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Aviation Maintenance Technician Handbook–General

U.S. Department of Transportation

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Aviation Maintenance Technician Handbook–General

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FEDERAL AVIATION ADMINISTRATION
Flight Standards Service

Preface

The *Aviation Maintenance Technician Handbook–General (FAA-H-8083-30A)* was developed as one of a series of three handbooks for persons preparing for mechanic certification with airframe or powerplant ratings, or both. It is intended that this handbook will provide basic information on principles, fundamentals, and technical procedures in the subject matter areas common to both the airframe and powerplant ratings. Emphasis in this volume is on theory and methods of application.

The handbook is designed to aid students enrolled in a formal course of instruction preparing for FAA certification as a maintenance technician as well as for current technicians who wish to improve their knowledge. This volume contains information on mathematics, aircraft drawings, weight and balance, aircraft materials, processes and tools, physics, electricity, inspection, ground operations, and FAA regulations governing the certification and work of maintenance technicians. New to this volume is a section addressing how successful aviation maintenance technicians incorporate knowledge and awareness of ethics, professionalism and human factors in the field.

Because there are so many different types of airframes and powerplants in use today, it is reasonable to expect that differences exist in the components and systems of each. To avoid undue repetition, the practice of using representative systems and units is implemented throughout the handbook. Subject matter treatment is from a generalized point of view, and should be supplemented by reference to manufacturers' manuals or other textbooks if more detail is desired. This handbook is not intended to replace, substitute for, or supersede official regulations or the manufacturers' instructions.

The companion handbooks to *Aviation Maintenance Technician Handbook–General (FAA-H-8083-30A)* are the *Aviation Maintenance Technician Handbook–Airframe (FAA-H-8083-31 (as amended))*, and the *Aviation Maintenance Technician Handbook–Powerplant (FAA-H-8083-32 (as amended))*.

This handbook is available for download, in pdf format, from www.faa.gov. Please visit this website for the latest version of all FAA handbooks.

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Chapter 1

Safety, Ground Operations, and Servicing

Aircraft maintenance technicians (AMTs) devote a portion of their aviation career to ground handling and operating aircraft. Technicians also need to be proficient in operating ground support equipment. The complexity of support equipment and the hazards involved in the ground handling of aircraft require that maintenance technicians possess a detailed knowledge of safety procedures used in aircraft servicing, taxiing, run-up, and in the use of ground support equipment. The information provided in this chapter is intended as a general guide for safely servicing and operating aircraft.

Introducing human factors to aircraft maintenance personnel makes them aware of how it affects maintenance performance. Although there are many human factors involved when dealing with maintenance performance, several areas can be considered. Some of these include fatigue, deadline pressure, stress, distractions, poor communication skills, complacency, and lack of information. Maintenance technicians need to understand how human factors can impact their performance and safety while completing maintenance tasks.

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

Shop Safety

Keeping the shop, hangars, and flight line clean is essential to safety and efficient maintenance. The highest standards of orderly work arrangements and cleanliness must be observed during the maintenance of aircraft. Where continuous work shifts are established, the outgoing shift removes and properly stores personal tools, rollaway boxes, work stands, maintenance stands, hoses, electrical cords, hoists, crates, and boxes that were needed for the work to be accomplished.

Signs are posted to indicate dangerous equipment or hazardous conditions. Additionally, there are signs that provide the location of first aid and fire equipment. Safety lanes, pedestrian walkways, and fire lanes are painted around the perimeter inside the hangars. This is a safety measure to prevent accidents and to keep pedestrian traffic out of work areas.

Safety is everyone's business. However, technicians and supervisors must watch for their own safety and for the safety of others working around them. Communication is key to ensuring everyone's safety. If other personnel are conducting their actions in an unsafe manner, communicate with them, reminding them of their safety and that of others around them.

Electrical Safety

Physiological Safety

Working with electrical equipment poses certain physiological safety hazards. When electricity is applied to the human body, it can create severe burns in the area of entrance and at the point of exit from the body. In addition, the nervous system is affected and can be damaged or destroyed. To safely deal with electricity, the technician must have a working knowledge of the principles of electricity and a healthy respect for its capability to do both work and damage.

Wearing or use of proper safety equipment can provide a psychological assurance and physically protect the user at the same time. The use of rubber gloves, safety glasses, rubber or grounded safety mats, and other safety equipment contributes to the overall safety of the technician working on or with electrical equipment.

Two factors that affect safety when dealing with electricity are fear and overconfidence. These two factors are major causes of accidents involving electricity. While a certain amount of respect for electrical equipment is healthy and a certain level of confidence is necessary, extremes of either can be deadly.

Lack of respect is often due to lack of knowledge. Personnel who attempt to work with electrical equipment and have no knowledge of the principles of electricity lack the skills to deal with electrical equipment safely. Overconfidence leads to risk taking. The technician who does not respect the capabilities of electricity will, sooner or later, become a victim of electricity's power.

Fire Safety

Anytime current flows, whether during generation or transmission, a by-product is heat. The greater the current flow, the greater the amount of heat created. When this heat becomes too great, protective coatings on wiring and other electrical devices can melt, causing shorting. That in turn leads to more current flow and greater heat. This heat can become so great that metals can melt, liquids vaporize, and flammable substances ignite.

An important factor in preventing electrical fires is to keep the area around electrical work or electrical equipment clean, uncluttered, and free of all unnecessary flammable substances. Ensure that all power cords, wires, and lines are free of kinks and bends that can damage the wire. Never place wires or cords where they may be walked on or run over by other equipment. When several wires inside a power cord are broken, the current passing through the remaining wires increases. This generates more heat than the insulation coatings on the wire are designed to withstand and can lead to a fire. Closely monitor the condition of electrical equipment. Repair or replace damaged equipment before further use.

Safety Around Compressed Gases

Compressed air, like electricity, is an excellent tool when it is under control. A typical nitrogen bottle set is shown in *Figure 1-1*. The following "dos and don'ts" apply when working with or around compressed gases:

- Inspect air hoses frequently for breaks and worn spots. Unsafe hoses must be replaced immediately.
- Keep all connections in a "no-leak condition."
- Maintain in-line oilers, if installed, in operating condition.
- Ensure the system has water sumps installed and drained at regular intervals.
- Filter air used for paint spraying to remove oil and water.
- Never use compressed air to clean hands or clothing. Pressure can force debris into the flesh leading to infection.
- Never spray compressed air in the area of other personnel.
- Straighten, coil, and properly store air hoses when not in use.

Figure 1-1. *A typical nitrogen bottle.*

- Many accidents involving compressed gases occur during aircraft tire mounting. To prevent possible personal injury, use tire dollies and other appropriate devices to mount or remove heavy aircraft tires.

When inflating tires on any type of aircraft wheels, always use tire cage guards. Extreme caution is required to avoid over inflation of high-pressure tires because of possible personal injury. Use pressure regulators on high-pressure air bottles to eliminate the possibility of over inflation of tires. Tire cages are not required when adjusting pressure in tires installed on an aircraft.

Safety Around Hazardous Materials

Material safety diamonds are important with regard to shop safety. These diamond-shaped labels are a simple and quick way to determine the risk of hazardous material within the associated container and, if used properly with the tags, indicate what personal safety equipment to use.

The most observable portion of the Safety Data Sheets (SDSs) (formerly known as Material Safety Data Sheet (MSDS)) label is the risk diamond. It is a four-color segmented diamond that represents flammability (red), reactivity (yellow), health (blue), and special hazard (white). In the flammability, reactivity, and health blocks, there is a number from 0 to 4. Zero represents little or no hazard to the user, while 4 means that the material is very hazardous. The special hazard segment contains a word or abbreviation to represent the specific hazard. Some examples are RAD for radiation, ALK for alkali materials, Acid for acidic materials, and CARC for carcinogenic materials. The letter W with a line through it stands for high reactivity to water. *[Figure 1-2]*

The SDS is a more detailed version of the chemical safety issues. These forms have the detailed breakdown of the chemicals, including formulas and action to take if personnel come in contact with the chemicals. All sheets have the same information requirements; however, the exact location of the information on the sheet may vary depending on the SDS manufacturer. These forms are necessary for a safe shop that meets all the requirements of the governing safety body, the U.S. Department of Labor Occupational Safety and Health Administration (OSHA).

Safety Around Machine Tools

Hazards in a shop increase when the operation of lathes, drill presses, grinders, and other types of machines are used. Each machine has its own set of safety practices. The following discussions are necessary to avoid injury.

The drill press can be used to bore and ream holes, to do facing, milling, and other similar types of operations. The

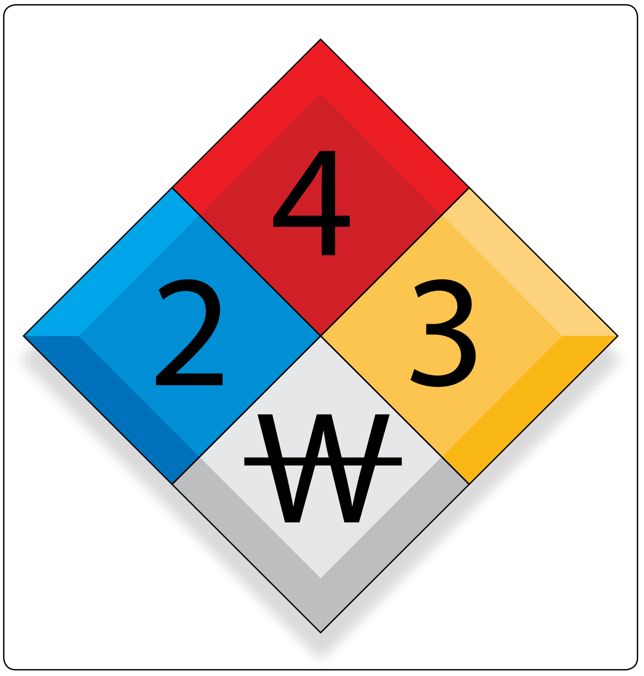


Figure 1-2. *A risk diamond.*

following precautions can reduce the chance of injury:

- Wear eye protection.
- Securely clamp all work.
- Set the proper revolutions per minute (RPM) for the material used.
- Do not allow the spindle to feed beyond its limit of travel while drilling.
- Stop the machine before adjusting work or attempting to remove jammed work.
- Clean the area when finished.

Lathes are used in turning work of a cylindrical nature. This work may be performed on the inside or outside of the cylinder. The work is secured in the chuck to provide the rotary motion, and the forming is done by contact with a securely mounted tool. The following precautions can reduce the chance of injury:

- Wear eye protection.
- Use sharp cutting tools.
- Allow the chuck to stop on its own. Do not attempt to stop the chuck by hand pressure.
- Examine tools and work for cracks or defects before starting the work.
- Do not set tools on the lathe. Tools may be caught by the work and thrown.
- Before measuring the work, allow it to stop in the lathe.

Milling machines are used to shape or dress; cut gear teeth, slots, or key ways; and similar work. The following precautions can reduce the chance of injury:

- Wear eye protection.
- Clean the work bed prior to work.
- Secure the work to the bed to prevent movement during milling.
- Select the proper tools for the job.
- Do not change the feed speed while working.
- Lower the table before moving under or away from the work.
- Ensure all clamps and bolts are passable under the arbor.

Grinders are used to sharpen tools, dress metal, and perform other operations involving the removal of small amounts of metal. The following precautions can reduce the chance of injury:

- Wear eye protection, even if the grinder has a shield.
- Inspect the grinding wheel for defects prior to use.
- Do not force grinding wheels onto the spindle. They fit snugly but do not require force to install them. Placing side pressure on a wheel could cause it to explode.
- Check the wheel flanges and compression washer. They should be one-third the diameter of the wheel.
- Do not stand in the arc of the grinding wheel while operating in case the wheel explodes.

Welding must be performed only in designated areas. Any part that is to be welded must be removed from the aircraft, if possible. Repair would then be accomplished in a controlled environment, such as a welding shop. A welding shop must 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, observe these precautions:

- During welding operations, open fuel tanks and work on fuel systems are not permitted.
- Painting is not permitted.
- No aircraft are to be within 35 feet of the welding operation.
- No flammable material is permitted in the area around the welding operation.
- Only qualified welders are permitted to do the work.
- The welding area is to be roped off and placarded.
- Fire extinguishing equipment of a minimum rating of 20B must be in the immediate area with 80B rated equipment as a backup.
- Trained fire watches are to be present in the area around the welding operation.
- The aircraft being welded must be in a towable condition, with a tug attached, and the aircraft parking brakes released. A qualified operator must be on the tug and mechanics available to assist in the towing operation should it become necessary to tow the aircraft. If the aircraft is in the hangar, the hangar doors are to be open.

Flight Line Safety

Hearing Protection

The flight line is a place of dangerous activity. Technicians who perform maintenance on the flight line must constantly be aware of what is going on around them. The noise on a flight line comes from many places. Aircraft are only one source of noise. There are auxiliary power units (APUs), fuel trucks, baggage handling equipment, and so forth. Each has its own frequency of sound. Combined all together, the noise on the ramp or flight line can cause hearing loss.

There are many types of hearing protection available. Hearing protection can be external or internal. Earmuffs or headphones are considered external protection. The internal type of hearing protection fits into the auditory canal. Both types reduce the sound level reaching the eardrum and reduce the chances of hearing loss.

Hearing protection is essential when working with pneumatic drills, rivet guns, or other loud tools. Even short duration exposure to these sounds can cause hearing loss because of their high frequency. Continued exposure will cause hearing loss.

Foreign Object Damage (FOD)

Foreign object damage (FOD) is any damage to aircraft, personnel, or equipment caused by any loose object. These loose objects can be anything, such as broken runway concrete, shop towels, safety wire, etc. To control FOD, keep ramp and operation areas clean, have a tool control program, and provide convenient receptacles for used hardware, shop towels, and other consumables.

Never leave tools or other items around the intake of a turbine engine. The modern gas turbine engine creates a low-pressure area in front of the engine that causes any loose object to be drawn into the engine. The exhaust of these engines can propel loose objects great distances with enough force to damage anything that is hit. The importance of a FOD program cannot be overstressed when a technician considers the cost of engines, components, or a human life.

Safety Around Airplanes

As with the previously mentioned items, it is important to be aware of propellers. Technicians cannot assume the pilot of a taxiing aircraft can see them and must stay within the pilot's view while on the ramp area. Turbine engine intakes and exhaust can also be very hazardous areas. Smoking or open flames are not permitted anywhere near an aircraft in operation. Be aware of aircraft fluids that can be detrimental to skin. When operating support equipment around aircraft, be sure to allow space between it and the aircraft, and secure it so it cannot roll into the aircraft. All items in the area of operating aircraft must be stowed properly.

Safety Around Helicopters

Every type of helicopter has different features. These differences must be learned to avoid damaging the helicopter or injuring the technician. When approaching a helicopter while the blades are turning, adhere to the following guidelines to ensure safety.

- Observe the rotor head and blades to see if they are level. This allows maximum clearance when approaching the helicopter.
- Approach the helicopter in view of the pilot.
- Never approach a helicopter carrying anything with a vertical height that the blades could hit. This could cause blade damage and injury to the individual.
- Never approach a single-rotor helicopter from the rear. The tail rotor is invisible when operating.
- Never go from one side of the helicopter to the other by going around the tail. Always go around the nose of the helicopter.

When securing the rotor on helicopters with elastomeric bearings, check the maintenance manual for the proper method. Using the wrong method could damage the bearing.

Fire Safety

Performing maintenance on aircraft and their components requires the use of electrical tools that can produce sparks, heat-producing tools and equipment, flammable and explosive liquids, and gases. As a result, a high potential exists for fire to occur. Measures must be taken to prevent a fire from occurring and to have a plan for extinguishing it.

The key to fire safety is knowledge of what causes a fire, how to prevent it, and how to put it out. This knowledge must be instilled in each technician, emphasized by their supervisors through sound safety programs, and occasionally practiced. Airport or other local fire departments can normally be called upon to assist in training personnel and helping to establish fire safety programs for the hangar, shops, and flight line.

Fire Protection

Requirements for Fire to Occur

Three things are required for a fire. Remove any one of these things and the fire extinguishes:

1. Fuel—combines with oxygen in the presence of heat, releasing more heat. As a result, it reduces itself to other chemical compounds.
2. Heat—accelerates the combining of oxygen with fuel, in turn releasing more heat.
3. Oxygen—the element that 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 1-3]*

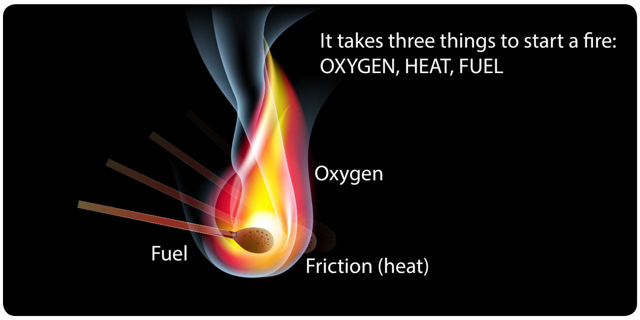


Figure 1-3. *Three elements of fire.*

Classification of Fires

For commercial purposes, the National Fire Protection Association (NFPA) has classified fires into three basic types: Class A, Class B, and Class C.

1. Class A fires involve ordinary combustible materials, such as wood, cloth, paper, upholstery materials, and so forth.
2. Class B fires involve flammable petroleum products or other flammable or combustible liquids, greases, solvents, paints, and so forth.
3. Class C fires involve energized electrical wiring and equipment.

A fourth class of fire, the Class D fire, involves flammable metal. Class D fires are not commercially considered by the NFPA to be a basic type of fire since they are caused by a Class A, B, or C fire. Usually Class D fires involve magnesium in the shop, or in aircraft wheels and brakes, or are the result of improper welding operations.

Any one of these fires can occur during maintenance on or around, or operations involving aircraft. There is a particular type of extinguisher that is most effective for each type of fire.

Types and Operation of Shop and Flight Line Fire Extinguishers

Water extinguishers are the best type to use on Class A fires. Water has two effects on fire. It deprives fire of oxygen and cools the material being burned.

Since most petroleum products float on water, water-type fire extinguishers are not recommended for Class B fires. Extreme caution must be used when fighting electrical fires (Class C) with water-type extinguishers. All electrical power must be removed or shut off to the burning area. Additionally, residual electricity in capacitors, coils, and so forth must be considered to prevent severe injury or possibly death from electrical shock.

Never use water-type fire extinguishers on Class D fires. The cooling effect of water causes an explosive expansion of the metal, because metals burn at extremely high temperatures.

Water fire extinguishers are operated in a variety of ways. Some are hand pumped, while others are pressurized. The pressurized types of extinguishers may have a gas charge stored in the container with the water, or it may contain a "soda-acid" container where acid is spilled into a container of soda inside the extinguisher. The chemical reaction of the soda and the acid causes pressure to build inside the fire extinguisher, forcing the water out.

Carbon dioxide (CO_2) extinguishers are used for Class A, B, and C fires, extinguishing the fire by depriving it of oxygen. *[Figure 1-4]* Additionally, like water-type extinguishers, CO_2 cools the burning material. Never use CO_2 on Class D fires. As with water extinguishers, the cooling effect of CO_2 on the hot metal can cause explosive expansion of the metal.

