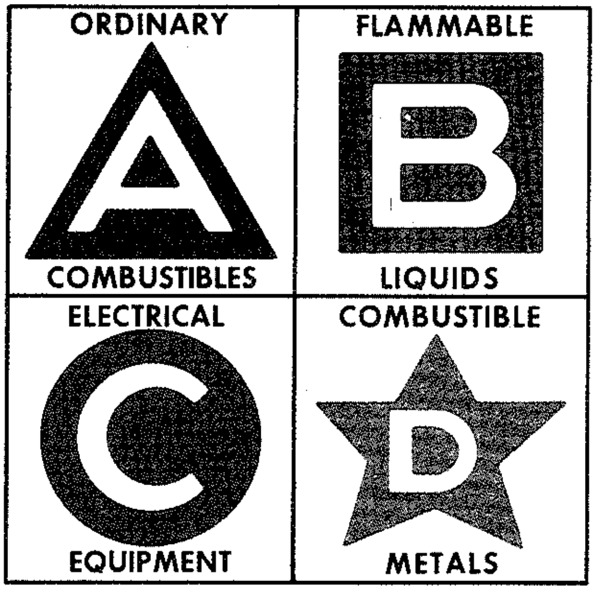


FIGURE 11–12. Identification of fire extinguisher type location.

The National Fire Protection Association (NFPA) Standard #408, Aircraft Hand Fire Extinguishers, suggests the type, capacity, location and quantity of hand fire extinguishers for the protection of aircraft compartments occupied by passengers and crew. This standard suggests carbon dioxide and water (water solution) as the extinguishing media for hand type extinguishers. Both type extinguishers are suggested for use in the passenger compartment, the number of units being regulated by the number of passengers carried. Carbon dioxide is suggested for the crew compartment. A halogenated hydrocarbon extinguishing agent (Halon 1211 or Halon 1301) having an Underwriter's Laboratory toxicity rating of 5 or higher may be substituted for the carbon dioxide, if there is sufficient free air volume in the immediate area to prevent serious irritating effects on the occupants.

The following extinguishing agents are not recommended for aircraft use:

1. Dry chemical extinguishers are very effective in Class B and C fires but they leave a residual dust or powder. This obstructs vision, is difficult to clean up and causes damage to electronic equipment.

2. Carbon tetrachloride is no longer approved as a fire extinguishing agent. It produces a poisonous gas (phosgene) when in contact with hot metals. Soda acid and foam, these are toxic to a degree and can be corrosive to adjacent materials.

3. Methyl bromide is more toxic than CO_2 and cannot be used in confined areas. It is also very corrosive to aluminum alloy, magnesium and zinc.

4. Chlorobromomethane, although an effective extinguishing agent, is toxic.

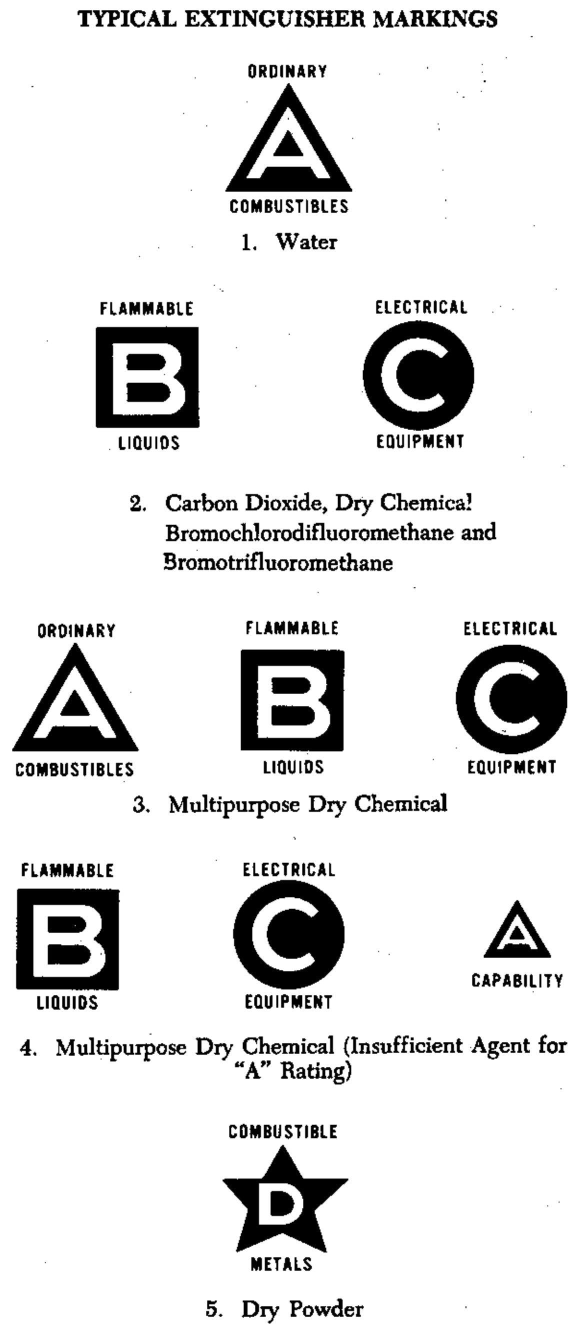


FIGURE 11–13. Typical extinguisher markings.

Extinguishers

The common aerosol can type extinguishers are definitely not acceptable as airborne hand type extinguishers. In one instance, an aerosol type foam extinguisher located in the pilot's seat back pocket exploded and tore the upholstery from the seat. The interior of the aircraft was damaged by the foam. This occurred when the aircraft was on the ground and the outside temperature was 90° F. In addition to the danger from explosion, the size is inadequate to combat even the smallest fire. In another instance, a dry chemical extinguisher was mounted near a heater vent on the floor. For an unknown reason, the position of the unit was reversed. This placed the extinguisher directly in front of the heater vent. During flight, with the heater in operation, the extinguisher became overheated and exploded filling the compartment with dry chemical powder. The proximity of heater vents should be considered when selecting a location for a hand fire extinguisher.

Additional information relative to airborne hand fire extinguishers may be obtained from the local FAA District Office and from the National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210.

Ground Type Extinguishers—Hand Type

The selection of a fire extinguisher for ground installation, shop, fueling station, etc., is not restricted as it is for airborne installations. The range of selection for agent and type extinguishers is shown in figure 11–11. (See figures 11–16 and 11–17).

Methods of Extinguisher Operation. The methods of operation of extinguishers are most conveniently arranged by grouping extinguishers according to their expelling means. Six methods are in common use.

Self-generating—actuation causes gases to be generated that provide expellent energy.

Self-expelling—the agents have sufficient vapor pressure at normal operating temperatures to expel themselves.

Gas cartridge or cylinder—expellent gas is confined in a separate pressure vessel until an operator releases it to pressurize the extinguisher shell.

Stored pressure—the extinguishing material and expellent gas are kept in a single container.

Mechanically pumped—the operator provides expelling energy by means of a pump and the vessel containing the agent is not pressurized.

Hand propelled—the material is applied with scoop, pail, or bucket.

Several different extinguishing materials are handled by each of these expelling means.

Discontinued Fire Extinguishers (see figures 11–14 and 11–15)

There are still in use today several million fire extinguishers of a design no longer manufactured. These are the $1\frac{1}{2}$, $2\frac{1}{2}$ and 5 gallon "invert to use" liquid extinguishers. The last of this type were manufactured in the $2\frac{1}{2}$ gallon size. The agents used in these extinguishers are:

1. Soda-acid.
2. Foam.
3. Water cartridge.
4. Loaded stream cartridge.

The reasons which influenced the decision to discontinue manufacturing these extinguishers are:

1. Invert to use—difficult and unorthodox method of activation.
2. Limited to the types of fires for which they are suitable. Mostly Class "A" fires, very limited application of foam on Class "B" fires.
3. None approved for electrical fires.
4. Effective on only minimal size fires.
5. The container does not meet current pressure vessel standards. This is the most significant of all.

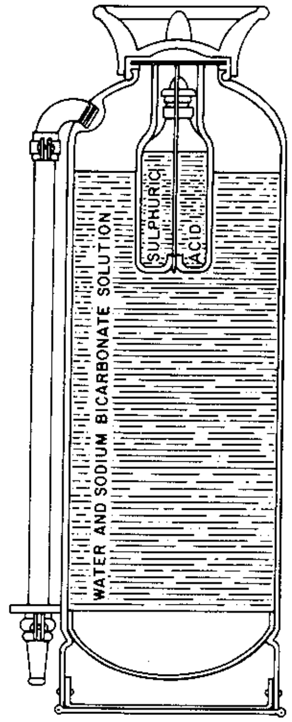
Comparison of Safety Factors

Discontinued types of extinguishers use a shell rated at either 350 or 500 p.s.i. However, when these extinguishers are inverted to operate, the pressures generated often are unpredictable, totally unlike the pressures in other extinguisher designs. Pressures may range from 100 to 300 p.s.i for soda-acid extinguishers and from 100 to 350 p.s.i. for the foam extinguishers.

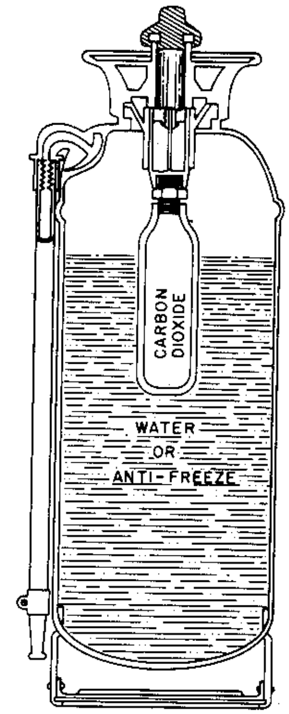
SERVICING AIRCRAFT WITH OIL

Aircraft oil tanks are normally checked at the same time the fuel tanks are filled. There are a few exceptions to this general rule, since some manufacturers recommend that the oil level in certain jet engines be checked within a specified time after engine shutdown. In all cases, the manufacturer's instructions should be followed for the specific aircraft not only for servicing procedures but also for type and grade of oil used.

Aircraft oil tanks should never be filled to capacity or above the labeled full mark on the gage or dipstick. This is because oil expands when it becomes hot, and at high altitude it bubbles and expands. The extra space in oil tanks allows for expansion and prevents overflowing. The aircraft's oil requirements should be checked, and no substitutions should be made for the type of oil to be used unless substitute oils have been approved

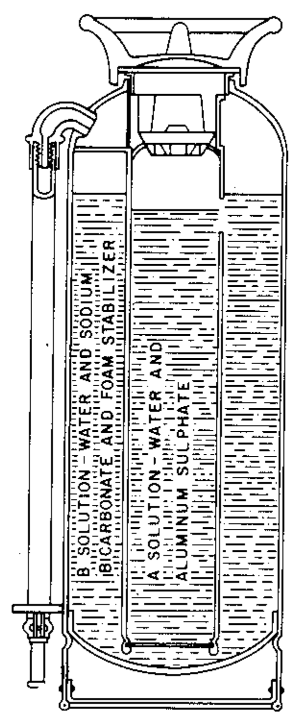


Soda-acid fire extinguisher.

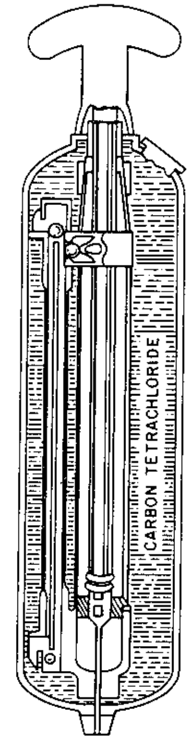


Cartridge operated water fire extinguisher.