Figure 1-4. *Carbon dioxide fire extinguisher.*

When using CO_2 fire extinguishers, all parts of the extinguisher can become extremely cold, and remain so for a short time after operation. Wear protective equipment or take other precautions to prevent cold injury, such as frostbite. Extreme caution must be used when operating CO_2 fire extinguishers in closed or confined areas. Not only can the fire be deprived of oxygen, but so too can the operator.

CO_2 fire extinguishers generally use the self-expelling method of operation. This means that the CO_2 has sufficient pressure at normal operating pressure to expel itself. This pressure is held inside the container by some type of seal or frangible disk that is broken or punctured by a firing mechanism, usually a pin. This means that once the seal or disk is broken, pressure in the container is released and the fire extinguisher is spent, requiring replacement. *[Figure 1-5]*

Halogenated hydrocarbon extinguishers are most effective on Class B and C fires. They can be used on Class A and D fires, but they are less effective. Halogenated hydrocarbon, commonly called Freon™ by the industry, are numbered according to chemical formulas with Halon™ numbers.

Extinguishing Materials	Classes of Fire				Self-Generating	Self-Expelling	Cartridge of N_2 Cylinder	Stored Pressure	Pump	Hand
	A	B	B	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 fire.

Figure 1-5. *Extinguisher operation and methods of expelling.*

Group	Definition	Examples
6 (Least toxic)	Gases or vapors in concentrations up to 20% by volume, for durations of exposure of up to approximately 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 in concentrations of the order of 2 to 2 ½%, for durations of exposure of up to approximately 2 hours are lethal or produce serious injury.	Dibromodifluormethane (Halon 1202)
3	Gases or vapors in concentrations of the order of 2 to 2 ½%, 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 in concentrations of approximately ½ to 1%, for durations of exposure of up to approximately ½ hour are lethal or produce serious injury.	Methyl bromide (Halon 1001)

Figure 1-6. *Toxicity table.*

Carbon tetrachloride (Halon 104), chemical formula CCl_4, has an Underwriters Laboratory (UL) toxicity rating of 3. As such, it is extremely toxic. *[Figure 1-6]* 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 not approved for any fire extinguishing use. Old containers of Halon 104 found in or around shops or hangars should be disposed of in accordance with Environmental Protection Agency (EPA) regulations and local laws and ordinances.

Methyl bromide (Halon 1001), chemical formula CH_3Br, is a liquefied gas with a UL toxicity rating of 2. It is very toxic and corrosive to aluminum alloys, magnesium, and zinc. Halon 1001 is not recommended for aircraft use. Chlorobromomethane (Halon 1011), chemical formula CH_2ClBr, is a liquefied gas with a UL toxicity rating of 3. Like methyl bromide, Halon 1011 is not recommended for aircraft use. Dibromodifluoromethane (Halon 1202), chemical formula CBr_2F_2, has a UL toxicity rating of 4. Halon 1202 is not recommended for aircraft use.

Bromochlorodifluoromethane (Halon 1211), chemical formula $CBrClF_2$, is a liquefied gas with a UL toxicity rating of 5. It is colorless, noncorrosive, and evaporates rapidly leaving no residue. It does not freeze or cause cold burns and does not harm fabrics, metals, or other materials it contacts. Halon 1211 acts rapidly on fires by producing a heavy blanketing mist that eliminates oxygen from the fire source. More importantly, it interferes chemically with the combustion process of the fire. Furthermore, it has outstanding properties in preventing re-flash after the fire has been extinguished.

Bromotrifluoromethane (Halon 1301), chemical formula CF_3Br, is also a liquefied gas and has 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.

Note: The EPA has restricted Halon to its 1986 production level due to its effect on the ozone layer.

Dry powder extinguishers, while effective on Class B and C fires, are best for use on Class D fires. The method of operation of dry powder fire extinguishers varies from gas cartridge charges, stored pressure within the container that forces the powder charge out of the container, to scooping pails or buckets of the powder from large containers or barrels to toss on the fire.

Dry powder is not recommended for aircraft use, except on metal fires, as a fire extinguisher. The leftover chemical residues and dust often make cleanup difficult and can damage electronic or other delicate equipment.

Inspection of Fire Extinguishers

Fire extinguishers need to be checked periodically utilizing a checklist. If a checklist is unavailable, check the following as a minimum:

- Proper location of appropriate extinguisher
- Safety seals unbroken
- All external dirt and rust removed
- Gauge or indicator in operable range
- Proper weight
- No nozzle obstruction
- No obvious damage

Airport or other local fire departments can usually help in preparing or providing extinguisher checklists. In addition, these fire departments can be helpful in answering questions and assisting in obtaining repairs to or replacement of fire extinguishers.

Identifying Fire Extinguishers

Fire extinguishers are marked to indicate suitability for a particular class of fire. The markings on *Figure 1-7* must be placed on the fire extinguisher and in a conspicuous place in the vicinity of the fire extinguisher. When the location is marked, however, take extreme care to ensure that the fire extinguisher kept at that location is in fact the type depicted by the marking. In other words, if a location is marked for a Class B fire extinguisher, ensure that the fire extinguisher in that location is in fact suitable for Class B fires.

Markings must be applied by decalcomanias (decals), painting, or similar methods. They are to be legible and as durable as necessary for the location. For example, markings used outside need to be more durable than those in the hangar or office spaces.

When markings are applied to the extinguisher, they are placed on the front of the shell, if one is installed, above or below the extinguisher nameplate. Markings must be large enough and in a form that is easily seen and identifiable by the average person with average eyesight at a distance of at least 3 feet.

When markings are applied to wall panels, and so forth, in the vicinity of extinguishers, they must be large enough and in a form that is easily seen and identifiable by the average

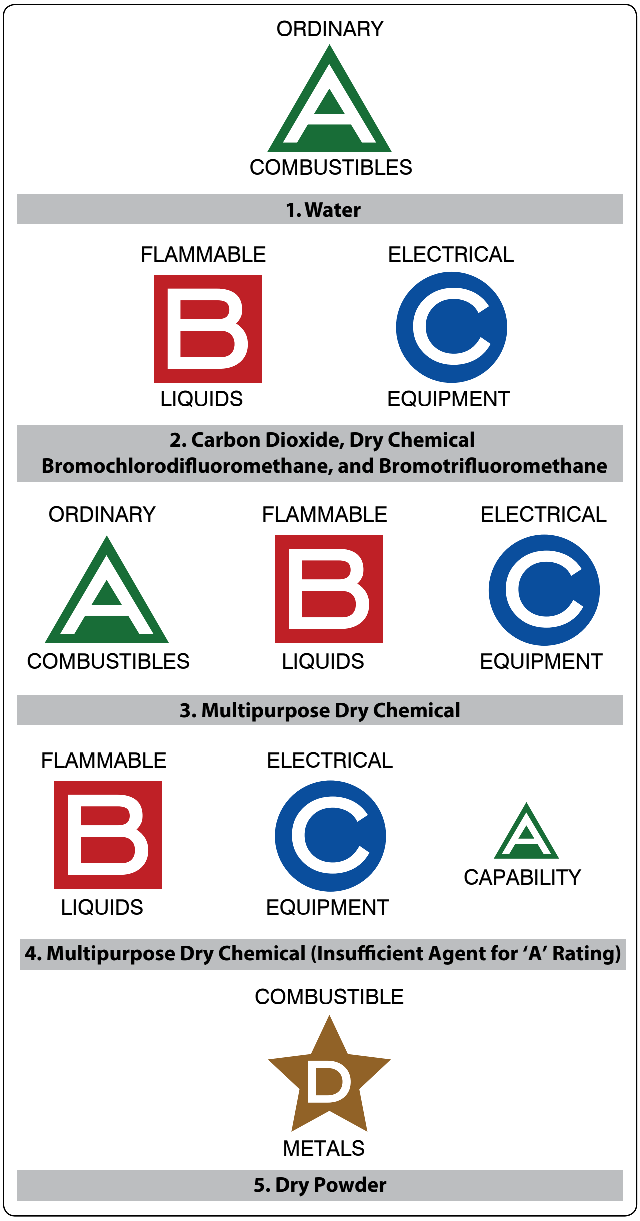


Figure 1-7. *Typical extinguisher markings.*

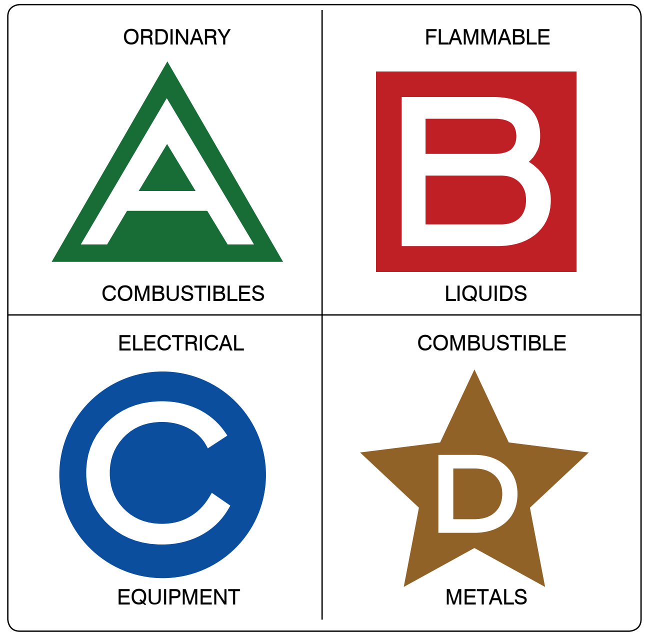


Figure 1-8. *Identification of fire extinguisher type location.*

person with average eyesight at a distance of at least 25 feet. *[Figure 1-8]*

Using Fire Extinguishers

When using a fire extinguisher, ensure the correct type is used for the fire. Most extinguishers have a pin to pull that allows the handle to activate the agent. Stand back 8 feet and aim at the base of the fire or flames. Squeeze the lever and sweep side to side until the fire is extinguished.

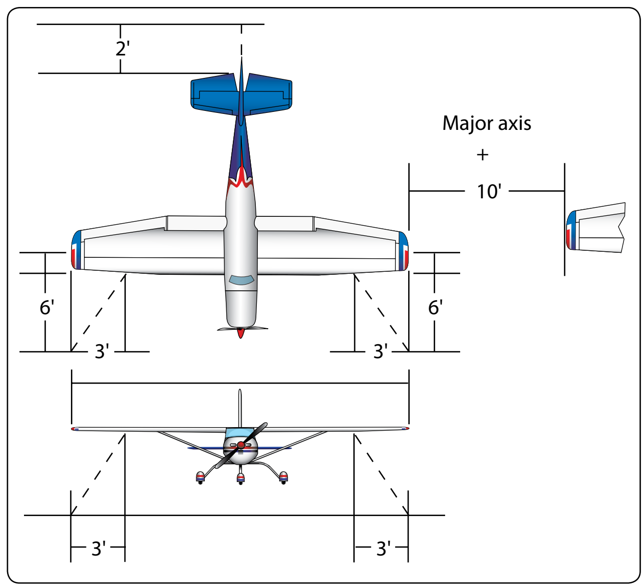


Figure 1-9. *Diagram of tiedown dimensions.*

Tie-Down Procedures

Preparation of Aircraft

Aircraft are to be tied down after each flight to prevent damage from sudden storms. The direction that aircraft are to be parked and tied down is determined by prevailing or forecast wind direction.

Aircraft are to be headed into the wind, depending on the locations of the parking area's fixed tie-down points. Spacing of tie-downs need to allow for ample wingtip clearance. *[Figure 1-9]* After the aircraft is properly located, lock the nosewheel or the tail wheel in the fore-and-aft position.

Tie-Down Procedures for Land Planes

Securing Light Aircraft

Light aircraft are most often secured with ropes tied only at the aircraft tie-down rings provided for securing purposes. Rope is never to 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. Since manila rope shrinks when wet, about 1 inch (1") of slack needs to be provided for movement. Too much slack, however, allows the aircraft to jerk against the ropes. Tight tie-down ropes put inverted flight stresses on the aircraft and many are not designed to take such loads.

A tie-down rope holds no better than the knot. Anti-slip knots, such as the bowline, are quickly tied and are easy to untie. *[Figure 1-10]* Aircraft not equipped with tie-down fittings must be secured in accordance with the manufacturer's instructions. Ropes are to be tied to outer ends of struts on high-wing monoplanes and suitable rings provided where structural conditions permit, if the manufacturer has not already provided them.

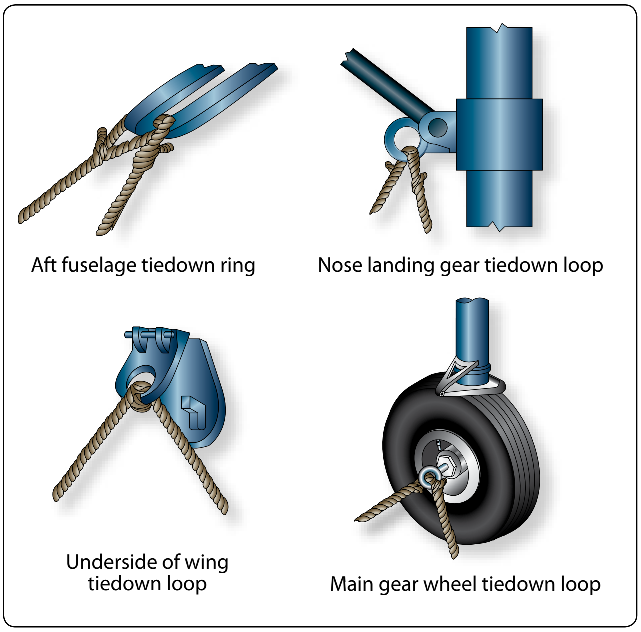


Figure 1-11. *Common tie-down points.*

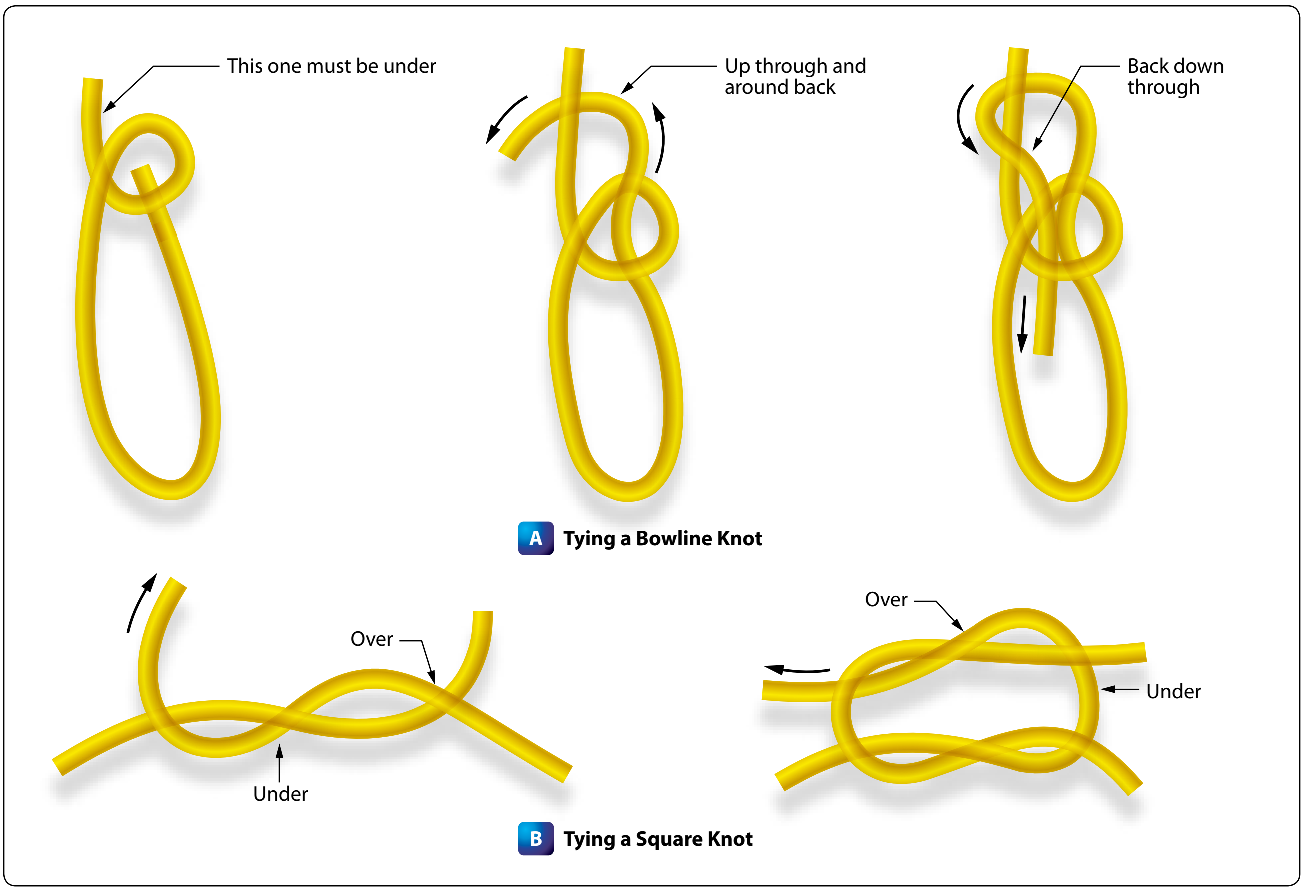


Figure 1-10. *Knots commonly used for aircraft tie-down.*

Figure 1-12. *Wheels chocked fore and aft.*

Securing Heavy Aircraft

The normal tie-down procedure for heavy aircraft can be accomplished with rope or cable tie-down. The number of tie-downs are governed by anticipated weather conditions.

Most heavy aircraft are equipped with surface control locks that are engaged or installed when the aircraft is secured. Since the method of locking controls vary on different types of aircraft, check the manufacturer's instructions for proper installation or engaging procedures. If high winds are anticipated, control surface battens can also be installed to prevent damage. *Figure 1-11* illustrates four common tie-down points on heavy aircraft.

The normal tie-down procedure for heavy aircraft includes 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. *[Figure 1-12]*
4. Attach tie-down reels to airplane tie-down loops, tie-down anchors, or tie-down stakes. Use tie-down stakes for temporary tie-down only. If tie-down reels are not available, ¼" wire cable or 1½" manila line may be used.

Tie-Down Procedures for Seaplanes

Seaplanes can be moored to a buoy, weather permitting, or tied to a dock. Weather causes wave action, and waves cause the seaplane to bob and roll. This bobbing and rolling while tied to a dock can cause damage.

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. Tie down the aircraft 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. During heavy weather, if possible, remove the seaplane from the water and tie down in the same manner as a land plane. If this is not possible, the seaplane could be anchored in a sheltered area away from the wind and waves.

Tie-Down Procedures for Ski Planes

Ski planes are tied down, if the securing means are available, in the same manner as land planes. Ski-equipped airplanes can be secured on ice or in snow by using a device called a dead-man. A dead-man is any item at hand, such as a piece of pipe, log, and so forth, that a rope is attached to and buried in a snow or ice trench. Using caution to keep the free end of the rope dry and unfrozen, snow is packed in the trench. If available, pour water into the trench; when it is frozen, tie down the aircraft with the free end of the rope.

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 tie-down procedures, aids in preventing damage from windstorms. Caution must be used when moving an aircraft that has been secured in this manner to ensure that a ski is not still frozen to the ground. Otherwise, damage to the aircraft or skis can occur.

Tie-Down Procedures for Helicopters

Helicopters, like other aircraft are secured to prevent structural damage that can occur from high-velocity surface winds. Helicopters are to be secured in hangars, when possible. If not, they must be tied down securely. Helicopters that are tied down can usually sustain winds up to approximately 65 mph. If at all possible, helicopters are evacuated to a safe area if tornadoes or hurricanes are anticipated. For added protection, helicopters can be moved to a clear area so that they are not damaged by flying objects or falling limbs from surrounding trees.

If high winds are anticipated with the helicopter parked in the open, tie down the main rotor blades. Detailed instructions for securing and mooring each type of helicopter can be found in the applicable maintenance manual. *[Figure 1-13]* Methods of securing helicopters 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 tie-downs, mooring covers, tip socks, tie-down assemblies, parking brakes, and rotor brakes are used to secure helicopters.
Typical mooring procedures are as follows:

1. Face the helicopter in the direction that the highest forecast wind or gusts are anticipated.

Figure 1-13. *Example of mooring of a helicopter.*

2. Spot the helicopter slightly more than one 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 ground handling wheels, lower the helicopter to rest on the skids, and install wheel position lock pins or remove the ground-handling wheels. Secure ground-handling wheels inside the aircraft or inside the hangar or storage buildings. Do not leave them unsecured on the flight line.
4. Align the blades and install tie-down assemblies as prescribed by the helicopter manufacturer. *[Figure 1-14]* Tie straps snugly without strain, and during wet weather, provide some slack to avoid the possibility of the straps shrinking, causing undue stress on the aircraft and/or its rotor system(s).
5. Fasten the tie-down ropes or cables to the forward and aft landing gear cross tubes and secure to ground stakes or tie-down rings.

Procedures for Securing Weight-Shift-Control

There are many types of weight-shift-controlled aircraft—engine powered and non-powered. These types of aircraft are very susceptible to wind damage. The wings can be secured in a similar manner as a conventional aircraft in light winds. In high winds, the mast can be disconnected from the wing and the wing placed close to the ground and secured. This type of aircraft can also be partially disassembled or moved into a hangar for protection.

Procedures for Securing Powered Parachutes

When securing powered parachutes, pack the parachute in a bag to prevent the chute from filling with air from the wind and dragging the seat and engine. The engine and seat can also be secured if needed.

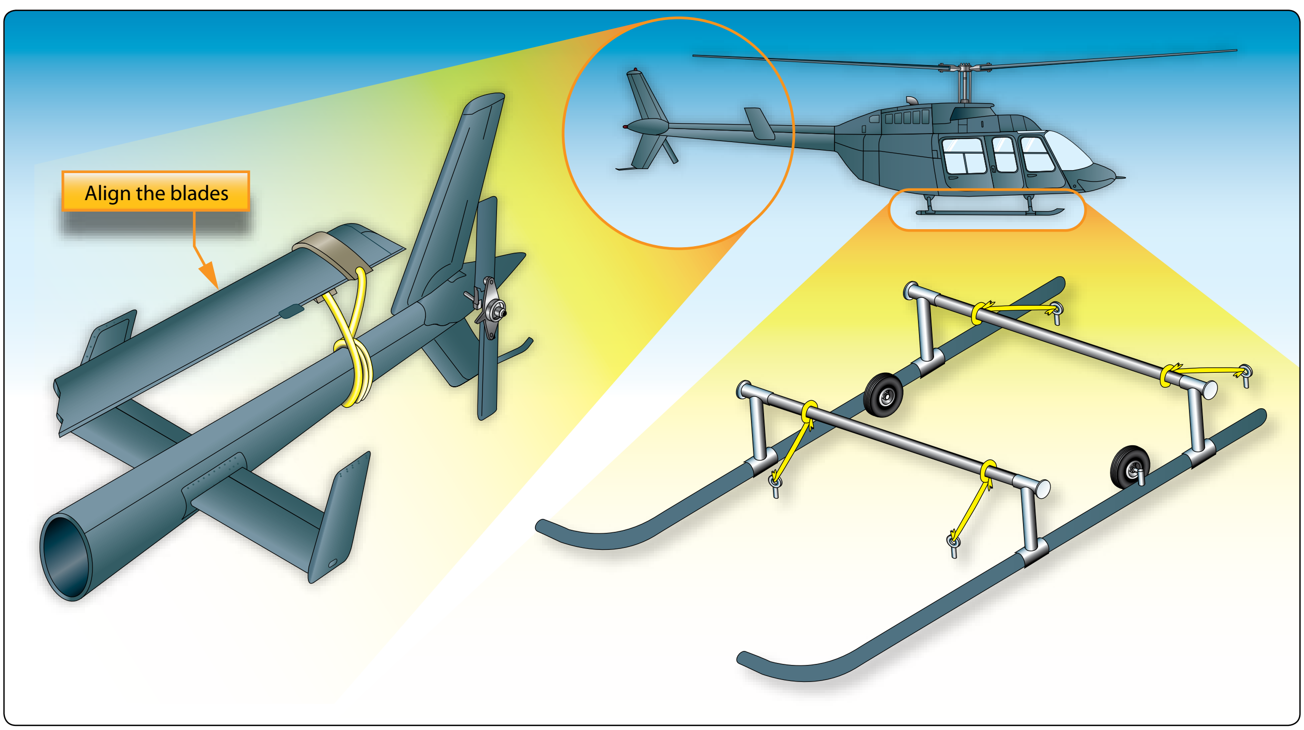


Figure 1-14. *Securing helicopter blades and fuselage.*

Ground Movement of Aircraft

Engine Starting and Operation

The following instructions cover the starting procedures for reciprocating, turboprop, turbofan, and APU. 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 ensure adequate airflow over the engine for cooling purposes.
2. Make sure that no property damage or personal injury occurs from the propeller blast or jet exhaust.
3. If external electrical power is used for starting, ensure that it can be removed safely, and it is sufficient for the total starting sequence.
4. During any and all starting procedures, a "fireguard" equipped with a suitable fire extinguisher shall be stationed in an appropriate place. A fireguard is someone familiar with aircraft starting procedures. The fire extinguisher should be a CO_2 extinguisher of at least 5-pound capacity. The appropriate place is adjacent to the outboard side of the engine, in view of the pilot, and also where he or she can observe the engine/aircraft for indication of starting problems.
5. If the aircraft is turbine-engine powered, the area in front of the jet inlet must be kept clear of personnel, property, and/or debris (FOD).
6. These "before starting" procedures apply to all aircraft powerplants.
7. Follow manufacturer's checklists for start procedures and shutdown procedures.

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. Do not attempt 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, flight deck, wheel, and so forth) protecting the aircraft must be removed before attempting to turn the engine. Use external sources of electrical power when starting engines equipped with electric starters, if possible or needed. This eliminates an excessive burden on the aircraft battery. Leave all unnecessary electrical equipment 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 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 direction opposite to normal rotation. This tends to inject the liquid from the cylinder into the intake pipe. The liquid is 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 the 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, put the mixture control in the "idle cut-off" position for fuel injection and in the "full rich" position for float-type carburetors. Many light aircraft are equipped with a mixture control pull rod that has no detent 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 cut-off" or "full lean" position. The operator can select unmarked intermediate positions between these two extremes to achieve any desired mixture setting.
3. Open the throttle to a position that provides 1,000 to 1,200 rpm (approximately ⅛" to ½" from the "closed" position).
4. Leave the pre-heat or alternate air (carburetor air) control in the "cold" position to prevent damage and fire in case of backfire. These auxiliary heating devices are 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. Move the primer switch to "on" intermittently (press to prime by pushing in on the ignition switch during the starting cycle), or prime with one to three strokes of priming pump, depending on how the aircraft is equipped. The colder the weather, the more priming is needed.
6. Energize the starter and after the propeller has made at least two complete revolutions, turn the ignition switch on. On engines equipped with an induction vibrator (shower of sparks, magneto incorporates a retard breaker assembly), turn the switch to the "both" position and energize the starter by turning the switch to the "start" position. After the engine starts, release the starter 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 start switch to the "start" position. When the engine starts, release the start switch. 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 (starter duty cycle) between successive attempts. Otherwise, the starter may be burned out due to overheating.
7. After the engine is operating smoothly, move the mixture control to the "full rich" position if started in the "idle cutoff" position. Carbureted engines are already in the rich mixture position. Check for oil pressure.
8. Instruments for monitoring the engine during operation include a tachometer for rpm, manifold pressure gauge, oil pressure gauge, oil temperature gauge, cylinder head temperature gauge, exhaust gas temperature gauge, and fuel flow gauge.

Hand Cranking Engines

If the aircraft has no self-starter, start the engine by turning the propeller by hand (hand propping the propeller). The person who is turning the propeller calls: "Fuel on, switch off, throttle closed, brakes on." The person operating the engine checks these items and repeats the phrase. The switch and throttle must not be touched again until the person swinging the prop calls "contact." The operator repeats "contact" and then turns on the switch. Never turn on the switch and then call "contact."

A few simple precautions help to avoid accidents when hand propping the engine. While touching a propeller, always assume that the ignition is on. The switches that 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. This condition could allow the engine to start when the switch is off.

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 when 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 a fall into the blades when the engine starts.

In swinging the prop, always move the blade downward by pushing with the palms of the hands. 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 after the engine has fired is the principal cause of backfiring during starting. Gradual opening of the throttle, while the engine is cold, reduces the potential for backfiring. Slow, smooth movement of the throttle assures correct engine operation.

Avoid over priming the engine before it is turned over by the starter. This can result in fires, scored or scuffed cylinders and pistons, or engine failures due to hydraulic lock. If the engine is inadvertently flooded or over primed, 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.

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 rpm for engine warmup. Warm-up rpm is usually between 1,000 to 1,300 rpm.

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. Closely monitor the engine instruments at all times. Do not close the cowl flaps for engine warm-up, they need to be in the open position while operating on the ground. When warming up the engine, ensure that personnel, ground 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. The fireguard must be familiar with the induction system of the engine so that in case of fire, he or she 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 then extinguishes 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

The starting of any turbine engine consists of three steps that must be carried out in the correct sequence. The starter turns the main compressor to provide airflow though the engine. At the correct speed that provides enough airflow, the igniters are turned on and provide a hot spark to light the fuel that is engaged next. As the engine accelerates, it reaches a self-sustaining speed and the starter is disengaged.

The various covers protecting the aircraft must be removed. Carefully inspect the engine exhaust areas for the presence of fuel or oil. Make a close visual inspection of all accessible parts of the engines and engine controls, followed by an inspection of all nacelle areas to determine that all inspection and access plates are secured. Check sumps for water. Inspect air inlet areas for general condition and foreign material. Check the compressor 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. Therefore, do not attempt 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.

Turboprop engines are usually fixed turbine or free turbine. The propeller is connected to the engine directly in a fixed turbine, resulting in the propeller being turned as the engine starts. This provides extra drag that must be overcome during starting. If the propeller is not at the "start" position, difficulty may be encountered in making a start due to high loads. The propeller is in flat pitch at shut down and subsequently in flat pitch during start because of this.

The free turbine engine has no mechanical connection between the gas generator and the power turbine that is connected to the propeller. In this type of engine, the propeller remains in the feather position during starting and only turns as the gas generator accelerates.

Instrumentation for turbine engines varies according to the type of turbine engine. Turboprop engines use the normal instruments—oil pressure, oil temperature, inter-turbine temperature (ITT), and fuel flow. They also use instruments to measure gas generator speed, propeller speed, and torque produced by the propeller. *[Figure 1-15]* A typical turboprop uses a set of engine controls, such as power levelers (throttle), propeller levers, and condition levers. *[Figure 1-16]*

The first step in starting a turbine engine is to provide an adequate source of power for the starter. On smaller turbine engines, the starter is an electric motor that turns the engine through electrical power. Larger engines need a much more powerful starter. Electric motors would be limited by current flow and weight. Air turbine starters were developed that were lighter and produced sufficient power to turn the engine at the correct speed for starting. When an air turbine starter is used, the starting air supply may be obtained from an APU onboard the aircraft, an external source (ground air cart), or an engine cross-bleed operation. In some limited cases, a low-pressure, large-volume tank can provide the air for starting an engine. Many smaller turboprop engines are started using the starter/generator, that is both the engine starter and the generator.

While starting an engine, always observe the following:

- Always observe the starter duty cycle. Otherwise, the starter can overheat and be damaged.
- Assure that there is enough air pressure or electrical capacity before attempting a start.
- Do not perform a ground start if turbine inlet temperature (residual temperature) is above that specified by the manufacturer.
- Provide fuel under low pressure to the engine's fuel pump.

Turboprop Starting Procedures

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

1. Turn the aircraft boost pumps on.

Figure 1-15. *Typical examples of turboprop instruments.*

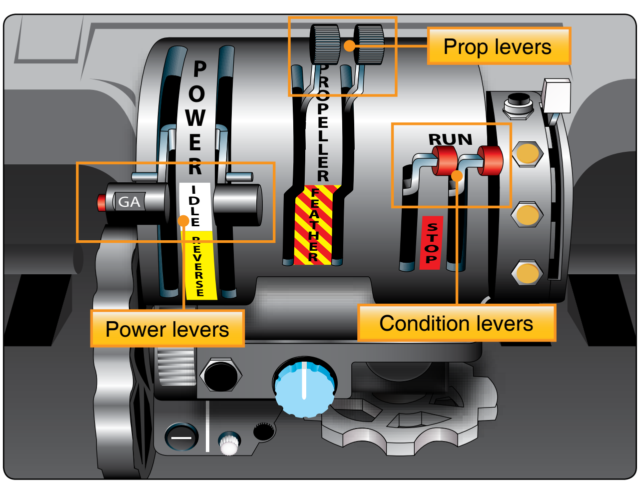


Figure 1-16. *Engine controls of a turboprop aircraft.*

2. Make sure that the power lever is in the "start" position.
3. Place the start switch in the "start" position. This starts the engine turning.
4. Place the ignition switch on. (On some engines, the ignition is activated by moving the fuel lever.)
5. The fuel is now turned on. This is accomplished by moving the condition lever to the "on" position.
6. Monitor the engine lights of the exhaust temperature. If it exceeds the limits, shut the engine down.
7. Check the oil pressure and temperature.
8. After the engine reaches a self-sustaining speed, the starter is disengaged.
9. The engine continues to accelerate up to idle.
10. Maintain the power lever at the "start" position until the specified minimum oil temperature is reached.
11. Disconnect the ground power supply, if used.

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.

- Turbine inlet temperature exceeds the specified maximum. Record the observed peak temperature.
- Acceleration time from start of propeller rotation to stabilized rpm exceeds the specified time.
- There is no oil pressure indication at 5,000 rpm for either the reduction gear or the power unit.
- Torching (visible burning in the exhaust nozzle).
- The engine fails to ignite by 4,500 rpm or maximum motoring rpm.
- Abnormal vibration is noted or compressor surge occurs (indicated by backfiring).
- Fire warning bell rings. (This may be due to either an engine fire or overheat.)

Turbofan Engines

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

Before starting, all protective covers and air inlet duct covers are removed. If possible, head the aircraft 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 run-up area around the aircraft is cleared of both personnel and loose equipment. The turbofan engine intake and exhaust hazard areas are illustrated in *Figure 1-17*. Exercise care to ensure that the run-up area is clear of all items, such as nuts, bolts, rocks, shop towels, or other loose debris. Many very serious accidents have occurred involving personnel in the vicinity of turbine engine air inlets. Use extreme caution when starting turbine aircraft.

Check the aircraft fuel sumps for water or ice. Inspect the engine air inlet for general condition and the presence of foreign objects. Visually inspect the fan blades, forward compressor blades, and the compressor inlet guide vanes for nicks and other damage. If possible, check the fan blades for free rotation by turning the fan blades by hand. All engine controls must be operational. Check engine instruments and warning lights for proper operation.

Starting a Turbofan Engine

The following procedures are typical of those used to start many turbine engines. There are, however, wide variations in the starting procedures used for turbine engines, and no attempts are to 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 turbine engines, refer to the detailed procedures contained in the applicable manufacturer's instructions or their approved equivalent.

Most turbofan engines can be started by either air turbine or electrical starters. Air-turbine starters use compressed air from an external source as discussed earlier. Fuel is turned on either by moving the start lever to "idle/start" position or by opening a fuel shutoff valve. If an air turbine starter is used, the engine "lights off" within a predetermined time after the fuel is turned on. This time interval, if exceeded, indicates a malfunction has occurred and the start must be discontinued.

Most turbofan engine controls consist of a power lever, reversing levers, and start levers. Newer aircraft have replaced the start levers with a fuel switch. *[Figure 1-18]* Turbofan engines also use all the normal instruments speeds, (percent of total rpm) exhaust gas temperature, fuel flow, oil pressure, and temperature. An instrument that measures the amount of thrust being delivered is the engine pressure ratio. This measures the ratio between the inlet pressures to the outlet pressure of the turbine.

The following procedures are useful only as a general guide and are included to show the sequence of events in starting a turbofan engine.

1. If the engine is so equipped, place the power lever in the "idle" position.
2. Turn the fuel boost pump(s) switch on.
3. A fuel inlet pressure indicator reading ensures fuel is being delivered to engine fuel pump inlet.
4. Turn engine starter switch on. Note that the engine rotates to a preset limit. Check for oil pressure.
5. Turn ignition switch on. (This is usually accomplished by moving the start lever toward the "on" position. A micro switch connected to the leveler turns on the ignition.)
6. Move the start lever to "idle" or "start" position, this starts fuel flow into the engine.
7. Engine start (light off) is indicated by a rise in exhaust gas temperature.
8. If a two-spool engine, check rotation of fan or N1.
9. Check for proper oil pressure.
10. Turn engine starter switch off at proper speeds.
11. After engine stabilizes at idle, ensure that none of the engine limits are exceeded.
12. Newer aircraft drop off the starter automatically.

Auxiliary Power Units (APUs)

APUs are generally smaller turbine engines that provide compressed air for starting engines, cabin heating and cooling, and electrical power while on the ground. Their operation is normally simple. By turning a switch on and up to the start position (spring loaded to on position), the engine starts automatically. During start, the exhaust gas temperature must be monitored. APUs are at idle at 100 percent rpm with no load. After the engine reaches its operating rpm, it can be used for cooling or heating the cabin and for electrical power. It is normally used to start the main engines.

Unsatisfactory Turbine Engine Starts

Hot Start

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. This condition can be caused by either too much fuel or not enough airflow. The fuel to the engine must be shut off immediately.

False or Hung Start

False or hung starts occur when the engine starts normally, but the rpm remains at some low value rather than increasing to the normal starting rpm. 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, shut the engine down.