FIGURE 11–14. Discontinued types of fire extinguishers #1.



Foam fire extinguisher.



Vaporizing liquid fire extinguisher.

FIGURE 11–15. Discontinued types of fire extinguishers #2.

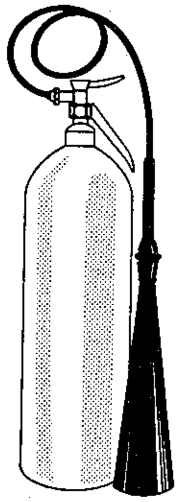


FIGURE 11–16. CO_2 fire extinguisher.

for use. When pouring oil into the tanks, be sure that cleaning rags or pieces of rag or other foreign substances do not get into the tanks. Foreign material in the oil system restricts the flow of oil and can cause engine failure.

Lubricating oil is nonexplosive, very difficult to ignite in bulk, and is not normally capable of spontaneous combustion. However, if oil is ignited, a hotter fire results than that from gasoline. The vapor of the oil, however, is explosive when mixed with air in certain proportions. Vapors of many petroleum products are highly toxic when inhaled or ingested. It is therefore necessary to take all precautions when handling lubricating oil.

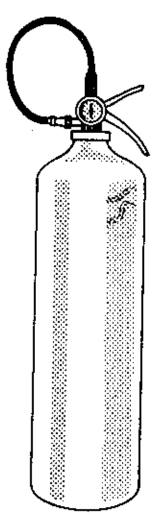


FIGURE 11–17. Dry chemical extinguisher.

MAINTENANCE SAFETY

Good housekeeping in hangars, shops, and on the flight line is essential to safety and efficient maintenance. The highest standards of orderly work arrangements and cleanliness should be observed during the maintenance of aircraft. Where continuous work shifts are established, the outgoing shift should remove and properly store personal tools, rollaway boxes, all workstands, maintenance stands, hoses, electrical cords, hoists, crates, and boxes that are superfluous to the work to be accomplished.

Safety Lanes

Pedestrian walkways or fire lanes should be painted around the perimeter inside the hangars. This should be done as a safety measure to prevent accidents and to keep pedestrian traffic out of work areas.

Power Cords

1. Power cords should be heavy industrial type which are able to resist abrasion and impact.
2. Power cords should not be run over by any equipment.
3. Lights should be explosion proof.
4. Connections should be locking type to prevent accidental disconnection.
5. All lights or equipment should be switched "off", to prevent arching before connecting or disconnecting.
6. Power cords should be straightened, coiled, and properly stored when not in use.

Disregard of the above suggestions may result in explosions and fires with damage into millions of dollars and loss of life.

Compressed Air System

Compressed air is like electricity—an excellent tool as long as it is under control.

1. Air hoses should be inspected frequently for breaks and worn spots. Unsafe hose should be replaced immediately.
2. All connections should be kept in a "no leak condition".
3. In line oilers, if installed, should be maintained in operating condition.
4. The system should have water sumps installed and they should be drained at regular intervals.

5. Air used for paint spraying should be filtered to remove oil and water.
6. Never use compressed air to clean hands or clothing. Pressure can force debris into the flesh leading to infection.
7. Never use compressed air for "horse play".
8. Air hoses should be straightened, coiled, and properly stored when not in use.

Spilled Oil and Grease

Oil, grease, and other substances spilled on hangar or shop floors should be immediately cleaned or covered with an absorbent material to prevent fire or personal injury. Drip pans should be placed beneath engines and engine parts wherever dripping exists. Waste oil and dirty cleaning fluid should be stored in containers for future salvage. Under no circumstances should oil or cleaning fluid be emptied into floor drains. Fumes from this type "disposal" may be ignited and cause severe property damage.

Aircraft Tire Mounting

To prevent possible personal injury, tire dollies and other appropriate lifting and mounting devices should be used in mounting or removing heavy aircraft tires. When inflating tires on wheels equipped with locking rings, tire cage guards should always be used. Where possible, all tires should be inflated in tire cage guards. Because of possible personal injury, extreme caution is required to avoid overinflation of high-pressure tires. Pressure regulators should be used on high pressure air bottles to eliminate the possibility of overinflation of tires.

Tire cages need not be used when adjusting pressure in tires installed on aircraft.

Welding

Welding should not be performed except in designated areas. Any part to be welded should be removed from the aircraft, if possible. Repair would then be accomplished in the welding shop under controlled environment. A welding shop should be equipped with proper tables, ventilation, tool storage, and fire prevention and extinguishing equipment.

Welding on an aircraft should be performed outside if possible. If welding in the hangar is necessary, these precautions should be observed:

1. No open fuel tanks or work on fuel systems should be in progress.
2. No painting in progress.
3. No aircraft within 35 feet.
4. Immaculate housekeeping should prevail around the welding area.
5. Only qualified welders should be permitted to do the work.
6. The area should be roped off and placarded.
7. Fire extinguishing equipment of a minimum rating of 20B should be in the immediate area with 80B rated equipment as a backup.
8. There should be trained fire watches in attendance at the above equipment.
9. Aircraft should be in towable condition, with a tug attached, aircraft brakes off, and a qualified operator on the tug with mechanics available to assist in the towing operation. Hangar doors should be opened.

SERVICING AIRCRAFT OXYGEN SYSTEMS

Before servicing any aircraft, consult the specific aircraft maintenance manual to determine the proper type of servicing equipment to be used. Two persons are required to service an aircraft with gaseous oxygen. One man should be stationed at the control valves of the servicing equipment and one man stationed where he can observe the pressure in the aircraft system. Communication between the two men is required in case of an emergency. Aircraft should not be serviced with oxygen during fueling, defueling, or other maintenance work which could provide a source of ignition. Oxygen servicing of aircraft should be accomplished outside hangars.

Oxygen Hazards

Gaseous oxygen is chemically stable and is nonflammable; however, combustible materials ignite more rapidly and burn with greater intensity in an oxygen-rich atmosphere. In addition, oxygen combines with oil, grease, or bituminous material to form a highly explosive mixture which is sensitive to impact. Physical damage to, or failure of, oxygen containers, valves, or plumbing can result in explosive rupture, with danger to life and property. It is imperative that the highest standard of housekeeping be observed in handling oxygen and that only authorized persons be permitted to service aircraft.

In addition to aggravating the fire hazard, liquid oxygen will cause severe "burns" (frostbite) if it comes in contact with the skin because of its low temperature. (It boils at $-297°$ F.)

Only oxygen marked "Aviators Breathing Oxygen" which meets Federal Specification BB–0–925a. Grade A or equivalent may be used in aircraft breathing oxygen systems.

AIRCRAFT TIEDOWN

Aircraft tiedown is a very important part of aircraft ground handling. The type of tiedown will be determined by the prevailing weather conditions. In normal weather a limited or normal tiedown procedure is used; but when storm conditions are anticipated, a heavy weather or storm condition tiedown procedure should be employed.

Normal Tiedown Procedure

Small aircraft should be tied down after each flight to preclude damage from sudden storms. The direction in which aircraft are to be parked and tied down will be determined by prevailing or forecast wind direction.

Aircraft should be headed, as nearly as possible, into the wind, depending on the locations of the fixed, parking area tiedown points. Spacing of tiedowns should allow for ample wingtip clearance (figure 11–18). After the aircraft is properly located, lock the nosewheel or the tailwheel in the fore-and-aft position.

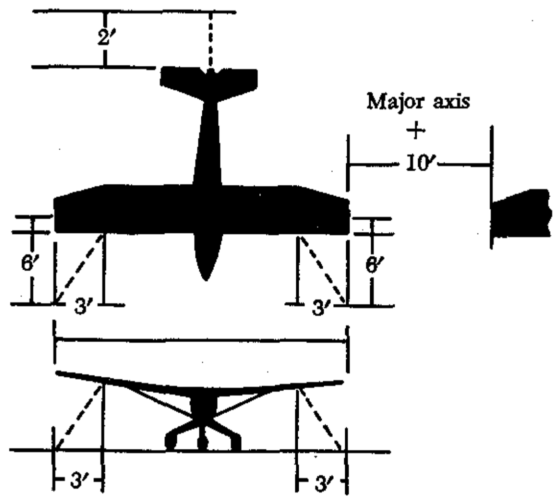


FIGURE 11–18. Diagram of tiedown dimensions.

Tiedown Anchors

All aircraft parking areas should be equipped for three-point tiedowns. This is facilitated at most airports by use of tiedown anchors installed in concrete parking areas. Tiedown anchors, sometimes called "pad eyes," are ringlike fittings installed when the parking area is poured. They are normally set flush with the surface of the concrete or no more than one inch above it. There are several types of tiedown anchors in use. The type selected is usually determined by the material used in aircraft parking areas, since it may be a concrete paved surface, a bituminous paved surface, or an unpaved turf area.

Location of tiedowns is usually indicated by some means such as white or yellow paint markings or by surrounding the tiedown anchor with crushed stone.

Tiedown anchors for small single-engine aircraft should provide a minimum holding power (strength) of approximately 3,000 pounds each. Although this minimum can be achieved when stake-driven tiedowns are used in dry or turfed areas, such stakes will almost invariably pull out

	Manila	Nylon	Dacron		Yellow Polypropylene	
Size (in.)	Minimum tensile strength (lbs.)	Minimum tensile strength (lbs.)	(Twist) Minimum tensile strength (lbs.)	(Braid) Minimum tensile strength (lbs.)	(Twist) Minimum tensile strength (lbs.)	(Braid) Minimum tensile strength (lbs.)
3/16	—	960	850	730	800	600
1/4	600	1,500	1,440	980	1,300	1,100
5/16	1,000	2,400	2,200	1,650	1,900	1,375
3/8	1,350	3,400	3,120	2,300	2,750	2,025
7/16	1,750	4,800	4,500	2,900	—	—
1/2	2,650	6,200	5,500	3,800	4,200	3,800
5/8	4,400	10,000	—	—	—	—
3/4	5,400	—	—	—	—	—
1	9,000	—	—	—	—	—

FIGURE 11–19. Comparison of common tiedown ropes.

when the ground becomes soaked from torrential rains which accompany hurricanes and some thunderstorms.