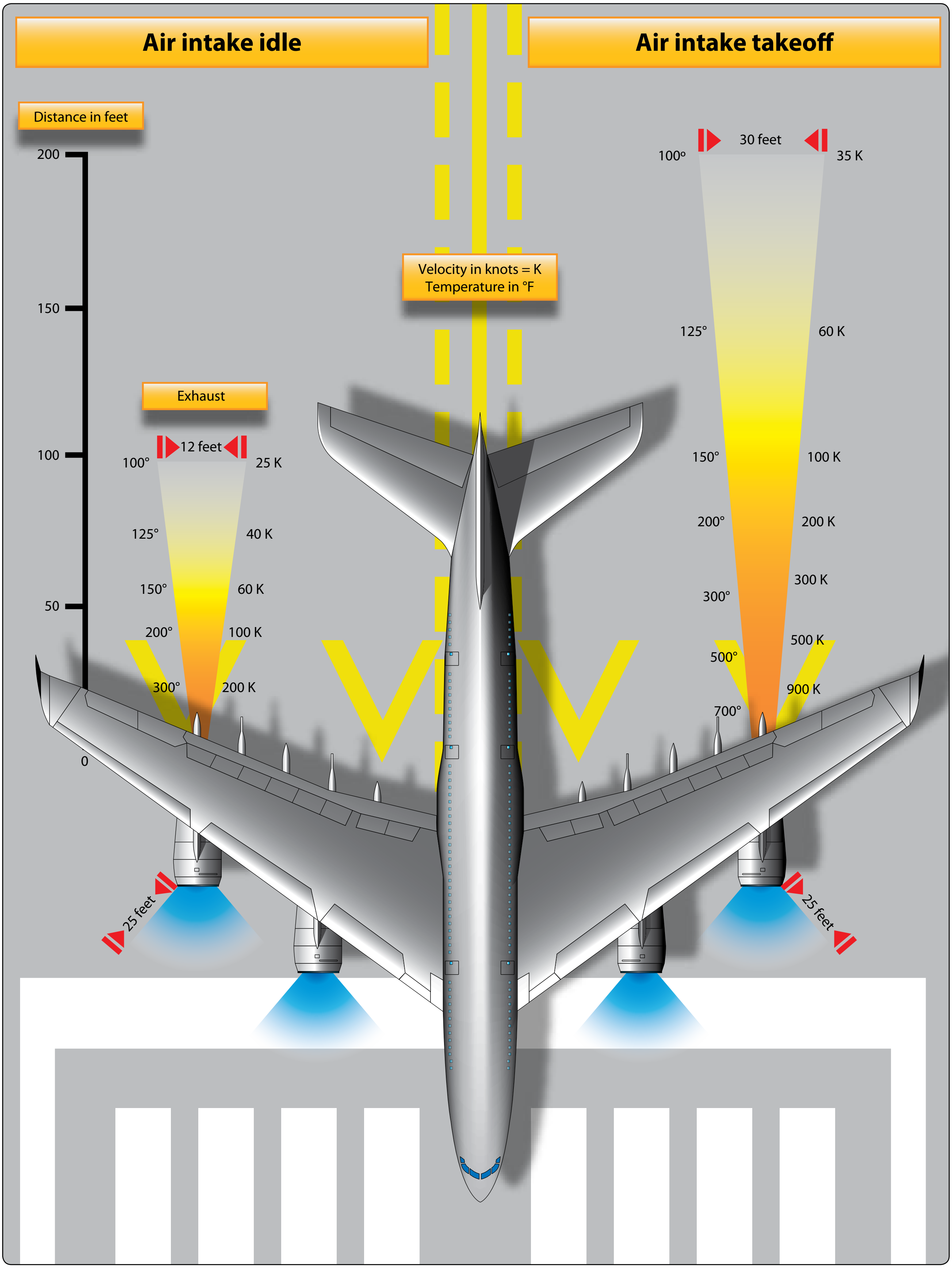


Figure 1-17. *Engine intake and exhaust hazard areas.*

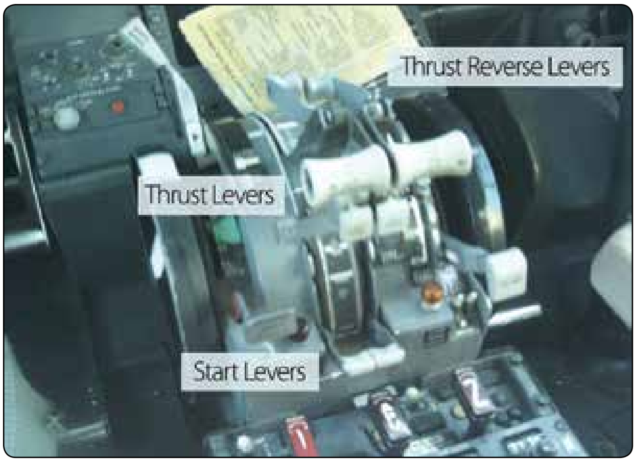


Figure 1-18. *Turbofan engine control levers.*

Engine Fails to Start

The engine failing to start within the prescribed time limit can be caused by lack of fuel to the engine, insufficient or no electrical power to the exciter in the ignition system, or incorrect fuel mixture. If the engine fails to start within the prescribed time, shut it down.

In all cases of unsatisfactory starts, the fuel and ignition must 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.

Towing of Aircraft

Movement of large aircraft about the airport, flight line, and hangar is usually accomplished by towing with a tow tractor (sometimes called a "tug"). *[Figure 1-19]* In the case of small aircraft, some moving is accomplished by hand pushing on the correct areas of the aircraft. Aircraft may also be taxied about the flight line but usually only by certain qualified personnel.

Figure 1-19. *Example of a tow tractor.*

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 are to be followed in all instances.

Before the aircraft to be towed is moved, a qualified person must be in the flight deck to operate the brakes in case the tow bar fails or becomes unhooked. The aircraft can then be stopped, preventing possible damage.

Some types of tow bars available for general use can be used for many types of towing operations. *[Figure 1-20]* These bars are designed with sufficient tensile strength to pull most aircraft, but are not intended to be subjected to torsional or twisting loads. Many have small wheels that permit them to be drawn behind the towing vehicle going to or from an aircraft. When the bar is attached to the aircraft, inspect all the engaging devices 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, do not rely upon the brakes of the towing vehicle alone to stop the aircraft. The person in the flight deck must coordinate the use of the aircraft brakes with those of the towing vehicle. A typical smaller aircraft tow tractor (or tug) is shown in *Figure 1-21*.

The attachment of the tow bar varies on different types of aircraft. Aircraft equipped with tail wheels are generally towed forward by attaching the tow bar to the main landing gear. In most cases, it is permissible to tow the aircraft in

Figure 1-20. *Example of a tow bar.*

Figure 1-21. *Typical smaller aircraft tow tractor.*

reverse by attaching the tow bar to the tail wheel axle. Any time an aircraft equipped with a tail wheel is towed, the tail wheel must be unlocked or the tail wheel locking mechanism may damage or break. 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 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 must be thoroughly familiar with all procedures pertaining to the types of aircraft being towed and local operation standards governing ground handling of aircraft. Competent persons that have been properly checked out direct the aircraft towing team.

1. The towing vehicle driver is responsible for operating the vehicle in a safe manner and obeying emergency stop instructions given by any team member.
2. The person in charge assigns team personnel as wing walkers. A wing walker is stationed at each wingtip, in such a position that he or she can ensure adequate clearance of any obstruction in the path of the aircraft. A tail walker is assigned when sharp turns are to be made or when the aircraft is to be backed into position.
3. A qualified person occupies 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 verifies 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 are not to attempt to steer or turn the nosewheel when the tow bar is attached to the aircraft.
5. Under no circumstances is anyone permitted to walk or to 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 is permitted.
6. The towing speed of the aircraft is not to 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 is to be charged before each towing operation. Aircraft with faulty brakes are towed into position only for repair of brake systems, and then personnel must be 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 are closed, ladders retracted, and gear-down locks 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 upon command by one of the tow team members in an emergency situation.
11. Aircraft are parked in specified areas. Generally, the distance between rows of parked aircraft is 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 are placed fore and aft of the main landing gear of the parked aircraft.
13. Internal or external control locks (gust locks or blocks) are 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 parked in a hangar must be statically grounded immediately.

Taxiing Aircraft

As a general rule, only rated pilots and qualified airframe and powerplant (A&P) technicians are authorized to start, run up, and taxi aircraft. All taxiing operations are performed in accordance with applicable local regulations. *Figure 1-22* contains the standard taxi light signals used by control towers to control and expedite the taxiing of aircraft. The following section provides detailed instructions on taxi signals and related taxi instructions.

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 the pilot around the flight line. In some aircraft configurations, the pilot's vision is obstructed while on the ground. The pilot cannot see obstructions close to the wheels or under the wings and has little idea of what is behind the aircraft. Consequently, the pilot depends upon the taxi signalman for directions. *Figure 1-23* 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 the left. *[Figure 1-24]* The signalman must stay far enough ahead of the wingtip to remain in the pilot's field of vision. It is a good practice to perform a foolproof test to be sure the pilot can see all signals. If the signalman can see the pilot's eyes, the pilot can see the signals.

Figure 1-24 shows the standard aircraft taxiing signals published in the Federal Aviation Administration (FAA) Aeronautical Information Manual (AIM). There are other standard signals, such as those published by the Armed Forces. Furthermore, operation conditions in many areas may call for a modified set of taxi signals. The signals shown in *Figure 1-24* 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 1-25* illustrates some of the most commonly used helicopter operating signals.

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 1-22. *Standard taxi light signals.*

Figure 1-23. *The taxi signalman.*

The taxi signals to be used must be studied until the taxi signalman can execute them clearly and precisely. The signals are to be given in such a way that the pilot cannot confuse their meaning. Remember that the pilot receiving the signals is always some distance away and often look out and down from a difficult angle. Thus, the signalman's hands must be kept well separated, and signals are to be over-exaggerated 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, use the "stop" sign and begin the series of signals again.

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

Taxi signals are usually given at night with the aid of illuminated wands attached to flashlights. *[Figure 1-26]* Night signals are made in the same manner as day signals with the

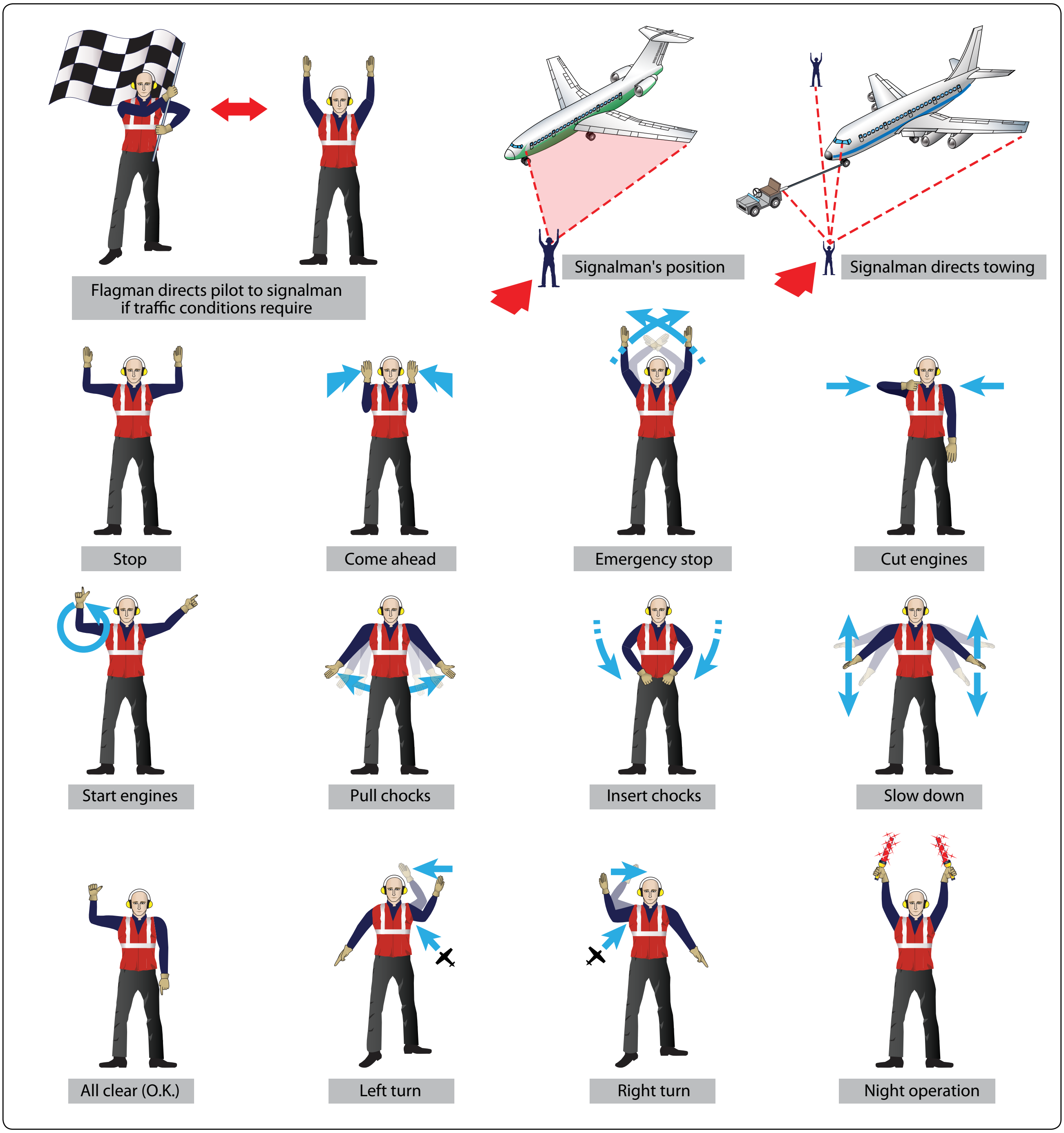


Figure 1-24. *Standard FAA hand taxi signals.*

exception of the stop signal. The stop signal used at night is the "emergence stop" signal. This signal is made by crossing the wands to form a lighted "X" above and in front of the head.

Servicing Aircraft

Servicing Aircraft Air/Nitrogen Oil and Fluids

Checking or servicing aircraft fluids is an important maintenance function. Before servicing any aircraft, consult the specific aircraft maintenance manual to determine the proper type of servicing equipment and procedures. In general, aircraft engine oil is checked with a dipstick or a sight gauge. There are markings on the stick or around the sight gauge to determine the correct level. Reciprocating engines are to be checked after the engine has been inactive, while the turbine engine must be checked just after shutdown. Dry sump oil systems tend to hide oil that has seeped from the oil tank into the gear case of the engine. This oil does not show up on the dipstick until the engine has been started or motored.

Figure 1-25. *Helicopter operating signals.*

If serviced before this oil is pumped back into the tank, the engine overfills. Never overfill the oil tank. Oil foams as it is circulated through the engine. The expansion space in the oil tank allows for this foaming (oil mixing with air). Also the correct type of oil must be used for the appropriate engine being serviced. Hydraulic fluid, fuel, and oil, if spilled on clothes or skin, must be removed as soon as possible because of fire danger and health reasons.

When servicing a hydraulic reservoir, the correct fluid must be used. Normally, this can be determined by the container or by color. Some reservoirs are pressurized by air that must be bled off before servicing. Efforts must be made to prevent any type of contamination during servicing. Also, if changing hydraulic filters, assure that the pressure is off the system before removing the filters. After servicing the filters (if large amounts of fluids were lost) or system quantity, air must be

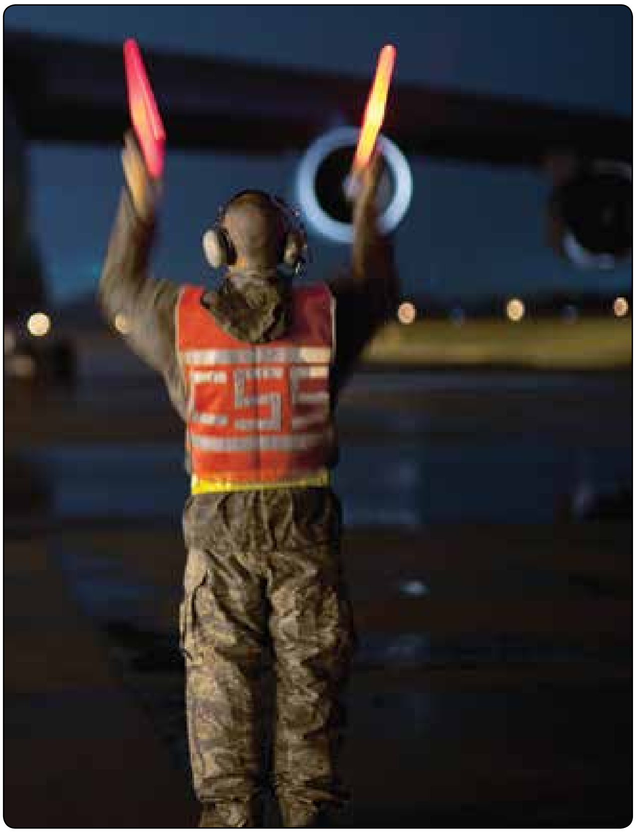


Figure 1-26. *Night operations with wands.*

purged and the system checked for leaks. While servicing tires or struts with high-pressure nitrogen, the technician must use caution while performing maintenance. Clean areas before connecting filling hose and do not overinflate.

Ground Support Equipment

Electric Ground Power Units

Ground support electrical APUs vary widely in size and type. However, they can be generally classified by towed, stationary, or self-propelled items of equipment. Some units are mainly for in-hangar use during maintenance. Others are designed for use on the flight line, either at a stationary gate area or towed from aircraft to aircraft. The stationary type can be powered from the electrical service of the facility. The movable type ground power unit (GPU) generally has an onboard engine that turns a generator to produce power. Some smaller units use a series of batteries. 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 are equipped with generators. Providing a wider range of output power, these power units are normally designed to supply constant-current, variable voltage DC electrical power for starting turbine aircraft engines and constant-voltage DC for starting reciprocating aircraft engines. Normally somewhat top-heavy, large towed power units are towed at restricted speeds, and sharp turns are avoided. An example of a large power unit is shown in *Figure 1-27*.

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. The stationary power unit, shown in *Figure 1-28,* is capable of supplying DC power in varying amounts, as well as 115/200-volt, 3-phase, 400-cycle AC power continuously for 5 minutes.

When using ground electrical power units, it is important to position the unit to prevent collision with the aircraft being serviced, or others nearby, in the event the brakes on the unit

Figure 1-27. *A mobile electrical power unit.*

Figure 1-28. *A stationary electrical power unit.*

fail. It must be parked so that the service cable is extended to near its full length away from the aircraft being serviced, but not so far that the cable is stretched or undue stress is placed on the aircraft electrical receptacle.

Observe all electrical safety precautions when servicing an aircraft. Additionally, never move a power unit when service cables are attached to an aircraft or when the generator system is engaged.