Tiedown Ropes

Tiedown ropes capable of resisting a pull of approximately 3,000 pounds should be used to

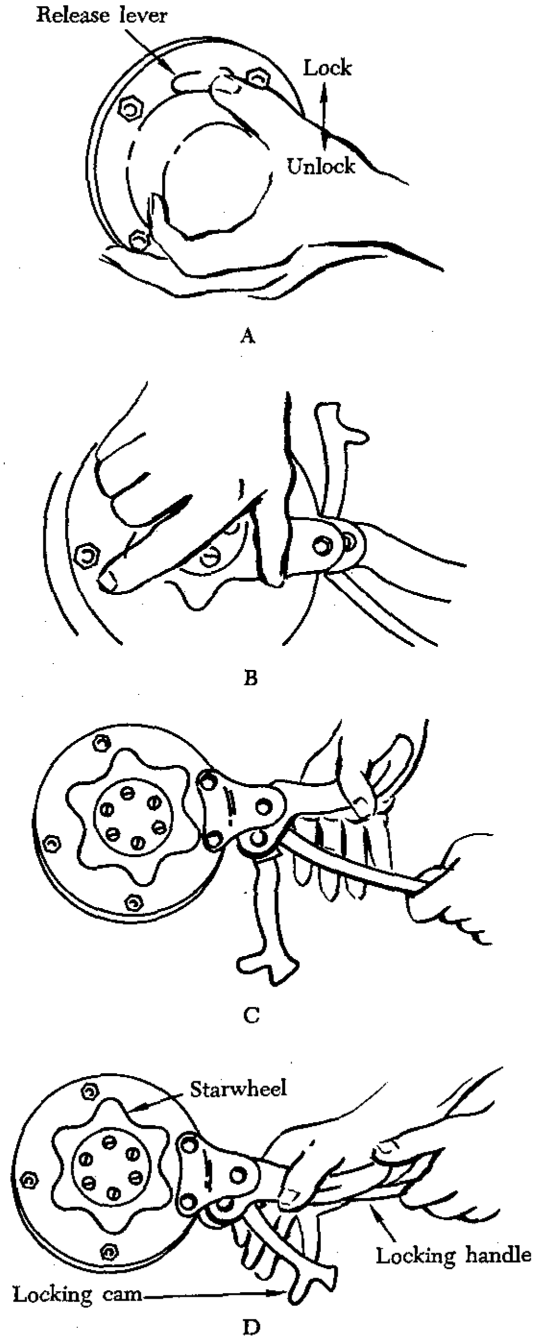


FIGURE 11–20. Operation of a cable tiedown reel.

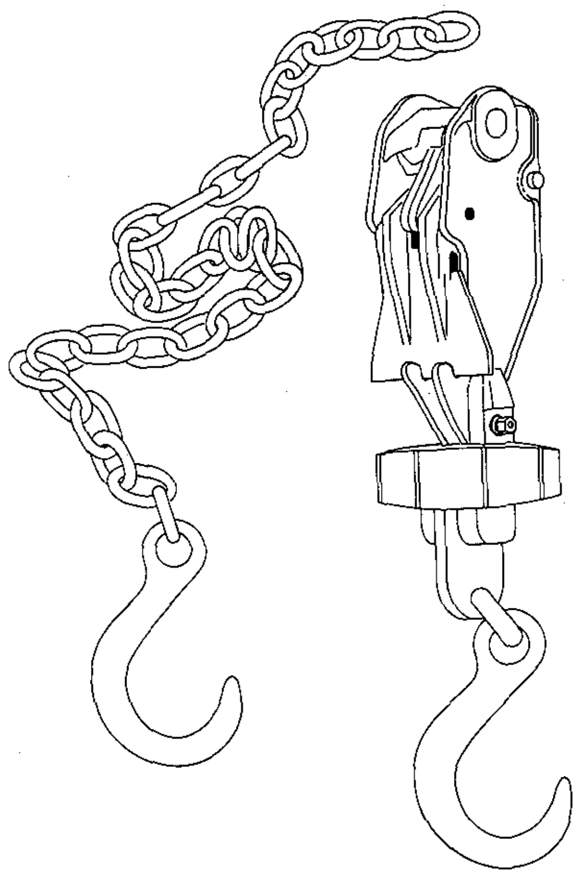


FIGURE 11–21. A multipurpose tiedown chain.

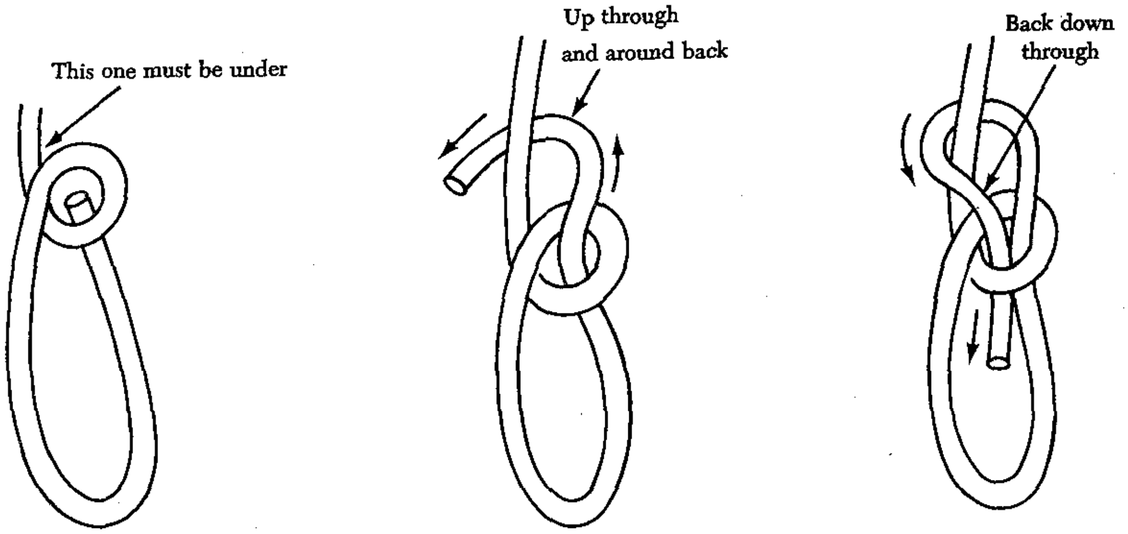
secure light aircraft. Cable or chain tiedown is usually preferred for tying down large aircraft.

Manila ropes should be inspected periodically for mildew and rot. Nylon or Dacron tiedown ropes are preferable to manila rope. The objection to manila rope is that it shrinks when wet, is subject to mildew or rot, and has considerably less tensile strength than either nylon or Dacron. Various types of commonly used tiedown rope are compared in figure 11–19.

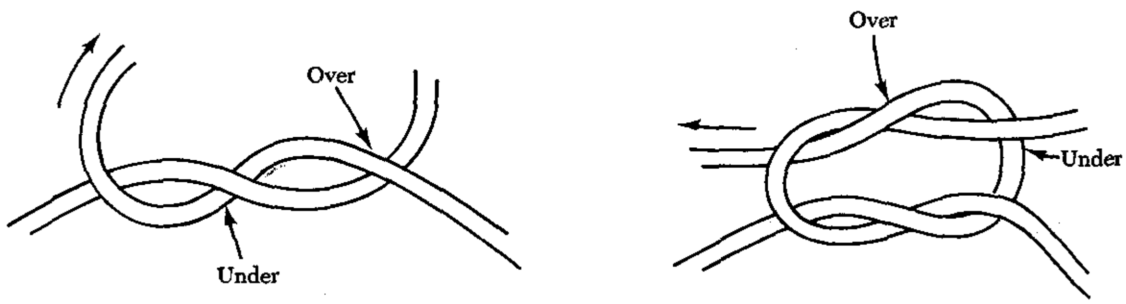
Tiedown Cable

Tiedown cables are often used to secure aircraft, especially in the case of large aircraft. Most cable-type tiedowns are accomplished with some form of tiedown reel designed for rapid and reliable securing of all types of aircraft. Figure 11–20 illustrates the operation of a typical cable tiedown reel.

In *A* of figure 11–20 the cable is released by depressing the release lever to provide cable slack. One end of the cable is then attached to the



(A) Tying a bowline knot.



(B) Tying a square knot.

FIGURE 11–22. Knots commonly used for aircraft tiedown.

aircraft tiedown ring and the other end to a tiedown anchor. The starwheel on the reel (*B* of figure 11–20) is then turned clockwise to remove excess slack from the cable. The locking handle is then secured to the bar when the cable has been adjusted for the desired tautness (*C* of figure 11–20). Finally, as shown in *D* of figure 11–20, the locking cam is secured to complete the tiedown procedure.

Tiedown Chains

The chain-type tiedown sometimes is used as a better and stronger tiedown to secure the heaviest aircraft. This tiedown assembly is composed of an all metal quick-release mechanism, a tensioning device, and a length of chain with hooks (figure 11–21).

SECURING LIGHT AIRCRAFT

Light aircraft are most often secured with ropes tied only at the aircraft tiedown rings provided for securing purposes. Rope should never be tied to a lift strut, since this practice can bend a strut if the rope slips to a point where there is no slack. Manila rope shrinks when wet; about 1 inch of slack should be provided for movement. Too much slack will allow the aircraft to jerk against the ropes. Tight tiedown ropes put inverted flight stresses on the aircraft, many of which are not designed to take such loads.

A tiedown rope holds no better than the knot. Antislip knots such as the bowline or square knots are quickly tied and are easy to untie (figure 11–22). Aircraft not equipped with tiedown fittings should be secured in accordance with the manufacturer's instructions. Ropes should be tied to outer ends of struts on high-wing monoplanes, and suitable rings should be provided where structural conditions permit, if the manufacturer has not already provided them.

SECURING HEAVY AIRCRAFT

The normal tiedown procedure for heavy aircraft can be accomplished with rope or cable tiedown. The number of such tiedowns should be governed by anticipated weather conditions.

Most heavy aircraft are equipped with surface control locks which should be engaged or installed when the aircraft is secured. Since the method of locking controls will vary on different type aircraft, check the manufacturer's instructions for proper installation or engaging procedures. In case high winds are anticipated, which may damage the control surfaces or locking devices, control surface battens can also be installed to prevent damage. Figure 11–23 illustrates four common tiedown points on heavy aircraft.

In general, the normal tiedown procedure for heavy aircraft should include the following:

1. Head airplane into prevailing wind whenever possible.
2. Install control locks, all covers and guards.
3. Chock all wheels fore and aft.
4. Attach tiedown reels to airplane tiedown loops and to tiedown anchors or tiedown stakes. Use tiedown stakes for temporary tiedown only. If tiedown reels are not available, ¼-inch wire cable or 1½-inch manila line may be used.

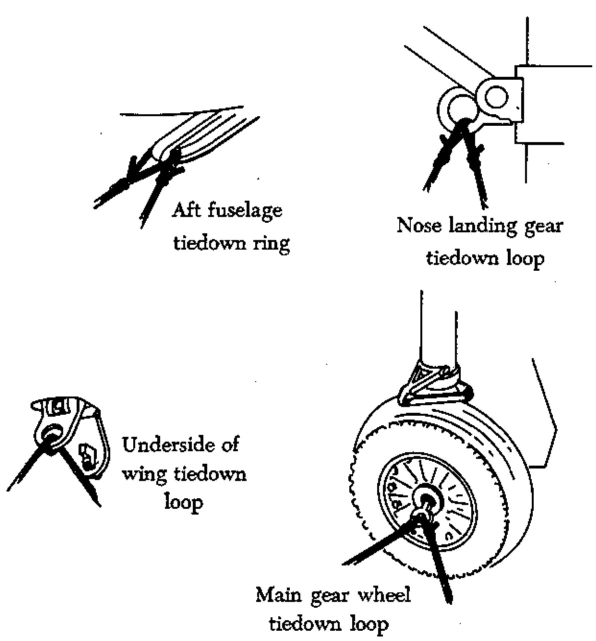


FIGURE 11–23. Common tiedown points.

AIRCRAFT TIEDOWN FOR STORM CONDITIONS

Each year many aircraft are needlessly damaged by windstorms because of negligence and improper tiedown procedures. A storm can turn a local airport into a junkyard in a matter of minutes. If an aircraft is damaged during a windstorm, the chances are it was improperly secured or was not tied down at all.