Hydraulic Ground Power Units

Portable hydraulic test stands are manufactured in many sizes and cost ranges. *[Figure 1-29]* 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. Hydraulic power units, sometimes called a hydraulic mule, provide hydraulic pressure to operate the aircraft systems during maintenance. They can be used to:

- Drain the aircraft hydraulic systems.
- Filter the aircraft system hydraulic fluid.
- Refill the aircraft system with clean fluid.
- Check the aircraft hydraulic systems for operation and leaks.

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 psi.

Figure 1-29. *A portable hydraulic power unit.*

Operating at pressures of 3,000 psi or more, extreme caution must be used when operating hydraulic power units. At 3,000 psi, a small stream from a leak can cut like a sharp knife. Therefore, inspect lines used with the system for cuts, frays, or any other damage, and keep them free of kinks and twists. When not in use, hydraulic power unit lines are to be stored (preferably wound on a reel) and kept clean, dry, and free of contaminants.

Ground Support Air Units

Air carts are used to provide low-pressure (up to 50 psi high volume flow) air that can be used for starting the engines and heating and cooling the aircraft on the ground (using the onboard aircraft systems). It generally consists of an APU built into the cart that provides bleed air from the APU's compressor for operating aircraft systems or starting engines. *[Figure 1-30]*

Ground Air Heating and Air Conditioning

Most airport gates have facilities that can provide heated or cooled air. The units that cool or heat the air are permanent installations that connect to the aircraft's ventilation system by use of a large hose. Portable heating and air conditioning units can also be moved close to the aircraft and connected by a duct that provides air to keep the cabin temperature comfortable.

Oxygen Servicing Equipment

Before servicing any aircraft, consult the specific aircraft maintenance manual to determine the proper types of servicing equipment to be used. Two personnel are required to service an aircraft with gaseous oxygen. One person is stationed at the control valves of the servicing equipment, and one person is stationed where he or she can observe the pressure in the aircraft system. Communication between the two people is required in the event of an emergency.

Figure 1-30. *Aircraft air start unit.*

Do not service aircraft with oxygen during fueling, defueling, or other maintenance work that could provide a source of ignition. Oxygen servicing of aircraft is to be accomplished outside hangars.

Oxygen used on aircraft is available in two types: gaseous and liquid. The type to use on any specific aircraft depends on the type of equipment in the aircraft. Gaseous oxygen is stored in large steel cylinders, while liquid oxygen (commonly referred to as LOX) is stored and converted into a usable gas in a liquid oxygen converter.

Oxygen is commercially available in three general types: aviator's breathing, industrial, and medical. Only oxygen marked "Aviator's Breathing Oxygen" that meets Federal Specification BB-0-925A, Grade A, or its equivalent is to be used in aircraft breathing oxygen systems. Industrial oxygen may contain impurities that could cause the pilot, crew, and/or passengers to become sick. Medical oxygen, although pure, contains water that can freeze in the cold temperatures found at the altitudes where oxygen is necessary.

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 that is sensitive to compression or impact. Physical damage to, or failure of, oxygen containers, valves, or plumbing can result in an explosive rupture with extreme danger to life and property. It is imperative that the highest standard of cleanliness be observed in handling oxygen and that only qualified and authorized persons be permitted to service aircraft gaseous oxygen systems. In addition to aggravating the fire hazard and because of its low temperature (it boils at −297 °F), liquid oxygen causes severe "burns" (frostbite) if it comes in contact with the skin.

Fuel Servicing of Aircraft

Types of Fuel and Identification

Two types of aviation fuel in general use are aviation gasoline, also known as AVGAS, and turbine fuel, also known as JET A fuel.

Aviation gasoline (AVGAS) is used in reciprocating engine aircraft. Currently, there are three grades of fuel in general use: 80/87, 100/130, and 100LL (low lead). A fourth grade, 115/145, is in limited use in the large reciprocating-engine aircraft. The two numbers indicate the lean mixture and rich mixture octane rating numbers of the specific fuel. In other words, with 80/87 AVGAS, the 80 is the lean mixture rating and 87 is the rich mixture rating number. To avoid confusing the types of AVGAS, it is generally identified as grade 80, 100, 100LL, or 115. AVGAS can also be identified by a color code. The color of the fuel needs to match the color band on piping and fueling equipment. *[Figure 1-31]*

Turbine fuel/jet fuel is used to power turbojet and turbo-shaft engines. Three types of turbine fuel generally used in civilian aviation are JET A and JET A-1, made from kerosene, and JET B, a blend of kerosene and AVGAS. While jet fuel is identified by the color black on piping and fueling equipment, the actual color of jet fuel can be clear or straw colored.

Before mixing AVGAS and turbine fuel, refer to the Type Certificate Data Sheet for the respective powerplant. Adding jet fuel to AVGAS causes a decrease in the power developed by the engine and could cause damage to the engine (through detonation) and loss of life. Adding AVGAS to jet fuel can cause lead deposits in the turbine engine and can lead to reduced service life.

Contamination Control

Contamination is anything in the fuel that is not supposed to be there. The types of contamination found in aviation fuel include water, solids, and microbial growths. The control of contamination in aviation fuel is extremely important, since contamination can lead to engine failure or stoppage and the loss of life. The best method of controlling contamination is to prevent its introduction into the fuel system. Some forms of contamination can still occur inside the fuel system. However, the filter, separators, and screens remove most of the contamination.

Water in aviation fuels generally take two forms: dissolved (vapor) and free water. The dissolved water is not a major problem until, as the temperature lowers, it becomes free water. This then poses a problem if ice crystals form, clogging filters and other small orifices.

Free water can appear as water slugs or entrained water. Water slugs are concentrations of water. This is the water that is drained after fueling an aircraft. Entrained water is suspended water droplets. These droplets may not be visible

Color	Grade
Red	80
Green	100
Blue	100LL
Purple	115

Figure 1-31. *Aviation gasoline color and grade reference.*

to the eye but give the fuel a cloudy look. The entrained water settles out in time.

Solid contaminants are insoluble in fuel. The more common types are rust, dirt, sand, gasket material, lint, and fragments of shop towels. The close tolerances of fuel controls and other fuel-related mechanisms can be damaged or blocked by particles as small as $\frac{1}{20}$ the diameter of a human hair.

Microbiological growths are a problem in jet fuel. There are a number of varieties of micro-organisms that can live in the free water in jet fuel. Some variations of these organisms are airborne, others live in the soil. The aircraft fuel system becomes susceptible to the introduction of these organisms each time the aircraft is fueled. Favorable conditions for the growth of micro-organisms in the fuel are warm temperatures and the presence of iron oxide and mineral salts in the water. The best way to prevent microbial growth is to keep the fuel dry.

The effects of micro-organisms are:

- Formation of slime or sludge that can foul filters, separators, or fuel controls.
- Emulsification of the fuel.
- Corrosive compounds that can attack the fuel tank's structure. In the case of a wet wing tank, the tank is made from the aircraft's structure. They can also have offensive odors.

Fueling Hazards

The volatility of aviation fuels creates a fire hazard that has plagued aviators and aviation engine designers since the beginning of powered flight. Volatility is the ability of a liquid to change into a gas at a relatively low temperature. In its liquid state, aviation fuel does not burn. It is, therefore, the vapor or gaseous state that the liquid fuel changes that is not only useful in powering the aircraft, but also a fire hazard.

Static electricity is a byproduct of one substance rubbing against another. Fuel flowing through a fuel line causes a certain amount of static electricity. The greatest static electricity concern around aircraft is that during flight, the aircraft moving through the air causes static electricity to build in the airframe. If that static electricity is not dissipated prior to refueling, the static electricity in the airframe attempts to return to the ground through the fuel line from the servicing unit. The spark caused by the static electricity can ignite any vaporized fuel.

Breathing the vapors from fuel can be harmful and must be limited. Any fuel spilled on the clothing or skin must be removed as soon as possible.

Fueling Procedures

The proper fueling of an aircraft is the responsibility of the owner/operator. This does not, however, relieve the person doing the fueling of the responsibility to use the correct type of fuel and safe fueling procedures.

There are two basic procedures when fueling an aircraft. Smaller aircraft are fueled by the over-the-wing method. This method uses the fuel hose to fill through fueling ports on the top of the wing. The method used for larger aircraft is the single point fueling system. This type of fueling system uses receptacles in the bottom leading edge of the wing to fill all the tanks. This decreases the time it takes to refuel the aircraft, limits contamination, and reduces the chance of static electricity igniting the fuel. Most pressure fueling systems consist of a pressure fueling hose and a panel of controls and gauges that permit one person to fuel or defuel any or all fuel tanks of an aircraft. Each tank can be filled to a predetermined level. These procedures are illustrated in *Figures 1-32* and *1-33*.

Prior to fueling, the person fueling must check the following:

1. Ensure all aircraft electrical systems and electronic devices, including radar, are turned off.
2. Do not carry anything in the shirt pockets. These items could fall into the fuel tanks.
3. Ensure no flame-producing devices are carried by anyone engaged in the fueling operation. A moment of carelessness could cause an accident.
4. Ensure that the proper type and grade of fuel is used. Do not mix AVGAS and JET fuel.
5. Ensure that all the sumps have been drained.
6. Wear eye protection. Although generally not as critical as eye protection, other forms of protection, such as rubber gloves and aprons, can also protect the skin from the effects of spilled or splashed fuel.
7. Do not fuel aircraft if there is danger of other aircraft in the vicinity blowing dirt in the direction of the aircraft being fueled. Blown dirt, dust, or other contaminants can enter an open fuel tank, contaminating the entire contents of the tank.
8. Do not fuel an aircraft when there is lightning within 5 miles.

Figure 1-32. *Refueling an aircraft by the over-the-wing method.*

9. Do not fuel an aircraft within 500 feet of operating ground radar.

When using mobile fueling equipment:

1. Approach the aircraft with caution, positioning the fuel truck so that if it is necessary to depart quickly, no backing needed.
2. Set the hand brake of the fuel truck, and chock the wheels to prevent rolling.
3. Ground the aircraft and then ground the truck. Next, ground or bond them together by running a connecting wire between the aircraft and the fuel truck. This may be done by three separate ground wires or by a "Y" cable from the fuel truck.
4. Ensure that the grounds are in contact with bare metal or are in the proper grounding points on the aircraft. Do not use the engine exhaust or propeller as grounding points. Damage to the propeller can result,

Figure 1-33. *Single point refueling station of a large aircraft.*

and there is no way of quickly ensuring a positive bond between the engine and the airframe.

5. Ground the nozzle to the aircraft, then open the fuel tank.
6. Protect the wing and any other item on the aircraft from damage caused by spilled fuel or careless handling of the nozzle, hose, or grounding wires.
7. Check the fuel cap for proper installation and security before leaving the aircraft.
8. Remove the grounding wires in the reverse order. If the aircraft is not going to be flown or moved soon, the aircraft ground wire can be left attached.

When fueling from pits or cabinets, follow the same procedures as when using a truck. Pits or cabinets are usually designed with permanent grounding, eliminating the need to ground the equipment. However, the aircraft still must be grounded, and then the equipment must be grounded to the aircraft as it was with mobile equipment.

Defueling

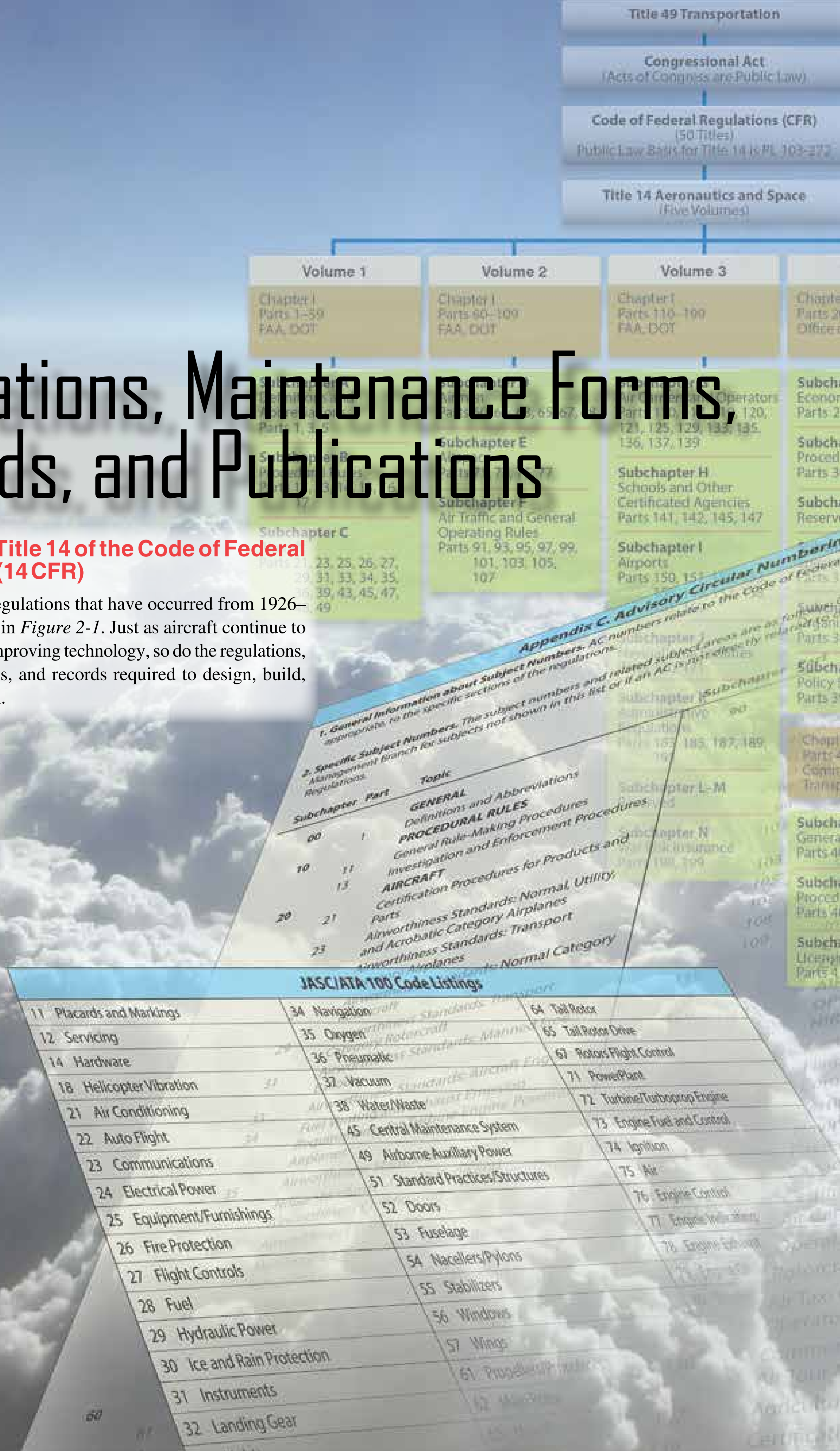
Defueling procedures differ with different types of aircraft. Before defueling an aircraft, check the maintenance/service manual for specific procedures and cautions. Defueling can be accomplished by gravity defueling or by pumping the fuel out of the tanks. When the gravity method is used, it is necessary to have a method of collecting the fuel. When the pumping method is used, care must be taken not to damage the tanks, and the removed fuel cannot be mixed with good fuel.

General precautions when defueling are:

- Ground the aircraft and defueling equipment.
- Turn off all electrical and electronic equipment.
- Have the correct type of fire extinguisher available.
- Wear eye protection.

Chapter 2

Regulations, Maintenance Forms, Records, and Publications



Overview — Title 14 of the Code of Federal Regulations (14 CFR)

Aviation-related regulations that have occurred from 1926–1966 are reflected in *Figure 2-1*. Just as aircraft continue to evolve with ever improving technology, so do the regulations, publications, forms, and records required to design, build, and maintain them.

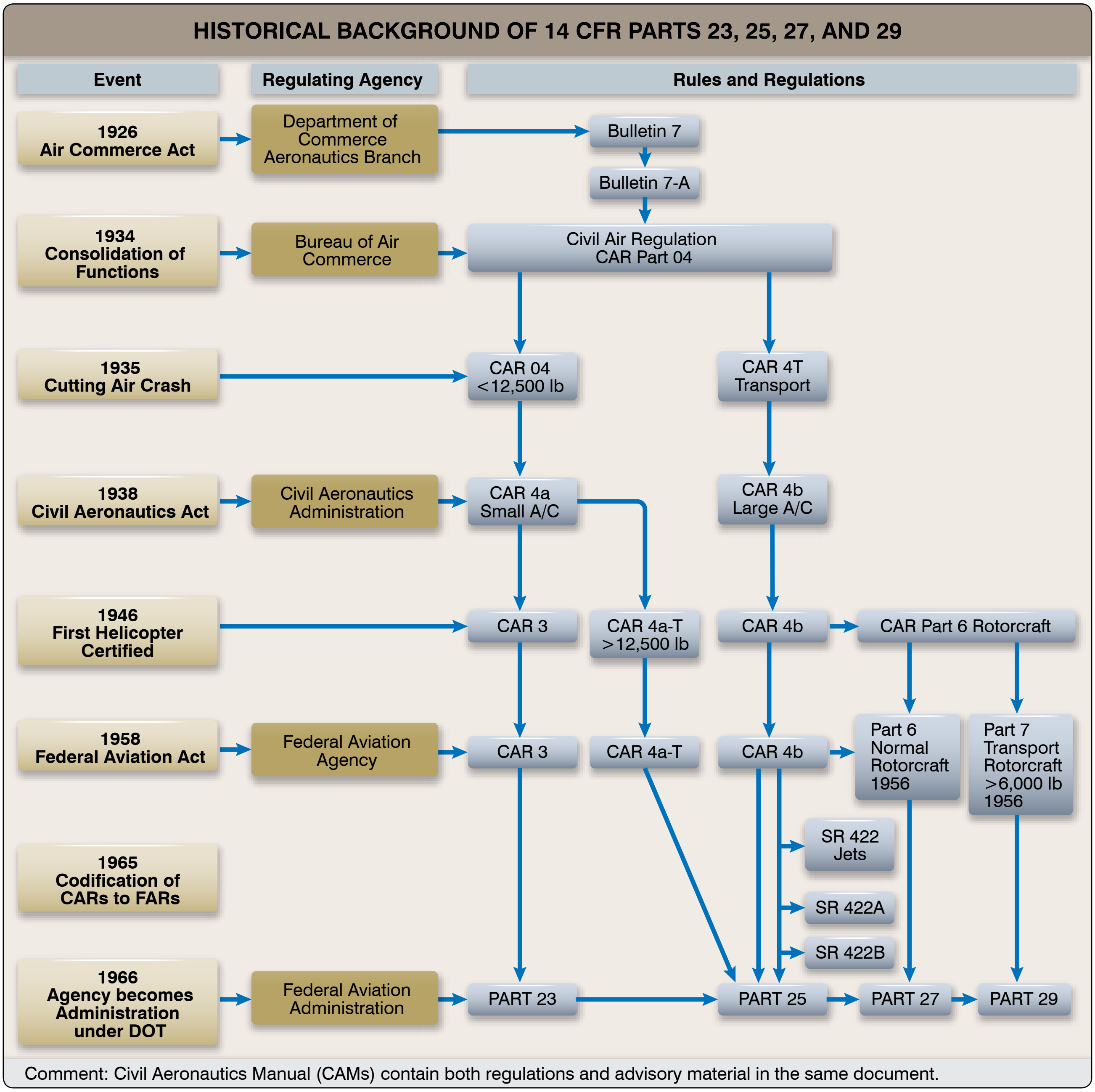


Figure 2-1. *FAA historical background of aircraft airworthiness regulations.*

The Federal Aviation Administration (FAA) regulations that govern today's aircraft are found in Title 14 of the Code of Federal Regulations (14 CFR). *[Figure 2-2]* There are five volumes under Title 14, Aeronautics and Space. The first three volumes containing 75 active regulations address the Federal Aviation Administration. The fourth volume deals with the Office of the Secretary of the Department of Transportation (Aviation Proceedings) and Commercial Space Transportation, while the fifth volume addresses the National Aeronautics and Space Administration (NASA) and Air Transportation System Stabilization.

These regulations can be separated into the following three categories:

1. Administrative
2. Airworthiness Certification
3. Airworthiness Operation

Since 1958, these rules have typically been referred to as "FARs," short for Federal Aviation Regulations. However, another set of regulations, Title 48, is titled "Federal Acquisitions Regulations," and this has led to confusion

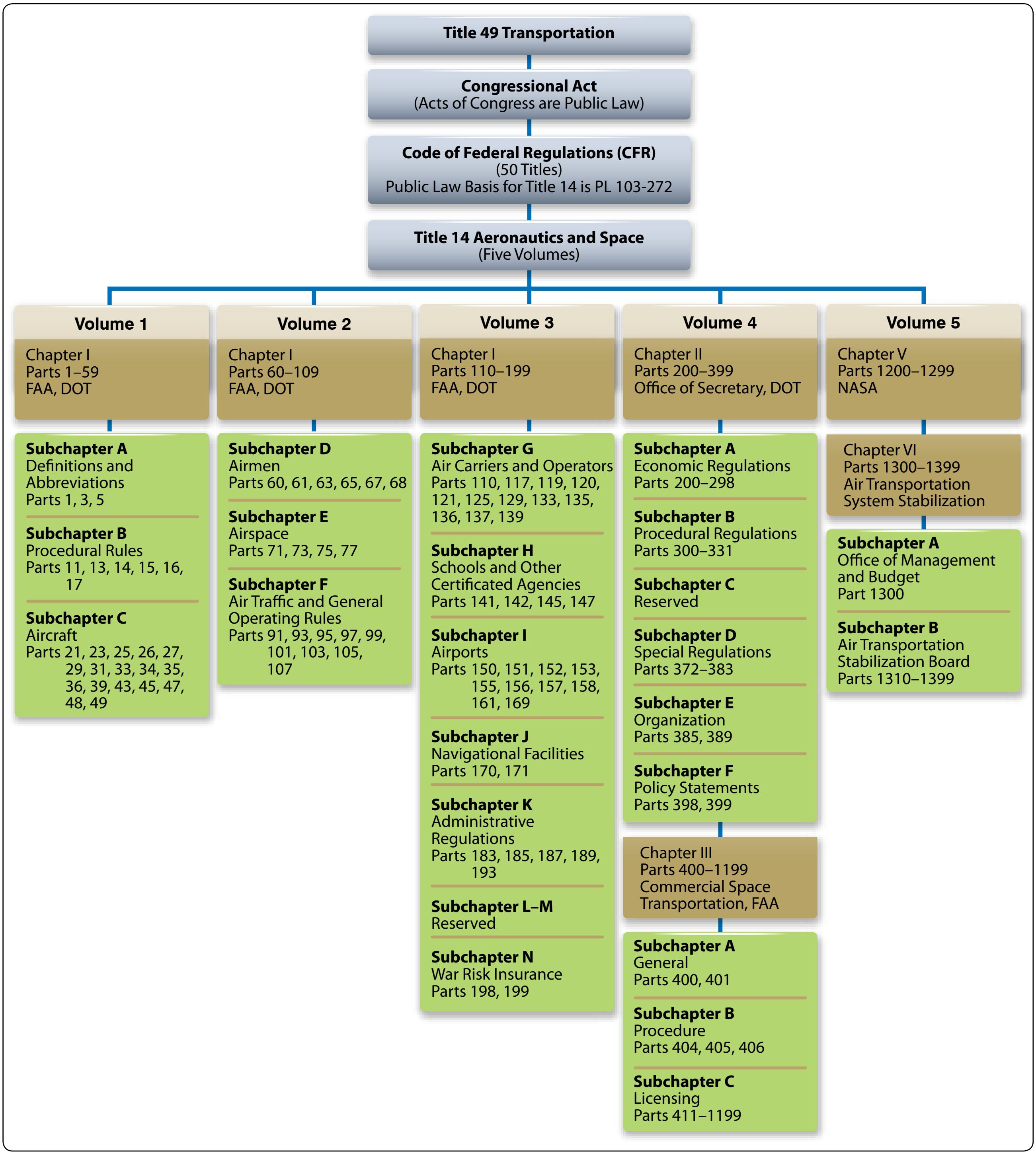


Figure 2-2. *Title 14 of the Code of Federal Regulations.*

with the use of the acronym "FAR." Therefore, the FAA began to refer to specific regulations by the term "14 CFR part XX." Most regulations and the sections within are odd numbered, because the FAA realized in 1958 when the Civil Aeronautics Regulations were recodified into the Federal Aviation Regulations that it would be necessary to add regulations later.

Over the years, the FAA has sometimes seen the need to issue Special Federal Aviation Regulations (SFAR). *[Figure 2-3]* These are frequently focused very specifically on a unique situation and are usually given a limited length of time for effectiveness. Note that the SFAR number is purely a sequential number and has no relevance to the regulation it is addressing or attached to.

Special Federal Aviation Regulations		
SFAR No	Title	Appears in 14 CFR
13	Table of Contents	Part 25
23	Special Federal Aviation Regulation No. 23	Part 23
27-5	Fuel venting and exhaust emission requirements for turbine engine powered airplanes.	Part 11
50-2	Special Flight rules in the Vicinity of the Grand Canyon National Park, AZ	Part 91
65-1	Removal of this SFAR effective 10/8/2004 - Prohibition Against Certain Flights Between the United States and Libya	Part 91
71	Special Operating Rules for Air Tour Operators in the State of Hawaii	Part 91
73	Robinson R-22/R-44 Special Training and Experience Requirements	Part 61
77	Prohibition Against Certain Flights Within the Territory and Airspace of Iraq	Part 91
79	Prohibition Against Certain Flights Within the Flight Information Region of the Democratic People's Republic of Korea	Part 91
82	Prohibition Against Certain Flights within the Territory and Airspace of Sudan	Part 91
84	Prohibition Against Certain Flights Within the Territory and Airspace of Serbia-Montenegro	Part 91
86	Airspace and Flight Operations Requirement for the Kodak Albuquerque International Balloon Fiesta; Albuquerque, NM	Part 91
88	Fuel Tank System Fault Tolerance Evaluation Requirements	Parts 21, 25, 91, 121, 125, 129
97	Special Federal Aviation Regulation No. 97 - Special Operating Rules for the Conduct of Instrument Flight Rules (IFR) Area Navigation (RNAV) Operations using Global Positioning Systems (GPS) in Alaska	Parts 71, 91, 95, 121, 125, 129, 135
98	Construction or Alteration in the Vicinity of the Private Residence of the President of the United States	Part 77
100-2	Relief for U.S. Military and Civilian Personnel Who Are Assigned Outside the United States in Support of U.S. Armed Forces Operations	Parts 61, 63, 65
103	Process for Requesting Waiver of Mandatory Separation Age for Certain Federal Aviation Administration (FAA) Air Traffic Control Specialists	Part 65
104	Prohibition Against Certain Flights by Syrian Air Carriers to the United States	Part 91
108	Special Federal Aviation Regulation No. 108 - Mitsubishi MU-2B Series Airplane Special Training, Experience, and Operating Requirements	Part 91
109	Special Requirements for Private Use Transport Category Airplanes	Parts 21, 25, 119
112	Prohibition Against Certain Flights Within the Tripoli (HLLL) Flight Information Region (FIR)	Part 91

Figure 2-3. *Special Federal Aviation Regulations From 14 CFR.*

The remainder of this text focuses only on those regulations relative to airworthiness certification. There are 30 of these listed in *Figure 2-4*, and they are shown graphically in *Figure 2-5*. A significant benefit of this chart is the visual effect showing the interaction of the regulation with other regulations and the placement of the regulation relative to its impact on airworthiness. It is fundamentally important that the definition of the term "airworthy" be clearly understood.

Only recently did the FAA actually define the term "airworthy" in a regulation. (Refer to the 14 CFR part 3 excerpt following this paragraph.) Prior to this definition in part 3, the term could be implied from reading part 21, section 21.183. The term was defined in other non-regulatory FAA publications, and could also be implied from the text found in block 5 of FAA Form 8100-2, Standard Airworthiness Certificate. This certificate is required to be visibly placed on board each civil aircraft. (Refer to "Forms" presented later in this chapter.)

Title 14 CFR Part 3—General Requirements

Definitions. The following terms have the stated meanings when used in 14 CFR part 3, section 3.5, Statements about products, parts, appliances and materials.

- Airworthy means the aircraft conforms to its type design and is in a condition for safe operation.
- Product means an aircraft, aircraft engine, or aircraft propeller.
- Record means any writing, drawing, map, recording, tape, film, photograph or other documentary material by which information is preserved or conveyed in any format, including, but not limited to, paper, microfilm, identification plates, stamped marks, bar codes or electronic format, and can either be separate from, attached to or inscribed on any product, part, appliance or material.

Part 1	Definitions and Abbreviations
Part 13	Investigative and Enforcement Procedures
Part 21	Certification Procedures for Products and Parts
Part 23	Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes
Part 25	Airworthiness Standards: Transport Category Airplanes
Part 27	Airworthiness Standards: Normal Category Rotorcraft
Part 29	Airworthiness Standards: Transport Category Rotorcraft
Part 31	Airworthiness Standards: Manned Free Balloons
Part 33	Airworthiness Standard: Aircraft Engines
Part 34	Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes
Part 35	Airworthiness Standards: Propellers
Part 36	Noise Standards: Aircraft Type and Airworthiness Certification
Part 39	Airworthiness Directives
Part 43	Maintenance, Preventive Maintenance, Rebuilding, and Alteration
Part 45	Identification and Registration Marking
Part 47	Aircraft Registration
Part 48	Registration and Marking Requirements for Small Unmanned Aircraft
Part 61	Certification: Pilots, Flight Instructors, and Ground Instructors
Part 63	Certification: Flight Crewmembers Other Than Pilots
Part 65	Certification: Airmen Other Than Flight Crewmembers
Part 68	Requirements for Operating Certain Small Aircraft Without a Medical Certificate
Part 91	General Operating and Flight Rules
Part 107	Small Unmanned Aircraft Systems
Part 119	Certification: Air Carriers and Commercial Operators
Part 121	Operating Requirements: Domestic, Flag, and Supplemental Operations
Part 125	Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More; and Rules Governing Persons on Board Such Aircraft
Part 135	Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board Such Aircraft
Part 145	Repair Stations
Part 147	Aviation Maintenance Technician Schools
Part 183	Representatives of the Administrator

Figure 2-4. *List of FAA regulations relative to airworthiness certification.*

Airworthiness can be divided into two areas: original airworthiness as depicted in *Figure 2-5,* and recurrent airworthiness as depicted in *Figure 2-6.* There are three primary regulations that govern the airworthiness of an aircraft:

1. 14 CFR part 21—Certification Procedures for Products and Parts
2. 14 CFR part 43—Maintenance, Preventive Maintenance, Rebuilding, and Alterations
3. 14 CFR part 91—General Operating and Flight Rules

Note that the chart in *Figures 2-5* and *2-6* show most of the other airworthiness certification regulations link to one of these regulations.

Although the history section that opens this chapter discusses the FAA as if it was a single unit, it is important to understand that there are various subgroups within the FAA, and each have different responsibilities of oversight in the aviation industry. These may vary by organizational chart or geographic location.

The maintenance technician interacts mostly with FAA personnel from the Flight Standards Service (AFS) and the Flight Standards District Office (FSDO) but may also have some interaction with FAA personnel from the Aircraft Certification Service (AIR).

Maintenance-Related Regulations

14 CFR Part 1—Definitions and Abbreviations

This section is a very comprehensive, but certainly not all inclusive, list of definitions that both pilots and mechanics must become familiar with. Many regulations often provide additional definitions that are unique to their use and interpretation in that specific part. Title 14 CFR part 1, section 1.2, Abbreviations and Symbols, tends to be highly focused on those abbreviations related to flight.

14 CFR Part 21—Certification Procedures for Products and Parts

This regulation, the first of the three, identifies the requirements of and the procedures for obtaining type certificates (TCs), supplemental type certificates (STCs), production certificates, airworthiness certificates, and import and export approvals. *[Figure 2-5]* Some of the other major areas covered in this part are the procedures for becoming a designated mechanic examiner (DME), designated aircraft maintenance inspector (DAMI), designated engineering representative, designated manufacturing inspection representative (DMIR), or designated Airworthiness Representative (DAR), or obtaining a Part Manufacture Approval (PMA) or an authorization related to producing a Technical Standard Order (TSO) part. Note that part 21's greatest significance is in the original airworthiness phase, although it has minor application in recurrent airworthiness. *[Figure 2-5]* One of the most important sections of this regulation is section 21.50, "Instructions for continued airworthiness and manufacturer's maintenance manuals having airworthiness limitations sections." When an aircraft is delivered new from the manufacturer, it comes with maintenance manuals that define the inspection and maintenance actions necessary to maintain the aircraft in airworthy condition. Also, any STC

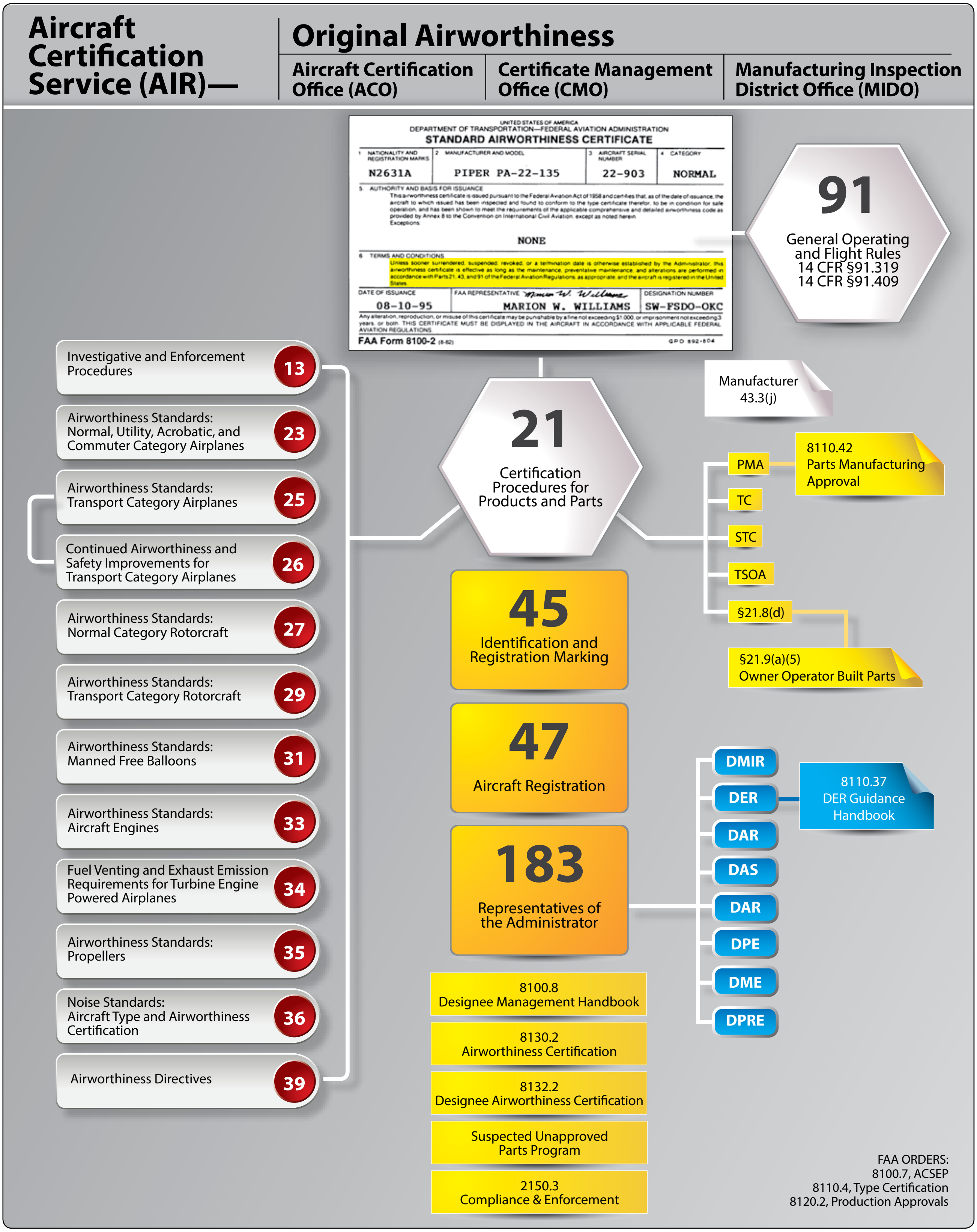


Figure 2-5. *Graphic chart of FAA regulations.*

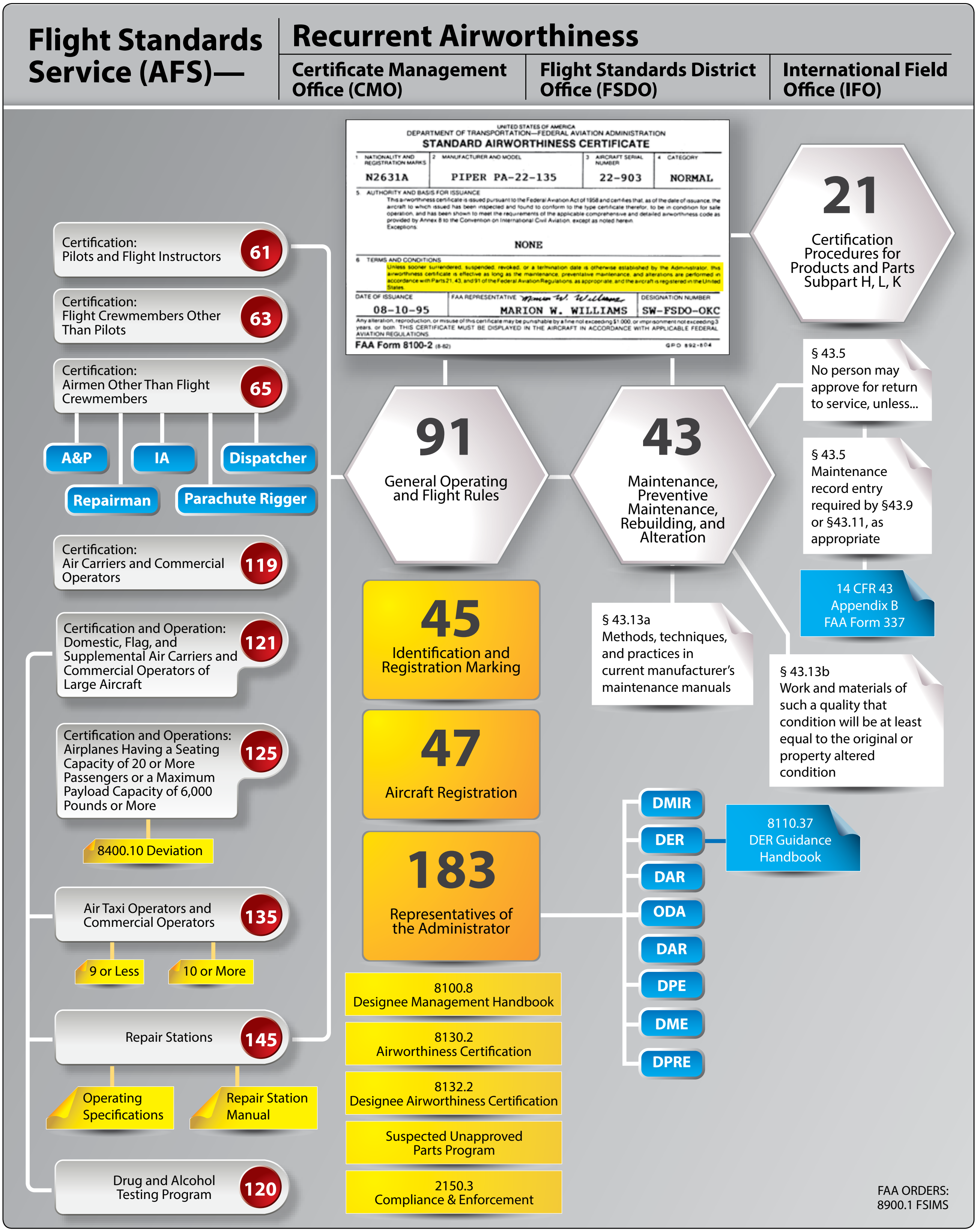


Figure 2-6. *Graphic chart of FAA regulations (continued).*

modification that was developed after 1981 must have, as part of the STC documentation, a complete set of instructions for continued airworthiness (ICA). This ICA contains inspection and maintenance information intended to be used by the technician in maintaining that part of the aircraft that has been altered since it was new. This ICA is comprised of 16 specific subjects. *[Figure 2-7]* An ICA developed in accordance with this checklist should be acceptable to the Aviation Safety Inspector (ASI) reviewing a major alteration.