Most windstorm damage occurs during the early summer months, but can continue with lessening frequency throughout the year. As a general rule, the large and very severe windstorms cause less damage than the small local ones. This is because there is usually sufficient advance warning for the former, but the latter build up quickly and give little warning of their coming.

According to available weather records, Tampa, Florida, is the storm center of this country, with an average of 94 thunderstorms a year. Santa Fe, New Mexico, is second with a yearly average of 73. Other cities are less frequently visited by such storms. The Pacific Coast States average only one to four such storms a year. Generally speaking, thunderstorms and tornadoes are accompanied by high surface winds which account for most of the damage to aircraft on the ground.

Although most storms are generated in the daytime, many sections of the United States, including the Southwest, the lower Michigan Peninsula, and an extensive area centered in eastern Nebraska, are plagued with night storms during the summer months. Thunderstorms are bothersome in the Central States during the months of July, August, and September. On the other hand, in the winter the greatest storm activity takes place in the lower Mississippi Valley.

The map in figure 11–24 shows the yearly average number of days with thunderstorms based on observations from all U. S. Weather Bureau first-order stations in the United States. A thunderstorm day is considered any day during which one or more thunderstorms occur. It should be realized, however, that there probably are variations which do not show on this map because

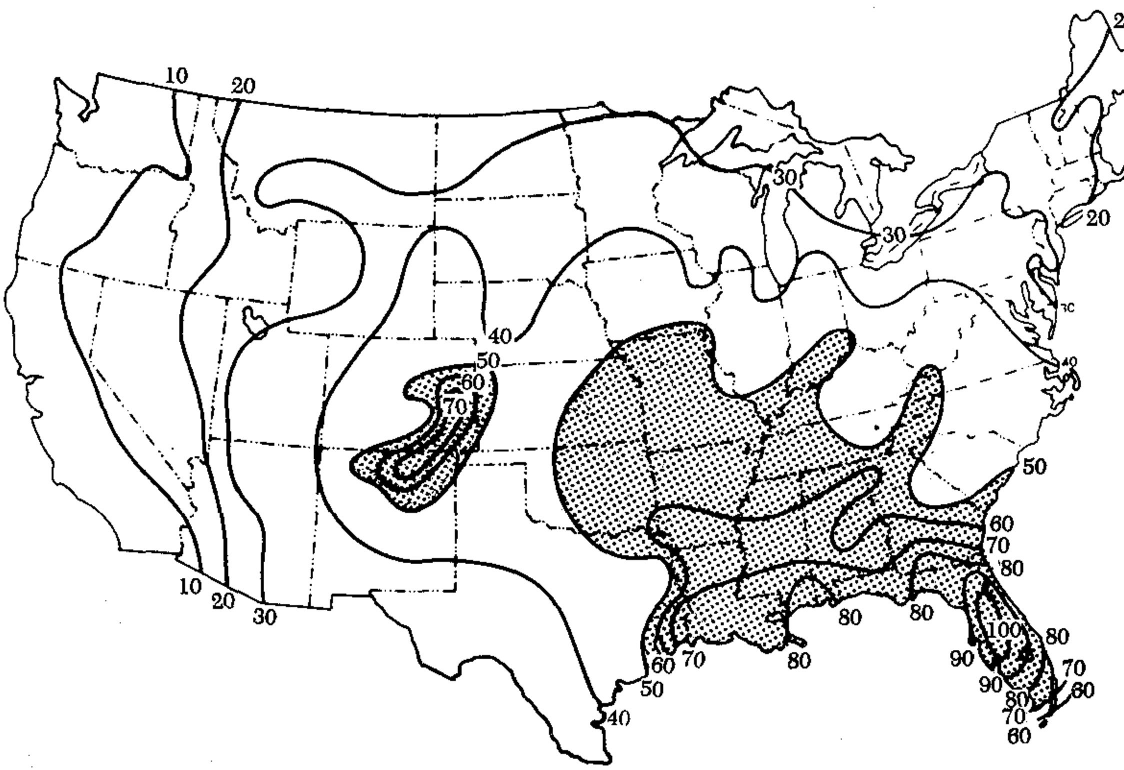


FIGURE 11–24. Map showing average number of thunderstorm days per year.

of the local nature of thunderstorms and the sparsity of observations from some areas. July and August are the months with the greatest number of thunderstorms over most sections of the United States, while December and January have the least number.

Thunderstorms are not the only concern of aircraft owners, fixed-base operators, airport service crews, etc., from a tiedown sense. There are also hurricanes and tornadoes. Figure 11–25 is a map showing the tornado frequency in the various states during a recent 10-year period.

A map showing the principal storm belts in the continental U.S.A. is presented in figure 11–26.

Precautions Against Windstorm Damage

The best protection against windstorm damage is, of course, to fly the aircraft out of the impending storm area when there is sufficient time. The next best protective measure is to secure the aircraft in a stormproof hangar or other suitable shelter. The remaining alternative is to assure that the aircraft is tied down securely. When securing aircraft, fasten all doors and windows properly to minimize damage inside the aircraft. Engine openings (intake and exhaust) for both reciprocating and gas-turbine type should be covered to prevent entry of foreign matter. Pitot-static tubes should also be covered to prevent damage.

Be prepared for the worst storm conditions; for example, pouring rain, and gusty winds with intermittent sheets of water flowing across the runways, ramps, and parking areas, with perhaps no hangar facilities available. With such conditions in mind, responsible service crews should plan in advance by becoming familiar with their aircraft manufacturer's instructions for the following: (1) Tiedown ropes; (2) installation of tiedown rings for attachment of tiedown ropes; (3) securing nosewheel type aircraft vs. tailwheel type aircraft; and (4) aircraft weights and relative wind velocities that would make varied tiedown procedures necessary for pending weather emergencies.

The following suggestions will materially reduce aircraft damage from windstorms:

1. Partially disassembled aircraft which are outdoors (particularly light aircraft with

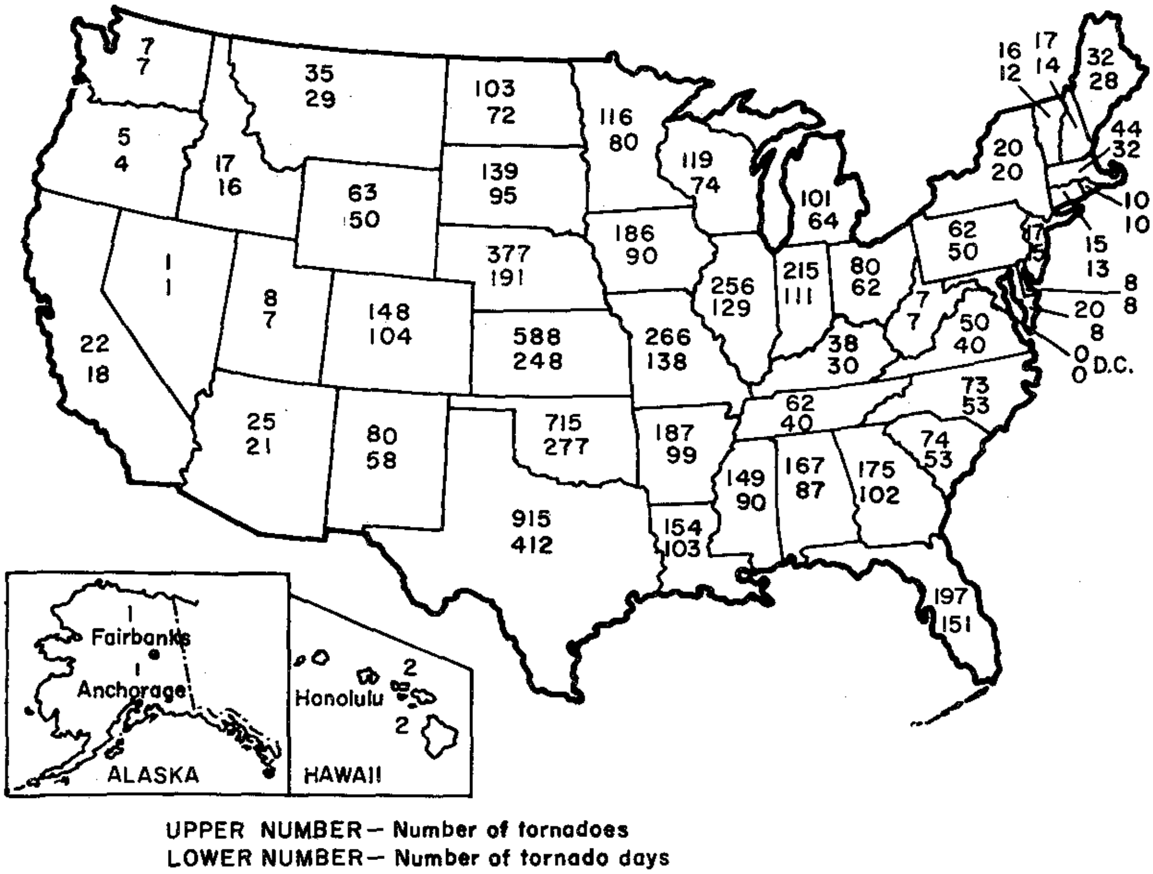


FIGURE 11–25. Tornado frequency during a recent 10-year period.

engines removed) should be hangared as soon as storm warnings are received. Loose wings should never be tied against a fuselage; they should be stored inside a hangar.

2. Whenever possible, fly aircraft out of anticipated storm danger zones. If impossible, hangar the aircraft in a storm-proof hangar.

3. Observe the minimum recommended strength for tiedown ropes.

4. A single row of properly secured sandbags or spoiler boards (2″ × 2′) on the top of a wing's leading edge will serve as an effective spoiler and reduce the lifting tendency of the wings. Do not overload the wings with sandbags. If the anticipated winds will exceed the lift-off speed of the aircraft, the makeshift spoilers should run the entire length of the wings.

Another means for tying down light aircraft (of various types and sizes) utilizes continuous lengths of parallel wire ropes passed through U-bolt anchors secured to ground tiedown points (figures 11–27 and 11–28). Tiedown chains are attached to the wire rope with round-pin galvanized anchor shackles. This allows tiedown chains to "float" along wire rope and gives a variable distance between anchor points so that a variety of aircraft can use a vertical tiedown without loss of space. The vertical anchor significantly reduces impact loads that may occur during gusty wind conditions. The distance between ropes will depend upon the types of aircraft which use the tiedown area.

The diagram in figure 11–28 shows a proper vertical anchor using wire rope tiedown line, straight link coil chain for connection between the wire rope and aircraft wing. One link on the free end is then passed through a link of the taut portion, and a safety snap is used to keep the link from passing back through. Any load on the chain is borne by the chain itself instead of the snap.

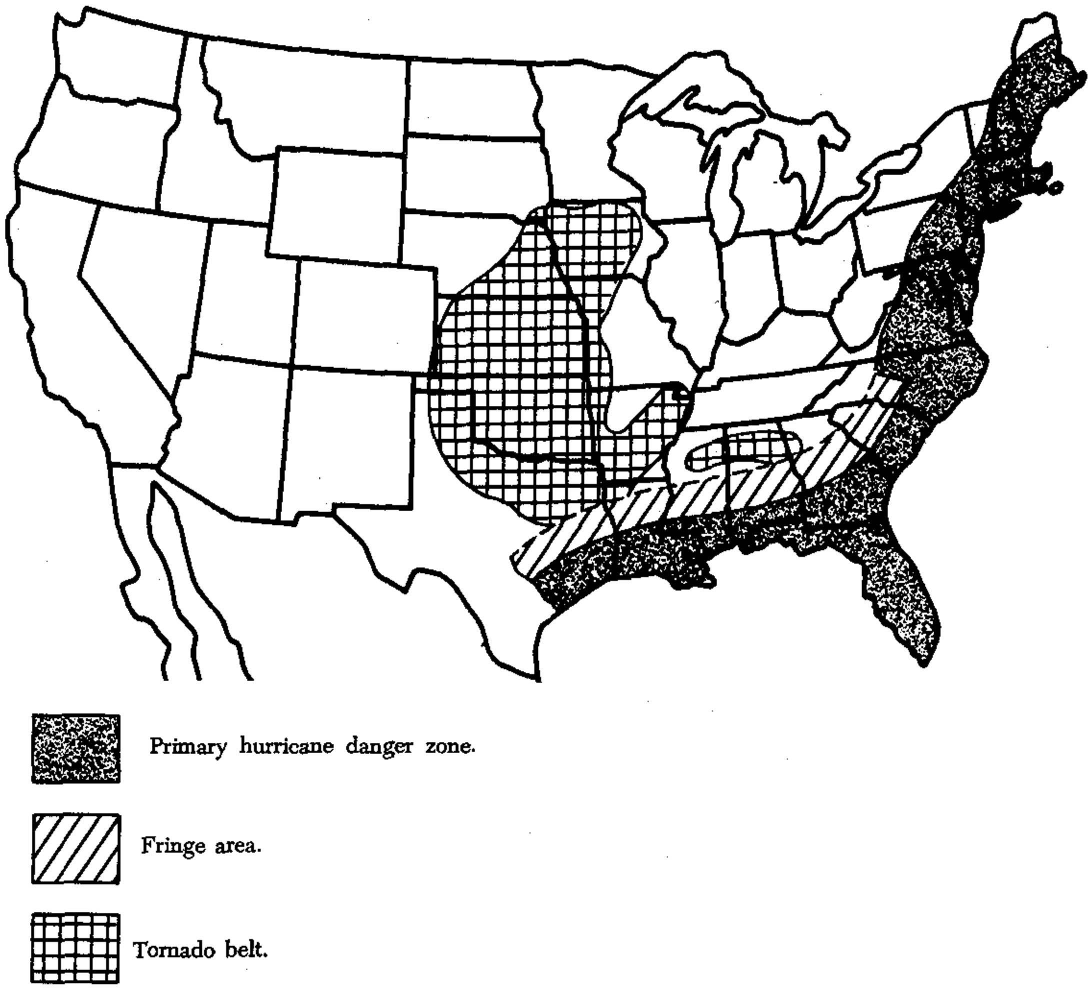


FIGURE 11–26. Storm belts in the continental U.S.

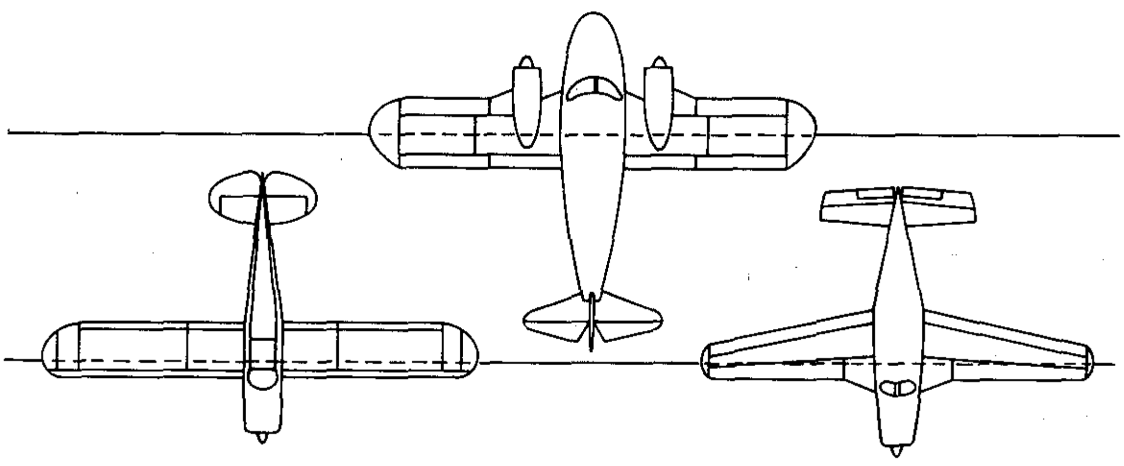


FIGURE 11–27. Typical aircraft tiedown using a wire rope system.

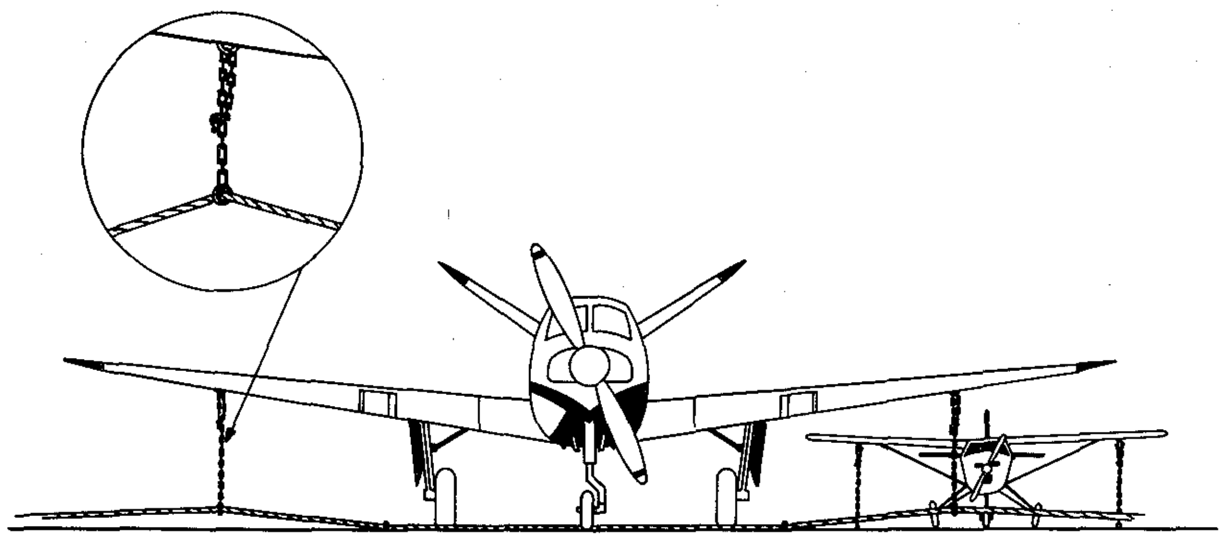


FIGURE 11–28. Wire rope tiedown line using vertical anchor chain.

Securing Multiengine Aircraft

Multiengine aircraft will obviously require stronger tiedown facilities because of the additional weight of these aircraft. The anchor should be capable of a holding power of 4,000 pounds each for the lighter executive twin-engine aircraft. Much higher load capacity is required for the heavier transport-type aircraft.

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

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

Securing Helicopters

Structural damage can occur from high-velocity surface winds. Therefore, if at all possible, helicopters should be evacuated to a safe area if tornadoes or hurricanes are anticipated.

When possible, helicopters should be secured in hangars. If not, they should be tied down securely. Helicopters that are tied down can usually sustain winds up to approximately 65 m.p.h.

For added protection, helicopters should be moved to a clear area so that they will not be damaged by flying objects or falling limbs from surrounding trees.

If high winds are anticipated with the helicopter parked in the open, the main rotor blades should be tied down. Detailed instructions for securing and mooring each type of helicopter can be found in the applicable maintenance manual. Methods of securing helicopters will vary with weather conditions, the length of time the aircraft is expected to remain on the ground, and location and characteristics of the aircraft. Wheel chocks, control locks, rope tiedowns, mooring covers, tip socks, tiedown assemblies, parking brakes, and rotor brakes are used to secure helicopters.

Typical mooring procedures are as follows:

1. Head the helicopter in the direction from which the highest forecasted wind or gusts are anticipated.
2. Spot the helicopter slightly more than rotor-span distance from other aircraft.
3. Place wheel chocks ahead of and behind all wheels (where applicable). On helicopters equipped with skids, retract the handling wheels, lower the helicopter to rest on the skids, and install wheel position lockpins.
4. Install a tiedown assembly on the end of the blade (figure 11–29 and align the blade over the tail boom. Secure the tiedown straps under the structural tubes of the tail boom. Tie the straps snugly without strain. During wet weather, provide some slack to avoid the possibility of the straps tightening.

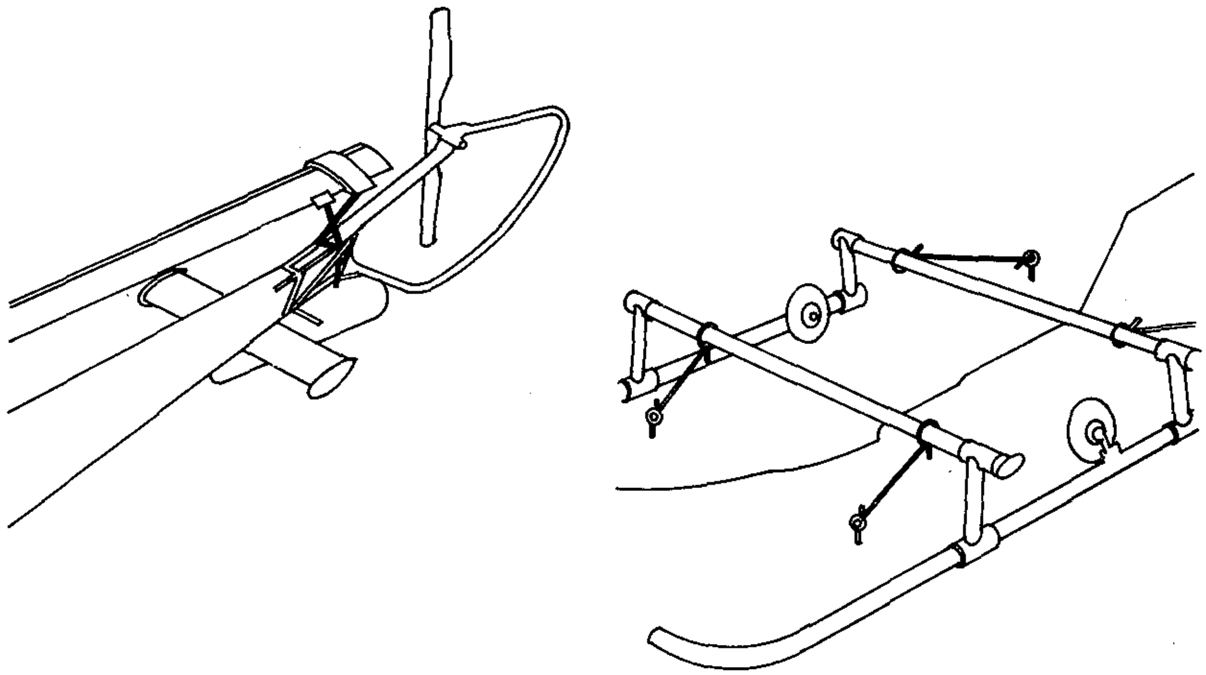


FIGURE 11–29. Securing helicopter blades and fuselage.

5. Fasten the tiedown ropes or cables to the forward and aft landing gear cross tubes and secure to ground stakes or tiedown rings.