14 CFR Part 23—Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

Aircraft certificated under 14 CFR part 23 represent the greatest portion of what the industry refers to as "general aviation." These aircraft vary from the small two-place piston engine, propeller-driven trainers that are frequently used for flight training, to turbine-powered corporate jets used to transport business executives. Seating capacity is limited to nine or less on all aircraft, except the commuter aircraft where the maximum passenger seating is 19, excluding the pilot and copilot seats.

This part specifies the airworthiness standards that must be met in order for a manufacturer to receive a TC and for the aircraft to receive an airworthiness certificate. Part 23 aircraft are those aircraft that have a maximum certificated takeoff weight of 12,500 pounds or less, except for those aircraft in the commuter category. The maximum certificated takeoff weight limit rises to 19,000 pounds or less for these aircraft.

Part 23 has seven subparts, six of them providing detailed criteria for the design of these aircraft. The first, subpart A, defines the applicability of this regulation. The others are:

- Subpart B—Flight
- Subpart C—Structures
- Subpart D—Design and Construction
- Subpart E—Powerplant
- Subpart F—Equipment
- Subpart G—Flightcrew Interface and Other Information

Within each of these subparts are numerous sections that specify details, such as center of gravity (CG), gust load factors, removable fasteners, the shape of certain flight deck controls, engine and propeller requirements, fuel tank markings, flight deck instrumentation marking and placards, cabin aisle width, and flammability resistant standards.

14 CFR Part 25—Airworthiness Standards: Transport Category Airplanes

The standards in 14 CFR part 25 apply to large aircraft with a maximum certificated takeoff weight of more than 12,500 pounds. This segment of aviation is usually referred to as "commercial aviation" and includes most of the aircraft seen at a large passenger airport, except for the commuter aircraft included in 14 CFR part 23. However, the ability to carry passengers is not a requirement for aircraft certified to 14 CFR part 25. Many of these aircraft are also used to transport cargo. This chapter is subdivided into similar design subpart categories and the same sequence as the requirements specified in 14 CFR part 23.

14 CFR Part 27—Airworthiness Standards: Normal Category Rotorcraft

This regulation deals with the small rotor wing aircraft and is consistent with 14 CFR part 23 with limiting the passenger seating to nine or less. However, the maximum certificated weight is limited to 7,000 pounds. It contains similar design subparts identified in 14 CFR part 23 that provide the details for designing the aircraft.

14 CFR Part 29—Airworthiness Standards: Transport Category Rotorcraft

This section specifies those standards applicable to helicopters with a maximum certified weight greater than 7,000 pounds. However, it also includes additional parameters based upon seating capacity and an additional weight limit. Those parameters are passenger seating, (nine or less, ten or more) and whether the helicopter is over or under a maximum weight of 20,000 pounds. The design subparts of part 29 are similar to those in 14 CFR parts 23, 25, and 27.

14 CFR Part 33—Airworthiness Standards: Aircraft Engines

Each of the four preceding 14 CFR regulations require that the engine used in the aircraft must be type certificated. Title 14 CFR part 33 details the requirements for both reciprocating and turbine style aircraft engines. It not only specifies the design and construction requirements, but also the block test requirements that subject the engine to extremely demanding testing in order to prove its capability of enduring the stresses of powering the aircraft.

14 CFR Part 35—Airworthiness Standards: Propellers

Just as each engine used on an aircraft must have a TC, the propeller must also be type certificated. This part is arranged the same way that 14 CFR part 33 is, in that subpart B specifies design and construction while subpart C covers tests and inspections.

ITEM SUBJECT

1. **Introduction:** Briefly describes the aircraft, engine, propeller, or component that has been altered. Include any other information regarding the content, scope, purpose, arrangement, applicability, definitions, abbreviations, precautions, units of measurement, list of parts used, referenced publications, and distribution of the ICA, as applicable.
2. **Description:** Of the major alteration and its functions, including an explanation of its interface with other systems, if any.
3. **Control, operation information:** Or special procedures, if any.
4. **Servicing information:** Such as types of fluids used, servicing points, and location of access panels, as appropriate.
5. **Maintenance instructions:** Such as recommended inspection/maintenance periods in which each of the major alteration components are inspected, cleaned, lubricated, adjusted, and tested, including applicable wear tolerances and work recommended at each scheduled maintenance period. This section can refer to the manufacturers' instructions for the equipment installed where appropriate (e.g., functional checks, repairs, inspections). It should also include any special notes, cautions, or warnings, as applicable.
6. **Troubleshooting information:** Describes probable malfunctions, how to recognize those malfunctions, and the remedial actions to take.
7. **Removal and replacement information:** Describes the order and method of removing and replacing products or parts, and any necessary precautions. This section should also describe or refer to manufacturer's instructions to make required tests, checks, alignment, calibrations, center of gravity changes, lifting, or shoring, etc., if any.
8. **Diagrams:** Of access plates and information, if needed, to gain access for inspection.
9. **Special inspection requirements:** Such as X-ray, ultrasonic testing, or magnetic particle inspection, if required.
10. **Application of protective treatments:** To the affected area after inspection and/or maintenance, if any.
11. **Data:** Relative to structural fasteners such as type, torque, and installation requirements, if any.
12. **List of special tools:** Special tools that are required, if any.
13. **For commuter category aircraft:** Provide the following additional information, as applicable:
    A. Electrical loads
    B. Methods of balancing flight controls
    C. Identification of primary and secondary structures
    D. Special repair methods applicable to the aircraft
14. **Recommended overhaul periods:** Required to be noted on the ICA when an overhaul period has been established by the manufacturer of a component or equipment. If no overhaul period exists, the ICA should state for item 14, "No additional overhaul time limitations."
15. **Airworthiness limitation section:** Includes any "approved" airworthiness limitations identified by the manufacturer or FAA Type Certificate Holding Office (e.g., An STC incorporated in a larger field-approved major alteration may have an airworthiness limitation). The FAA inspector should not establish, alter, or cancel airworthiness limitations without coordinating with the appropriate FAA Type Certificate Holding Office. If no changes are made to the airworthiness limitations, the ICA should state for item 15, "No additional airworthiness limitations" or "Not Applicable."
16. **Revision:** Includes information on how to revise the ICA. For example, a letter will be submitted to the local FAA Office with a copy of the revised FAA Form 337 and revised ICA. The FAA inspector accepts the change by signing block 3 and including the following statement: "The attached revised/new Instructions for Continued Airworthiness (date______) for the above aircraft or component major alteration have been accepted by the FAA, superseding the Instructions for Continued Airworthiness (date______)." After the revision has been accepted, a maintenance record entry will be made, identifying the revision, its location, and date on the FAA Form 337.

Figure 2-7. *Instructions for Continued Airworthiness (ICA) Checklist.*

Since regulations change over the years, not every aircraft presently flying meets the current design regulations as printed this year. When regulations are revised, they are printed in the Federal Register and released with an amendment number that ties them to the regulation being revised. Aircraft are required to meet only the specifications in force at the time the aircraft is built. NOTE: The preceding statement does not apply to the mandatory requirements imposed by Airworthiness Directives (AD), as these usually have a compliance date included in the text of the AD note.

14 CFR Part 39—Airworthiness Directives

In spite of all the emphasis on proper design and certification testing, sometimes the actual day-to-day use of the aircraft causes unanticipated wear or failure to occur. When that happens, if the FAA determines that the wear or failure represents an unsafe condition and that the condition is likely to exist in other products of the same type of design, it issues an AD. Actual AD notes are not included in 14 CFR part 39, but rather are printed in the Federal Register and are linked to this part as amendments to 14 CFR part 39, section 39.13. AD notes are legally enforceable rules that apply to aircraft, aircraft engines, propellers, and appliances.

14 CFR Part 43—Maintenance, Preventive Maintenance, Rebuilding, and Alteration

This regulation represents the heart of aviation maintenance and is one of the three major regulations previously identified. The 13 rules and 6 appendices contained within 14 CFR part 43 provide the standard for maintaining all civilian aircraft currently registered in the United States. Note that 14 CFR part 43 has a significant relationship with part 91 and other parts in maintaining continued airworthiness. *[Figure 2-6]* A more detailed explanation of this regulation is presented later in this text.

14 CFR Part 45—Identification and Registration Marking

Title 14 of the CFR part 45 includes the requirements for the identification of aircraft, engines, propellers, certain replacement and modification parts, and the nationality and registration marking required on U.S.-registered aircraft. All type-certificated products must have the following information on a fireproof dataplate or similar approved fireproof method.

1. Builder's name
2. Model designation
3. Builder's serial number
4. TC number (if any)
5. Production certificate number (if any)
6. For aircraft engines, the established rating
7. Reference to compliance or exemption to 14 CFR Part 34, Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes
8. Any other information that the FAA determines to be appropriate

Replacement and modification parts are produced in accordance with a Parts Manufacturer Approvals (PMA) (14 CFR part 21, section 21.303) and must have the following information permanently and legibly marked:

1. The letters "FAA-PMA"
2. The name, symbol, or trademark of the holder of the PMA
3. The part number
4. The name and model designation for each type certificated product it can be installed on

If a part has a specified replacement time, inspection interval, or other related procedure specification in the maintenance manual or ICA, that part must have a part number and a serial number (or the equivalent of each).

The manufacturer of a life-limited part must either provide marking instructions for that part, or state that the part cannot be marked without a compromise to its integrity. Exceptions are made for the identification of parts that are too small to be practical to mark the required data.

Nationality and registration marks (commonly known as the N-number for U.S.-registered aircraft) can vary in size, depending on the year that the aircraft was built and whether or not the aircraft has been repainted. The most common size is at least 12 inches in height. Small aircraft built at least 30 years ago, or replicas of these, or experimental exhibition or amateur-built aircraft may use letters at least 2 inches in height. Only a few aircraft are authorized to display registration markings of at least 3 inches. Note that this regulation sits directly on the vertical line in *Figure 2-5* indicating that it applies to both original and recurrent airworthiness.

14 CFR Part 47—Aircraft Registration

This regulation provides the requirements for registering aircraft. It includes procedures for both owner and dealer registration of aircraft.

14 CFR Part 65—Certification: Airmen Other Than Flight Crewmembers

Pilots, flight instructors, and ground instructors are certificated under 14 CFR part 61. Flight crew other than pilots are certificated under 14 CFR part 63. However, many other people are also required to be certificated by the FAA for the U.S. aviation fleet to operate smoothly and efficiently. Title 14 CFR part 65 addresses many of those other people.

- Subpart B—Air Traffic Control Tower Operators
- Subpart C—Aircraft Dispatchers
- Subpart D—Mechanics
- Subpart E—Repairmen
- Subpart F—Parachute Riggers

A more detailed discussion of this chapter with a special emphasis on mechanics is included in Chapter 15, The Mechanic Certificate.

NOTE: SFAR 100-2. Relief for U.S. Military and Civilian Personnel who are assigned outside the United States in support of U.S. Armed Forces Operations is a good example of the specific nature and limited time frame that are part of a SFAR.

14 CFR Part 91—General Operating and Flight Rules

This is the final regulation of the three major regulations identified earlier in this chapter. Note its interaction in *Figure 2-6* with other regulations visually indicating its "operational" involvement or "recurrent airworthiness." Although it is an operational regulation that is focused toward the owner, operator, and/or pilot of the aircraft, the maintenance technician must have an awareness of this regulation. Two examples of these maintenance related issues are:

1. Section 91.207—Emergency Locator Transmitters

   Paragraph (c)(2)—battery replacement interval and requirement for a logbook entry indicating the expiration date of the new battery.

2. Section 91.213—Inoperative Instruments and Equipment

   Paragraph (a)(2)—a letter of authorization from the FSDO authorizing the operation of the aircraft under a Minimum Equipment List (MEL) constitutes a STC and must be carried in the aircraft during flight.

Subpart E—Maintenance, Preventive Maintenance, and Alterations (Sections 91.401 through 91.421)

This is the section of most interest to the technician. He or she must be familiar with it, because it does carry some (indirect) responsibility for the technician. Note that the 14 CFR part 91 icon in *Figure 2-6* has a direct line to 14 CFR part 43. This is because section 91.403(b) states, "No person may perform maintenance, preventive maintenance, or alterations on an aircraft other than as prescribed in this subpart and other applicable regulations, including part 43 of this chapter." A more complete discussion of this regulation, especially Subpart E—Maintenance, Preventive Maintenance, and Alterations is presented later in this chapter.

14 CFR Part 119—Certification: Air Carriers and Commercial Operators

In order to better understand the next three regulations discussed here (14 CFR parts 121, 125, and 135) a brief overview of 14 CFR part 119 is beneficial. [*Figure 2-8]* There are more than 50 Advisory Circulars (ACs) in the 120 series alone providing additional non-regulatory information concerning the variety of procedures involved with these operations. There are basically three different criteria that must be analyzed in order to properly determine the regulation that applies. These are:

1. Is the service provided for Private Carriage or Common Carriage?
2. Is the aircraft For Hire or is it Not for Hire?
3. Is it a large or small aircraft?

AC 120-12, as revised, provides the following definition regarding this criterion: A carrier becomes a common carrier when it "holds itself out" to the public, or to a segment of the public, as willing to furnish transportation within the limits of its facilities to any person who wants it. There are four elements in defining a common carrier:

1. A holding out of a willingness to
2. Transport persons or property
3. From place to place
4. For compensation

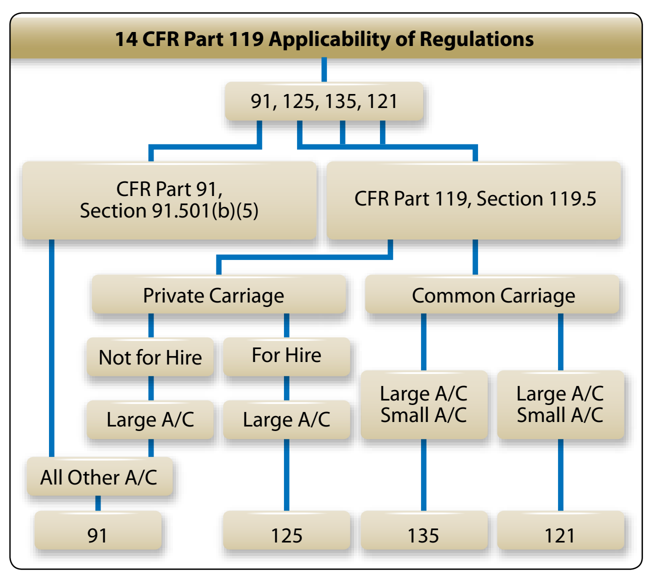


Figure 2-8. *Applicability of regulations.*

This “holding out” that makes a person a common carrier can be done in many ways, and it does not matter how it is done. Signs and advertising are the most direct means of “holding out,” but are not the only ones.

Carriage for hire which does not involve "holding out" is private carriage. Private carriers for hire are sometimes called “contract carriers,” but the term is borrowed from the Interstate Commerce Act and legally inaccurate when used in connection with the Federal Aviation Act. Private carriage for hire is carriage for one or several selected customers, generally on a long-term basis. The number of contracts must not be too great; otherwise, it implies a willingness to make a contract with anybody. A carrier operating pursuant to 18 to 24 contracts has been held to be a common carrier, because it held itself out to serve the public generally to the extent of its facilities. Private carriage has been found in cases where three contracts have been the sole basis of the operator’s business.

Operations that constitute common carriage are required to be conducted under 14 CFR part 121 or 135. Private carriage may be conducted under 14 CFR part 91 or 125.

The term “for hire” is not defined in any of the FAA documents but is generally understood to mean that compensation for both direct and indirect expenses associated with the flight, as well as a profit margin for the operator, are collected from the person or persons benefiting from the flight operation.

The determination of whether the aircraft is large or small is based upon the definition provided in 14 CFR part 1. If the aircraft has maximum certificated takeoff weight of 12,500 pounds or more, it is a large aircraft. All aircraft less than 12,500 maximum certificated takeoff weight are considered to be small aircraft.

It may also help the reader understand when 14 CFR parts 121, 125, and 135 regulations apply, by taking a brief look at a list of flight operations where 14 CFR part 119 does not apply.