Securing Seaplanes and Aircraft on Skis

Aircraft mounted on floats or skis should be secured to tiedown anchors or "deadmen" sunk under the water or ice. When warning of an impending storm is received and it is not possible to fly the aircraft out of the storm area, some compartments of the seaplane can be flooded, partially sinking the aircraft. In addition, the aircraft should be tied down securely to anchors. Seaplanes tied down on land have been saved from high-wind damage by filling the floats with water in addition to tying the aircraft down in the usual manner. Operators of ski-equipped aircraft sometimes pack soft snow around the skis, pour water on the snow, and permit the skis to freeze to the ice. This, in addition to the usual tiedown procedures, aids in preventing damage from windstorms.

MOVEMENT OF AIRCRAFT

General

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

Towing of Aircraft

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

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

Some types of tow bars available for general use (figure 11–30) can be used for many types of towing operations. These bars are designed with sufficient tensile strength to pull most aircraft, but are not intended to be subjected to torsional or twisting loads. Although many have small wheels that permit them to be drawn behind the towing vehicle going to or from an aircraft, they will suffer

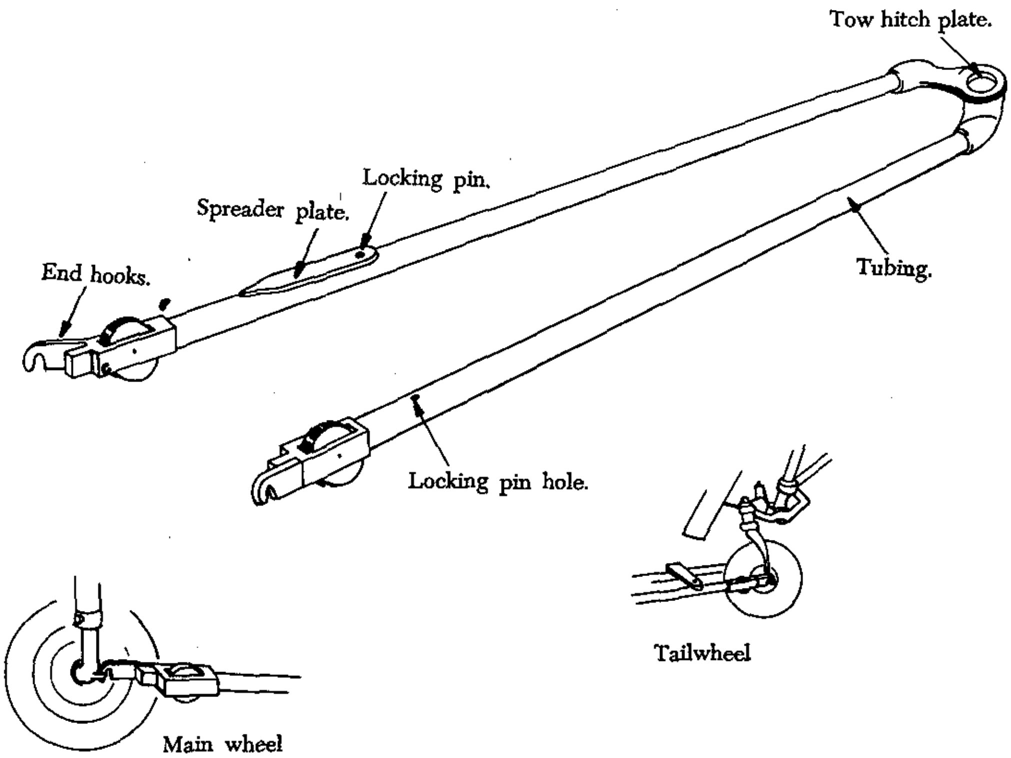


FIGURE 11–30. A front or rear tow bar.

less damage and wear if they are loaded aboard the vehicle and hauled to the aircraft. When the bar is attached to the aircraft, all the engaging devices should be inspected for damage or malfunction before moving the aircraft.

Some tow bars are designed for towing various types of aircraft; however, other special types can be used on a particular aircraft only. Such bars are usually designed and built by the aircraft manufacturer.

When towing the aircraft, the towing vehicle speed must be reasonable, and all persons involved in the operation must be alert.

When the aircraft is stopped, the brakes of the towing vehicle alone should not be relied upon to stop the aircraft. The man in the cockpit should coordinate the use of the aircraft brakes with those of the towing vehicle. A typical tow tractor (or tug) is shown in figure 11–31.

The attachment of the tow bar will vary on different types of aircraft. Aircraft equipped with tailwheels are generally towed forward by attaching the tow bar to the tow rings on the main landing gear. In most cases it is permissible to tow the aircraft in reverse by attaching the tow bar to the tailwheel axle. Anytime an aircraft equipped with a tailwheel is towed, the tailwheel must be unlocked or the tailwheel locking mechanism will be damaged or broken.

Aircraft equipped with tricycle landing gear are generally towed forward by attaching a tow bar to the axle of the nosewheel. They may also be towed forward or backward by attaching a towing bridle or specially designed towing bar to

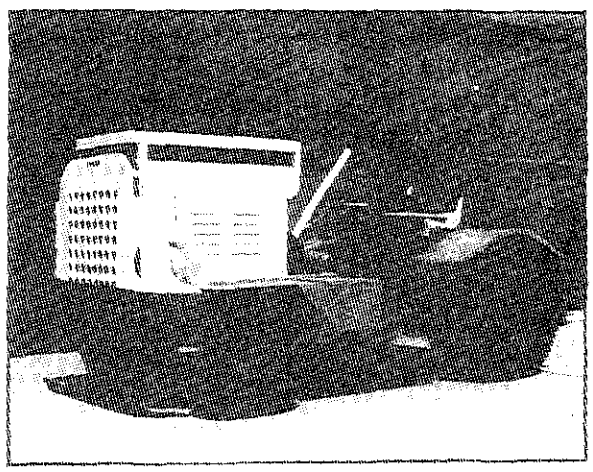


FIGURE 11–31. Tow tractor.

the towing lugs on the main landing gear. When an aircraft is towed in this manner, a steering bar is attached to the nosewheel to steer the aircraft.

The following towing and parking procedures are typical of one type of operation. They are examples, and not necessarily suited to every type of operation. Aircraft ground-handling personnel should be thoroughly familiar with all procedures pertaining to the types of aircraft being towed and local operating standards governing ground handling of aircraft. Only competent persons properly checked out should direct an aircraft towing team.

1. The towing vehicle driver is responsible for operating his vehicle in a safe manner and obeying emergency stop instructions given by any team member.
2. The person in charge should assign team personnel as wing walkers. A wing walker should be stationed at each wingtip in such a position that he can ensure adequate clearance of any obstruction in the path of the aircraft. A tail walker should be assigned when sharp turns are to be made, or when the aircraft is to be backed into position.
3. A qualified person should occupy the pilot's seat of the towed aircraft to observe and operate the brakes as required. When necessary, another qualified person is stationed to watch and maintain aircraft hydraulic system pressure.
4. The person in charge of the towing operation should verify that, on aircraft with a steerable nosewheel, the locking scissors are set to full swivel for towing. The locking device must be reset after the tow bar has been removed from the aircraft. Persons stationed in the aircraft should not attempt to steer or turn the nosewheel when the tow bar is attached to the aircraft.
5. Under no circumstances should anyone be permitted to walk or ride between the nosewheel of an aircraft and the towing vehicle, nor ride on the outside of a moving aircraft or on the towing vehicle. In the interest of safety, no attempt to board or leave a moving aircraft or towing vehicle should be permitted.
6. The towing speed of the aircraft should not exceed that of the walking team members. The aircraft's engines usually are not operated when the aircraft is being towed into position.
7. The aircraft brake system should be charged before each towing operation. Aircraft with faulty brakes should be towed into position only for repair of brake systems, and then only with personnel standing by ready with chocks for emergency use. Chocks must be immediately available in case of an emergency throughout any towing operation.
8. To avoid possible personal injury and aircraft damage during towing operations, entrance doors should be closed, ladders retracted, and gear downlocks installed.
9. Prior to towing any aircraft, check all tires and landing gear struts for proper inflation. (Inflation of landing gear struts of aircraft in overhaul and storage is excluded.)
10. When moving aircraft, do not start and stop suddenly. For added safety, aircraft brakes must never be applied during towing except in emergencies, and then only upon command by one of the tow team members.
11. Aircraft should be parked in specified areas only. Generally, the distance between rows of parked aircraft should be great enough to allow immediate access of emergency vehicles in case of fire, as well as free movement of equipment and materials.
12. Wheel chocks should be placed fore and aft of the main landing gear of the parked aircraft.
13. Internal or external control locks (gust locks or blocks) should be used while the aircraft is parked.
14. Prior to any movement of aircraft across runways or taxiways, contact the airport control tower on the appropriate frequency for clearance to proceed.
15. An aircraft should not be parked in a hangar without immediately being statically grounded.

Taxiing Aircraft

As a general rule, only rated pilots and qualified airframe and powerplant technicians are author-

Lights	*Meaning*
Flashing green	Cleared to taxi.
Steady red	Stop.
Flashing red	Taxi clear of runway in use.
Flashing white	Return to starting point.
Alternating red and green	Exercise extreme caution.

FIGURE 11–32. Standard taxi light signals.

ized to start, run up, and taxi aircraft. All taxiing operations should be performed in accordance with applicable local regulations. Figure 11–32 contains the standard taxi light signals used by control towers to control and expedite the taxiing of aircraft. Refer to the following section, "Taxi Signals," for detailed instructions on taxi signals and related taxi instructions.

FIGURE 11–33. The taxi signalman.

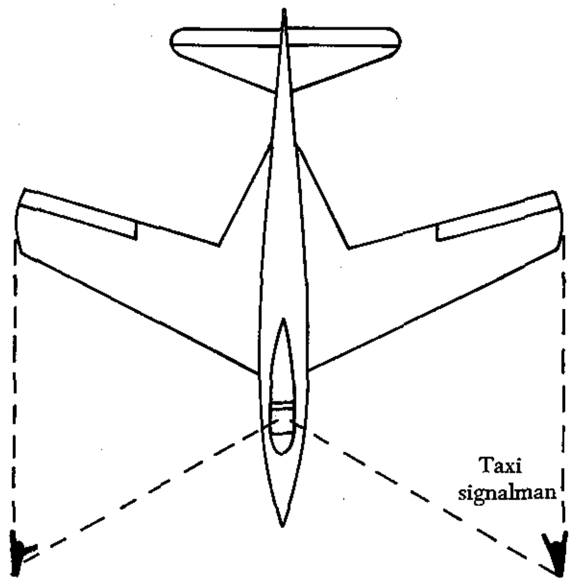


FIGURE 11–34. Position of the taxi signalman.

Taxi Signals

Many ground accidents have occurred as a result of improper technique in taxiing aircraft. Although the pilot is ultimately responsible for the aircraft until the engine is stopped, a taxi signalman can assist him around the flight line. In some aircraft configurations, the pilot's vision is obstructed while he is on the ground. He cannot see obstructions close to the wheels nor under the wings, and has little idea of what is behind him. Consequently, he depends upon the taxi signalman for directions. Figure 11–33 shows a taxi signalman indicating his readiness to assume guidance of the aircraft by extending both arms at full length above his head, palms facing each other.

The standard position for a signalman is slightly ahead of and in line with the aircraft's left wingtip. As the signalman faces the aircraft, the nose of the aircraft is on his left (figure 11–34). He must stay far enough ahead of the wingtip for the pilot to see him easily. He should follow a foolproof test to be sure the pilot can see his signals. If he can see the pilot's eyes, the pilot can see his signals.

Figure 11–35 shows the standard aircraft taxiing signals published in the Airmen's Information Manual by the Federal Aviation Administration. It should be emphasized that there are other standard signals, such as those published by the Armed Forces. In addition, operating conditions in many areas may call for a modified set of taxi

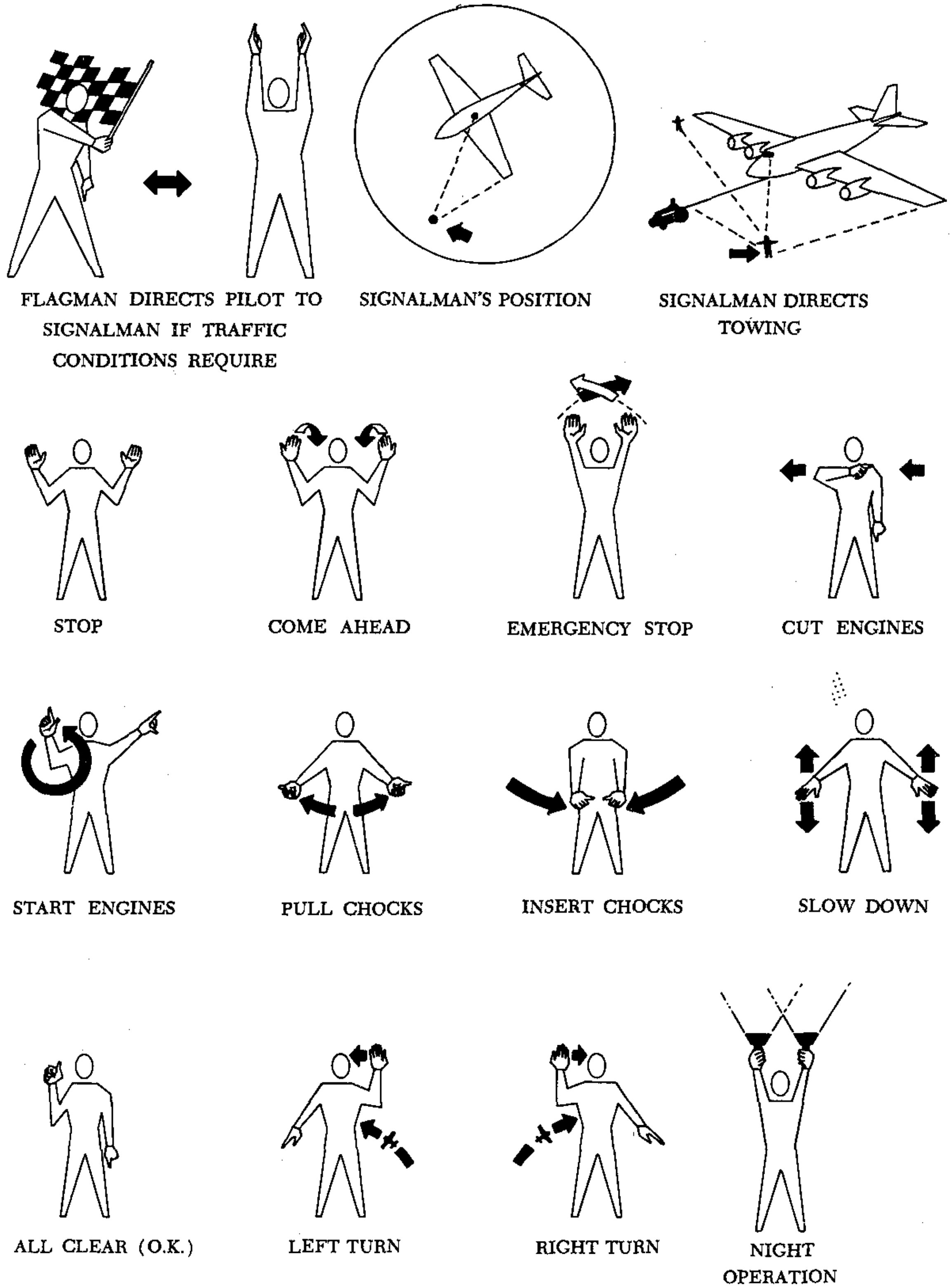


FIGURE 11–35. Standard FAA hand taxi signals.

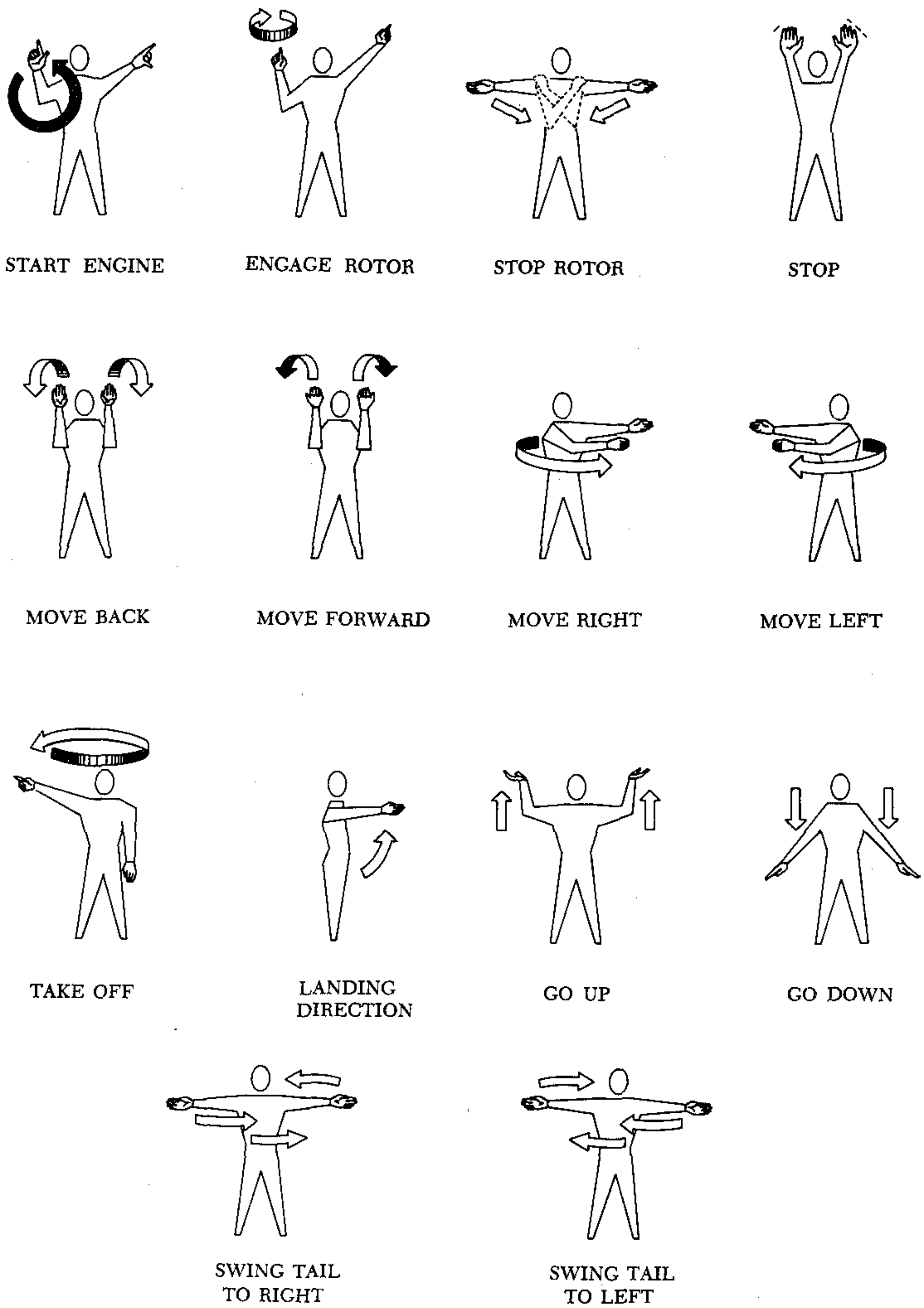


FIGURE 11–36. Helicopter operating signals.

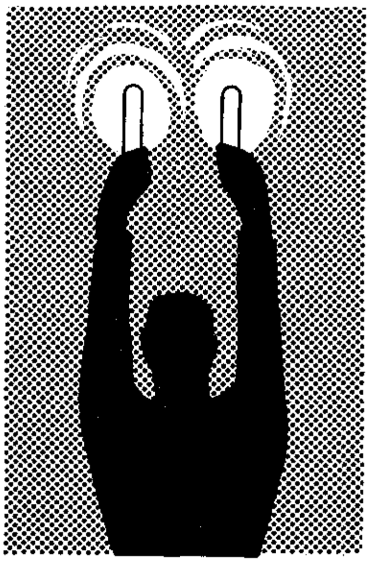


FIGURE 11–37. Night operations with wands.

signals. The signals shown in figure 11–35 represent a minimum number of the most commonly used signals. Whether this set of signals or a modified set is used is not the most important consideration, as long as each flight operational center uses a suitable, agreed-upon set of signals.

Figure 11–36 illustrates some of the most commonly used helicopter operating signals.

The taxi signals to be used should be studied until the taxi signalman can execute them clearly and precisely. The signals must be given in such a way that the pilot cannot confuse their meaning. It should be remembered that the pilot receiving the signals is always some distance away, and must often look out and down from a difficult angle. Thus, the signalman's hands should be kept well separated, and signals should be overexaggerated rather than risk making indistinct signals. If there is any doubt about a signal, or if the pilot does not appear to be following the signals, the "stop" signal should be used and the series of signals begun again.

The signalman should always try to give the pilot an indication of the approximate area in which the aircraft is to be parked. The signalman should glance behind himself often when walking backward to prevent backing into a propeller or tripping over a chock, fire bottle, tiedown line, or other obstruction.

Taxi signals are usually given at night with the aid of illuminated wands attached to flashlights (figure 11–37). Night signals are made in the same manner as day signals with the exception of the stop signal. The stop signal used at night is the "emergency stop" signal. This signal is made by crossing the wands to form a lighted "X" above and in front of the head.

JACKING AIRCRAFT

The aviation technician must be familiar with the jacking of aircraft in order to perform maintenance and inspection. Since jacking procedures and safety precautions vary for different types of aircraft, only general jacking procedures and precautions are discussed. Consult the applicable aircraft manufacturer's maintenance instructions for specific jacking procedures.

Extensive aircraft damage and serious personal injury have resulted from careless or improper jacking procedures. As an added safety measure, jacks should be inspected before use to determine the specific lifting capacity, proper functioning of safety locks, condition of pins, and general serviceability. Before raising an aircraft on jacks, all workstands and other equipment should be removed from under and near the aircraft. No one should remain in the aircraft while it is being raised or lowered, unless maintenance manual procedures require such practice for observing leveling instruments in the aircraft.