1. Student instruction
2. Nonstop sightseeing flights with less than 30 seats and less than 25 nautical miles (NM) from the departure airport
3. Ferry or training flights
4. Crop dusting or other agricultural operations
5. Banner towing
6. Aerial photography or surveying
7. Fire fighting
8. Powerline or pipeline patrol
9. Parachute operations on nonstop flights within 25 NM from the departure airport
10. Fractional ownership in accordance with 14 CFR part 91, subpart K

14 CFR Part 121—Operating Requirements: Domestic, Flag, and Supplemental Operations

Title 14 CFR part 121 establishes the operational rules for air carriers flying for compensation or hire. A domestic operation is any scheduled operation (within the 48 contiguous states, the District of Columbia, or any territory or possession) conducted with either a turbo-jet aircraft, an airplane having 10 or more passenger seats, or a payload capacity greater than 7,500 pounds.

A “flag” operation means any scheduled operation (operating in Alaska or Hawaii to any point outside of those states, or to any territory or possession of the United States, or from any point outside the United States to any point outside the United States) conducted with either a turbo-jet aircraft, an airplane having 10 or more passenger seats, or a payload capacity greater than 7,500 pounds.

“Supplemental” operation means any common carriage operation conducted with airplanes having more than 30 passenger seats (if less than 30, the airplane must also be listed on the operations specifications of domestic and flag carriers), with a payload capacity of more than 7,500 pounds.

Part 121 operators are required by 14 CFR part 119 to have the following personnel:

- Director of Safety
- Director of Operations
- Director of Maintenance
- Chief Pilot
- Chief Inspector

There are 28 subparts and 16 appendices in this regulation. However, only subparts J and L are of concern for the mechanic. Subpart J—Maintenance, Preventive Maintenance, and Alterations, identifies Special Airworthiness Requirements that deals with many of the mechanical aspects of a passenger or cargo aircraft. Subpart L—Maintenance, Preventive Maintenance, and Alterations, requires that a part 121 operator have an operational manual that contains the following information:

- Organizational chart
- List of individuals who may perform required inspections

- Company maintenance, preventive maintenance, or alterations
- A system to both preserve and retrieve maintenance and inspection related information

Also, 14 CFR part 121, section 121.1105, establishes the requirement for conducting inspections on aging aircraft.

14 CFR Part 125—Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More; and Rules Governing Persons on Board Such Aircraft

This regulation applies to private and noncommon carriage when such operations are conducted in airplanes having 20 or more seats (excluding crewmembers) or having a payload capacity of 6,000 pounds or more. There must also be "operations specifications" issued to the operator that include the following information:

- Kinds of operations authorized
- Types of aircraft and registration numbers of the airplanes authorized for use
- Approval of the provisions of the operator's manual relating to airplane inspections, together with the necessary conditions and limitations
- Registration numbers of the airplanes that are to be inspected under an approved airplane inspection program (AAIP) under 14 CFR part 125, section 125.247
- Procedures for the control of weight and balance of airplanes
- Any other item that the administrator determines is necessary

Just as in 14 CFR part 121, subpart E identifies special airworthiness requirements dealing mostly with the mechanical devices of the aircraft.

14 CFR Part 135—Operating Requirements: Commuter and On-Demand Operations and Rules Governing Persons on Board Such Aircraft

As the title of this section states, this regulation is applicable to short distance commercial aircraft operations or "commuters" and nonscheduled carriers that operate "on-demand." These aircraft are frequently referred to as air taxi or air charter aircraft.

Aircraft operated under 14 CFR part 135 must be operated and maintained in accordance with the certificate holder's operations manual. This manual, when accepted by the FAA, specifies how the flight crew, ground personnel, and maintenance technicians conduct their operations.

A pivotal portion of this regulation is the first section in subpart J, 14 CFR part 135, section 135.411, Application. This section specifies that having a type certificated passenger seating configuration of nine or less may be maintained in accordance with the maintenance manual provided by the aircraft manufacturer. Those aircraft having a type certificated passenger seating configuration of 10 or more seats must be maintained in accordance with a maintenance manual written by the air carrier and must then be submitted to the FAA for approval. The requirements for the maintenance manual are specified in 14 CFR part 135, section 135.427. 14 CFR part 135, sections 135.415 through 135.417 and 135.423 through 135.443 specify additional maintenance requirements. 14 CFR part 135, sections 135.415 and 135.417 are applicable regardless of the number of seats in the aircraft.

A major change in the "nine or less" aircraft maintenance requirements occurred in February of 2005 when section 135.422, Aging Aircraft, was incorporated into 14 CFR part 135. This new subpart (note the even number) to 14 CFR 135 specifically prohibits a certificate holder from operating certain aircraft unless the Administrator has completed the aging aircraft inspection and records review. This inspection requires the certificate holder to show the FAA that the maintenance of age sensitive parts and components has been adequate to ensure safety.

This section only applies to multi-engine aircraft in scheduled operation with nine or fewer passenger seats. It does not apply to aircraft operating in Alaska. The required record review start date varies depending on the age of the aircraft. However, once initiated, the repetitive inspection intervals are not to exceed 7 years.

The certificate holder must make both the aircraft and the records available to the FAA for inspection and review. The certificate holder must notify the Administrator at least 60 days in advance of the availability of the aircraft and the records for review.

The records must include the following information:

1. Total years in service of the airplane
2. Total time in service of the airframe
3. Date of the last inspection and records review required by this section
4. Current status of life-limited parts
5. Time since the last overhaul of all structural components required to be overhauled on a specific time basis

6. Current inspection status of the airplane, including the time since the last inspection required by the inspection program that the airplane is maintained under
7. Current status of applicable ADs, including the date and methods of compliance, and, if the AD involves recurring action, the time and date when the next action is required
8. A list of major structural alterations
9. A report of major structural repairs and the current inspection status of those repairs

14 CFR Part 145—Repair Stations

This regulation underwent a major rewrite released in 2004 and was the most comprehensive change in nearly 20 years. It may be of interest to note an airframe and powerplant (A&P) certificate is not necessary to be employed at a repair station. The repair station may also employ both repairmen (under 14 CFR part 65, subpart E) and non FAA-certificated personnel. All work that is signed off is done so using the repair station certificate number and must be done only by persons authorized by 14 CFR part 65 to approve an article for return to service (RTS). Just as other certificate holders must have an operations manual, the repair station must have a repair station manual that contains the following:

- An organizational chart
- Procedures for maintaining rosters
- Description of housing, facilities, and equipment
- Procedures for revising the capability list and conducting a self-evaluation (audit)
- Procedures for revising the training program
- Procedures governing work done at another location
- Procedures for working on air carrier aircraft
- Description of the required records and record keeping
- Procedures for revising the repair station manual
- Description of the system to identify and control the sections of the manual

All records from repair station maintenance activity must be kept a minimum of 2 years. Domestic repair station certificates are effective until they are surrendered, suspended, or revoked. The certificates of foreign repair stations expire, usually after 1 or 2 years and must be renewed.

14 CFR Part 147—Aviation Maintenance Technician Schools

Title 14 CFR part 147 defines the requirements for obtaining a maintenance training certificate. This certificate may be for either airframe, powerplant, or a combination of the two. The minimum number of curriculum hours for conducting either airframe or powerplant training independently is 1,150.

If both A&P ratings are offered, the combined total curriculum hours are 1,900. This is because of the 1,150 hours specified to obtain either the airframe or the powerplant rating, 400 hours are devoted to general studies. Only one set of general studies hours is applicable to the combined total. Therefore, 400 hours can be subtracted from the implied total of 2,300 hours (1,150 × 2) to obtain the reduced figure of 1,900 hours. Requirements are detailed as follows:

- Appendix A—Curriculum Requirements
- Appendix B—General Curriculum Subjects
- Appendix C—Airframe Curricular Subjects
- Appendix D—Powerplant Curriculum Subjects

14 CFR Part 183—Representatives of the Administrator

As the aviation industry grows and the design, manufacture, and testing of aircraft gets more complex, the FAA faces both budget constraints and personnel shortages. As early as 1962, the FAA began a program to allow private sector persons in various areas of industry to be "designees" or "representatives of the FAA Administrator." These people are NOT FAA employees, but rather are designated by the FAA to act on their behalf. Regular doctors may serve as "aviation medical examiners," skilled pilots can become "pilot examiners," and experienced airframe and/or powerplant mechanics can become "designated mechanic examiners (DME)" to administer the oral and practical portion of the FAA testing.

Other lesser known designees are the designated engineering representatives (DER), the designated manufacturing inspection representatives (DMIR), and the designated airworthiness representatives (DAR).

- DERs approve data based upon their engineering training and their knowledge of FAA regulations.
- DMIRs make conformity inspections only at their employer. They are similar to "designated repairmen" because they are only authorized to inspect parts at their employers' facility.
- DARs conduct aircraft certification and aircraft inspection functions on behalf of the FAA depending on specific functions they are authorized. They may perform work for either manufacturing facilities or maintenance entities depending on their designation.

Explanation of Primary Regulations (Parts 43 and 91)

14 CFR Part 43—Maintenance, Preventative Maintenance Rebuilding, and Alteration

Section 43.1—Applicability

Paragraph (a) states quite clearly that aircraft (whether U.S.- or foreign-registered operating under 14 CFR part 121 or 135) and component parts thereof must be maintained in accordance with the rules set forth in this part. Although paragraph b states quite clearly the type of aircraft that this part does not apply to, it seems to have led to considerable confusion within the aviation industry. If an aircraft is flying with a Special Airworthiness—Experimental Certificate (FAA Form 8130-7, Special Airworthiness Certificate—pink color certificate) and that is the only airworthiness certificate this aircraft has ever had, then 14 CFR part 43 does not apply.

Conversely, sometimes during maintenance (especially STC modification—the STC is addressed later in this chapter), it becomes necessary to temporarily place the aircraft into Special Airworthiness—Experimental. This is done to show compliance with federal regulations. These aircraft must still be maintained in accordance with 14 CFR part 43, because the aircraft had a different kind of airworthiness (in this example a Standard) prior to being issued the Special Airworthiness Certificate.

Section 43.2—Records of Overhaul and Rebuilding

These terms are not defined in 14 CFR part 1 and are given full explanation in this subpart. Each term states that it may not be used to describe work done on an aircraft, airframe, aircraft engine, propeller, appliance, or component part unless that item has been:

- Disassembled
- Cleaned
- Inspected
- Repaired, as necessary
- Reassembled
- Tested

The key difference between the two terms is in determining how the item is tested. If it is "tested in accordance with approved standards acceptable to the Administration that have been developed and documented by the manufacturer, the item is said to be overhauled." This is basically another way of describing "service limits," a term frequently used to describe manufacturer specified acceptable limits for used parts. A "rebuilt item, on the other hand, must be tested to the same tolerances and limits as a new item."

Section 43.3—Persons authorized to perform maintenance, preventive maintenance, rebuilding, and alterations

There are nine different persons who may perform maintenance: (Reminder: Per 14 CFR part 1, the FAA definition of a person is "an individual, firm, partnership, corporation, association, joint-stock association, or governmental entity. It includes a trustee, receiver, assignee, or similar representative of any of them.")

1. Certificated mechanic, per 14 CFR part 65
2. Certificated repairman, per 14 CFR part 65
3. Person working under the supervision of a certificated mechanic or repairman
4. Holder of repair station certificate
5. Holder of an air carrier certificate
6. Except for holders of a sport pilot certificate, the holder of a pilot certificate issued under part 61 may perform preventive maintenance on any aircraft owned or operated by that pilot which is not used under 14 CFR part 121, 129, or 135. The holder of a sport pilot certificate may perform preventive maintenance on an aircraft owned or operated by that pilot and issued a special airworthiness certificate in the light-sport category.
7. Pilot of a helicopter (when operated under 14 CFR part 135 and in remote areas) may perform specific preventive maintenance actions. These actions may only be accomplished under the following conditions:
    - The mechanical difficulty or malfunction occurred en route to or in the remote area.
    - The pilot has been satisfactorily trained and is authorized in writing by the certificate holder to perform the required maintenance.
    - There is no certificated mechanic available.
    - The certificate holder has procedures to evaluate the work performed when a decision for airworthiness is required. The work done is listed in paragraph (c) of Appendix A of this chapter.
8. Holder of part 135 certificate may allow pilots of aircraft with nine or less passenger seats to remove and reinstall cabin seats and stretchers and cabin mounted medical oxygen bottles. These actions may only be accomplished under the following conditions:
    - The pilot has been satisfactorily trained and is authorized in writing by the certificate holder to perform the required maintenance.

- The certificate holder has written procedures available to the pilot to evaluate the work performed.

9. Manufacturer may inspect and rebuild any item it has manufactured.

Section 43.5—Approval for return to service after maintenance, preventive maintenance, rebuilding, and alterations

Approving an aircraft component for return to service after maintenance, preventive maintenance, rebuilding, or alteration must be done by creating an appropriate maintenance record entry as required by either 14 CFR part 43, section 43.9 or 43.11. This may include the use of FAA Form 337, Major Repair and Alteration, if the maintenance action was a major repair or a major alteration. Whenever a maintenance action is being planned, it is critical that the technician understands exactly:

1. What he/she is going to do.
2. How that work is classified by the FAA.
3. What type of documentation is required to support this activity.

First consider whether this a repair or an alteration. This should be a relatively simply decision since a repair basically returns the aircraft to its previous or unaltered condition (i.e., replacing magnetos, an exhaust system, tires, or brakes). Even replacing an entire engine (although it is a big job) is still a repair if it is the one properly specified for that aircraft. An alteration on the other hand, always changes or modifies the aircraft from its previous state (i.e., installing winglets, new avionics, or an engine that is not listed in the aircraft TCDS).

The second question to consider is whether or not the work that to be performed constitutes a major or a minor maintenance action. A "major" action is typically one that might appreciably affect weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness and that are not done according to accepted practices or cannot be done by elementary operations. This is a much more complex question, but it is extremely important as it drives the final question concerning the substantiating documentation. Please refer to 14 CFR part 1 and part 43, appendix A, for additional clarification and examples.

The third question deals with the type of documentation required to substantiate the work performed. Minor repairs and alterations need only to refer to "acceptable" data, such as manufacturers' maintenance manuals or AC 43.13-1. The maintenance action can simply be recorded in the maintenance record as a logbook entry. Major repairs and alterations require "approved data." Some examples of approved data are AD notes, STCs, TCDS, DER-specific delegations, and FAA-approved manufacturer Service Bulletins (SB).

Sometimes the repair or alteration being performed does not have previously-approved data. In that case, the technician may request that the FAA accomplish a "Field Approval." In this procedure, the technician completes the front side of Form 337 through block 6 (leaving block 3 open for later FAA approval) and then indicates in block 8 on the back what work is to be done and what the substantiating reference data is. Form 337 is then submitted to the local FAA FSDO office for review and approval by an ASI. If necessary, this ASI may seek input from other ASIs or FAA specialists to assist in the review of the data. If the data is found to comply with FAA regulations, the ASI enters one of the following statements in block 3, depending on whether the ASI has performed a review of the data only or has physically inspected the aircraft:

- "The technical data identified herein has been found to comply with applicable airworthiness requirements and is hereby approved for use only on the above described aircraft, subject to conformity inspection by a person authorized in 14 CFR part 43, section 43.7."

  or

- "The alteration or repair identified herein complies with the applicable airworthiness requirements and is approved for use only on the above described aircraft, subject to conformity inspection by a person authorized in 14 CFR part 43, section 43.7."

Section 43.7—Persons authorized to approve aircraft, airframes, aircraft engines, propellers, appliances, or component parts for return to service after maintenance, preventive maintenance, rebuilding, or alteration

There are seven different persons listed in this section who may sign RTS documentation:

1. Certificated mechanic or holder of an inspection authorization (IA)
2. Holder of a repair station certificate
3. Manufacturer
4. Holder of an air carrier certificate
5. Certificated private pilot
6. Repairman certificated with a maintenance rating for light sport aircraft (LSA) only

7. Certificated sport pilot for preventive maintenance on an aircraft owned and or operated by him or her

Note that although a certificated repairman is authorized to work on a product undergoing maintenance, preventive maintenance, rebuilding, or alterations (refer to 14 CFR part 43, section 43.3), he or she is not authorized to approve that product for RTS. He or she must make the appropriate maintenance record entry per the requirements of 14 CFR part 43, section 43.9 or 43.11.

Section 43.9—Content, form and disposition of maintenance, preventive maintenance, rebuilding, and alteration records (except inspection performed in accordance with parts 91 and 125, and sections 135.411(a)(1) and 135.419 of this chapter)

The first observation is that this section specifically excludes inspection entries (those are covered in 14 CFR part 43, section 43.11). This section deals exclusively with maintenance record entries.

The next observation is that the list of maintenance actions includes "preventive maintenance." As stated in the explanation of 14 CFR part 43, section 43.3, a certificated pilot is authorized to perform preventive maintenance on the aircraft he or she owns or operates. Therefore, remember that the pilot must make a record entry of the preventive maintenance he or she has accomplished. There are three distinct issues to be addressed in the maintenance entry and they answer the questions of "what?, when?, and who?"

- What—a description of the work performed
- When—the date the work was completed
- Who—the name of the person who did the work if other than the person who approves the RTS

  —the signature, certificate number, and type of certificate of the person who is approving the work for RTS

NOTE: Frequently, logbooks have a statement entered that ends something like this: " … and is hereby returned to service. Joe Fixer A&P, Certificate #123456789." As this section of the regulation currently reads, that part of the record entry is not required. Title 14 of the CFR part 43, section 43.9 clearly states that "the signature constitutes the approval for return to service only for the work performed." Furthermore, the technician is only signing off the work he or she has done. Later, 14 CFR part 43, section 43.11 explains that an inspection write-up usually carries a broader scope of responsibility. This section is very clear that the entry completed in accordance with this section only holds the technician responsible for the service maintenance action he or she entered.

If the maintenance accomplished was a major repair or alteration, the work must be documented on FAA Form 337 and requires supporting approved data. If the maintenance action was a major repair and it was done by a certificated repair station, a signed copy of the completed customer work order accompanied by a signed maintenance release may be used in lieu of the FAA Form 337.

Section 43.10—Disposition of Life-Limited Aircraft Parts

(Note the even number again. This regulation became part of 14 CFR part 43 in 2002.)

This section presents two terms not previously defined in 14 CFR:

1. Life-limited part means any part that has specified a mandatory replacement limit.
2. Life status means the accumulated cycles, hours, or any other mandatory limit of a life-limited part.

This section then goes on to specify what to do with parts that are temporarily removed from and then reinstalled on a type-certificated product; what to do with parts that are removed from a type certified product and not immediately reinstalled; and how to transfer life-limited parts from one type-certificated product to another.

When a life-limited part is removed, the person removing it from the type-certificated product must control the part and ensure proper tracking of the life-limiting factor. This is to prevent the installation of the part after it has reached its life limit. There are seven possible methods the technician or repair facility may choose from to comply with this requirement.

1. Recordkeeping
2. Tagging
3. Non-permanent marking
4. Permanent marking
5. Segregation
6. Mutilation
7. Any other method approved or accepted by the FAA

When a life-limited part is transferred, the information concerning the life status of that part must be transferred with it. Although regulations already did exist that required the tracking of life-limited parts when they were installed on an aircraft, this regulation was generated to govern the disposition of such parts when they were removed from the aircraft.