The aircraft to be jacked must be located in a

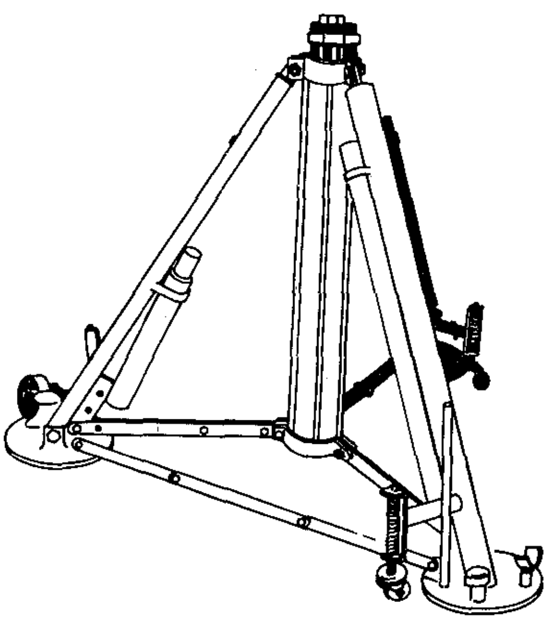


FIGURE 11–38. Typical tripod jack.

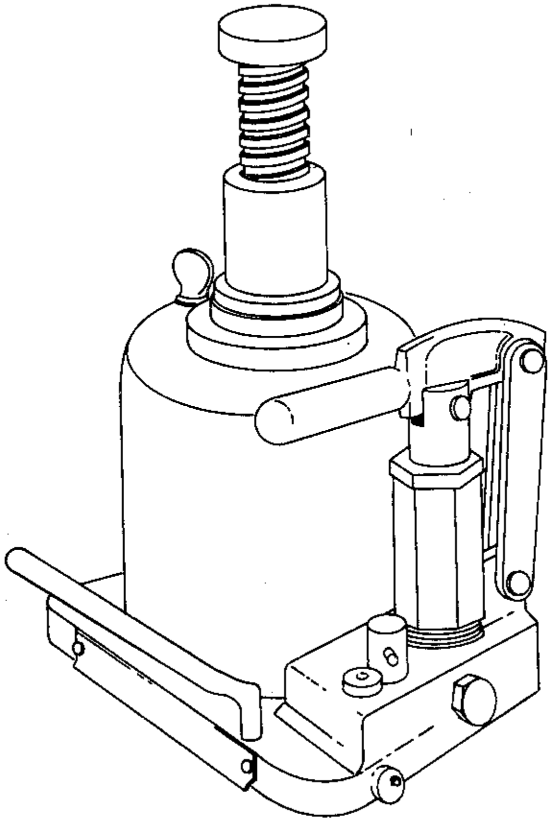


FIGURE 11–39. Typical single-base jack.

level position, well protected from the wind. A hangar should be used if possible. The manufacturer's maintenance instructions for the aircraft being jacked should be consulted for the location of the jacking points. These jacking points are usually located in relation to the aircraft center of gravity so the aircraft will be well balanced on the jacks. However, there are some exceptions to this. On some aircraft it may be necessary to add weight to the nose or tail of the aircraft to achieve a safe balance. Sandbags are usually used for this purpose.

Tripod jacks similar to the one shown in figure 11–38 are used when the complete aircraft is to be jacked.

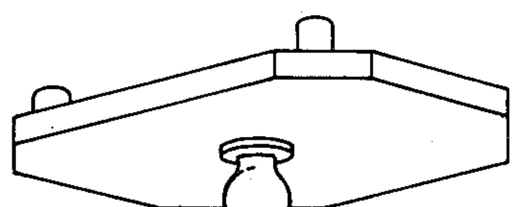
A small single-base jack similar to the one shown in figure 11–39 is used when only one wheel is to be raised. The jacks used for jacking aircraft must be maintained in good condition; a leaking or damaged jack must never be used. Also, each jack has a maximum capacity, which must never be exceeded.

Jacking Complete Aircraft

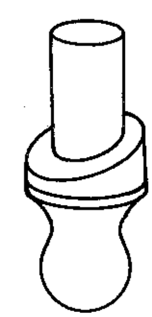
Prior to jacking the aircraft, an overall survey of the complete situation should be made to determine if any hazards to the aircraft or personnel exist. Tripod jacks of the appropriate size for the aircraft being jacked should be placed under the aircraft jacking points and perfectly centered to prevent them from cocking when the aircraft is raised. The legs of the jacks should be checked to see that they will not interfere with the operations to be performed after the aircraft is jacked, such as retracting the landing gear.

At least three places or points are provided on aircraft for jacking purposes; a fourth place on some aircraft is used to stabilize the aircraft while it is being jacked at the other three points. The two main places are on the wings, with a smaller one on the fuselage near either the tail or the nose, depending on the landing gear design.

Most aircraft have jack pads located at the jack points. Others have removable jack pads that are inserted into receptacles bolted in place prior to jacking. The correct jack pad should be used in all cases. The function of the jack pad is to ensure that the aircraft load is properly distributed at the jack point and to provide a convex bearing surface to mate with the concave jack stem. Figure 11–40 illustrates two types of jack pads.



Wing jack pad assembly



Forward jack fitting

FIGURE 11–40. Typical jack pads.

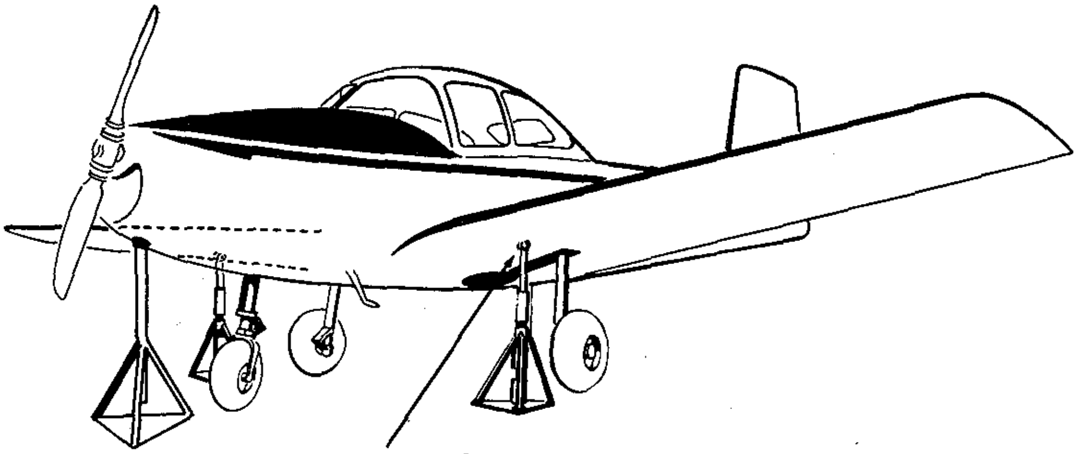


FIGURE 11–41. Jacking a complete aircraft.

Prior to jacking, determine if the aircraft configuration will permit jacking. There may be equipment or fuel which has to be removed if serious structural damage is to be avoided during jacking. If any other work is in progress on the aircraft, ascertain if any critical panels have been removed. On some aircraft the stress panels or plates must be in place when the aircraft is jacked to avoid structural damage.

Extend the jacks until they contact the jack pads. A final check for alignment of the jacks should be made before the aircraft is raised, since most accidents during jacking are the result of misalined jacks.

When the aircraft is ready to be raised, a man should be stationed at each jack. The jacks should be operated simultaneously to keep the aircraft as level as possible and to avoid overloading any of the jacks. This can be accomplished by having the crew leader stand in front of the aircraft and give instructions to the men operating the jacks. Figure 11–41 shows an aircraft being jacked.

Caution should be observed, since on many jacks the piston can be raised beyond the safety point; therefore, never raise an aircraft any higher than is necessary to accomplish the job.

The area around the aircraft should be secured while the aircraft is on jacks. Climbing on the aircraft should be held to an absolute minimum, and no violent movements should be made by persons who are required to go aboard. Any cradles or necessary supports should be placed under the fuselage or wings of the aircraft at the earliest possible time, particularly if the aircraft is to remain jacked for any length of time.

On collet-equipped jacks, the collet should be kept within two threads of the lift tube cylinder during raising, and screwed down firmly to the cylinder after jacking is completed to prevent settling.

Before releasing jack pressure and lowering the aircraft, make certain that all cribbing, work-stands, equipment, and persons are clear of the aircraft, that the landing gear is down and locked, and that all ground locking devices are properly installed.

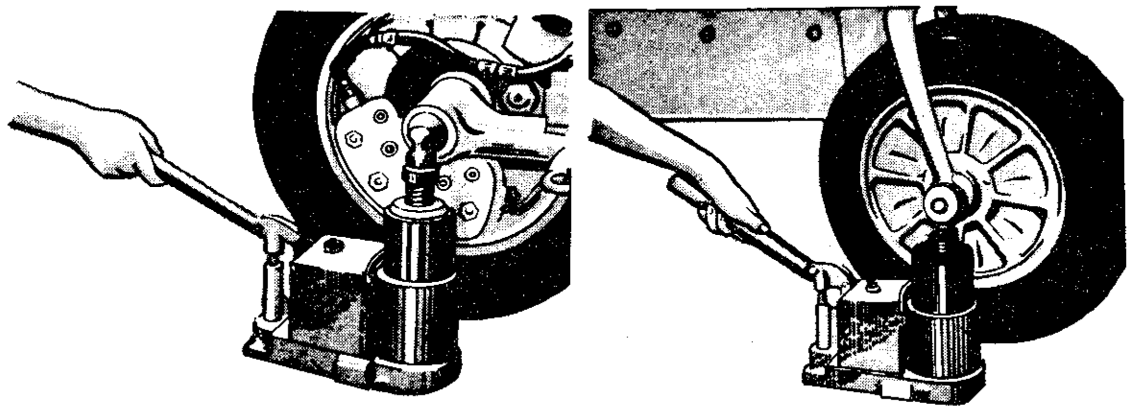
Jacking One Wheel of an Aircraft

When only one wheel has to be raised to change a tire or to grease wheel bearings, a low single-base jack is used. Before the wheel is raised, the remaining wheels must be chocked fore and aft to prevent movement of the aircraft. If the aircraft is equipped with a tailwheel, it must be locked. The wheel should be raised only high enough to clear the concrete surface. Figure 11–42 shows a wheel being raised using a single-base jack.

COLD WEATHER SUGGESTIONS

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

If the aircraft is to be parked in snow or ice



Main landing gear jack pad

Nose landing gear jack pad

FIGURE 11–42. Jacking one wheel.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

After a flight, the oil is diluted prior to shutdown of reciprocating engines equipped with an oil dilution system, if temperatures near or below freezing are expected before or at the time of the next start. When it is necessary to dilute the oil, consult the manufacturer's instructions for the applicable aircraft. These instructions should be strictly followed; otherwise the engine can be damaged.

When fueling aircraft, the fuel tanks should be left about 3 to 5 percent below maximum capacity. This allows for expansion in the event the aircraft is brought into the hangar prior to the next flight. Fuel expands approximately 1 percent for each 10° C. increase in temperature. If fuel tanks are filled to the normal levels, at a temperature of approximately 0° C. to 10° C., and later brought into a warm hangar (20° C.), the ensuing expansion will overflow the tanks, causing a fire hazard.

Tires should be inflated to load standards, regardless of possible rise in pressure under warmer conditions. Underinflation quickly causes overheat that would result in more tire damage and more possibility of blowout than a slight amount of overinflation. If a tire is frozen to the ground, it should be thawed with warm air or water and, moved before it re-freezes.

It is easy to exceed nose gear towing load limits in snow or slush. If the airplane must be towed in deep snow, it should be pulled by cables attached to the main landing gear lugs.

The aircraft battery should require no special attention other than the normal routine servicing.