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Aircraft Fuel Systems Journeyman

Volume 2. Integral Tank and Fuel Cell Maintenance

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WELCOME TO VOLUME 2 and the final volume of career development course (CDC) 2A654, *Aircraft Fuel Systems Journeyman*. It could be said that this volume is where the "rubber meets the road." You will study many aspects of fuel systems maintenance and problems that may arise while you are repairing the systems. From the information presented in this volume, you will obtain a basic understanding of aircraft construction, special tools, and equipment used in our profession; procedures involved in preparing an aircraft for confined space entry; integral tank maintenance fundamentals; and fuel cell maintenance and inspection.

This volume of CDC 2A654 covers specific information pertaining to integral tank and fuel cell maintenance.

Unit 1 covers aircraft construction, hardware, plumbing, safetying devices, and corrosion control.

Unit 2 covers special tools and equipment used to perform fuel systems maintenance.

Unit 3 focuses on basic circuits, multimeter use and electrical fundamentals.

Unit 4 deals with the preparation for fuel tank maintenance, confined space entry requirements, purging and depuddling procedures.

Unit 5 focuses on integral tank maintenance, fuel-leak evaluation, integral tank sealant repair, and temporary repairs procedures.

Unit 6 covers fuel cell maintenance and inspection procedures, cell familiarization and handling, fuel-leak troubleshooting, fuel cell repair, and fuel cell inspection and testing.

A glossary is included for your use.

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For Guard and Reserve personnel, this volume is valued at 20 hours and 4 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Unit 1. Aircraft Familiarization

THIS FIRST UNIT OF VOLUME 2 covers aircraft constructional features. We will look at the major assemblies of an airframe and their purposes, as well as various types of hardware used in the construction of an aircraft. We will also discuss plumbing systems, safety devices, and some basic corrosion control concepts. Information in this unit is designed to increase your knowledge from that of a 3-skill level to that of a 5-skill level. At this point in your maintenance career, it is important that you become familiar with basic concepts of aircraft construction. A good background knowledge in aircraft structures will aid you with any maintenance responsibilities in these areas.

1–1. Aircraft Construction

The foundation of any aircraft is the airframe. All other systems attach to the airframe and are a part of it. In this study of the airframe, we will cover the purpose and function of the major aircraft assemblies such as the fuselage, wings, empennage, and landing gear. Let's start with the construction of a fuselage.

201. Structural features of the fuselage, wings, and empennage

The fuselage is the main structural unit of the aircraft. Other structural units directly or indirectly attach to it and help to support its mission of housing cargo, personnel, engines, and miscellaneous equipment. The fuselage of one aircraft is much the same as others in purpose and general design. Over the years, many designs have been successful for United States Air Force purposes and missions. In fact, those designs are found to be most satisfactory and are still used in the construction of modern aircraft. The difference between aircraft fuselages are size and the arrangement of compartments. The design details vary with the manufacturer and the aircraft's mission. The three basic types of fuselage construction are the truss, monocoque, and semi-monocoque.

Truss construction

The truss type of fuselage construction is a rigid framework made up of welded members such as beams, struts, and bars, which resist deformation from applied loads. The truss-framed fuselage is covered with fabric and/or thin metal and is used on many small, lightweight aircraft having slow speeds and requiring light construction. The nose section framework of many reciprocating (turboprop) engine aircraft is made of steel tube truss construction. This is for crash protection.

Monocoque construction

The word *monocoque* is French for "a single shell." The monocoque type of construction is like a shell in which the skin of the fuselage carries the primary stress load. Former rings and bulkheads give the fuselage its shape. Figure 1–1 illustrates the monocoque type of construction. Since there are no longitudinal bracing members, the skin must have enough thickness and strength to keep the fuselage rigid. Thus, the total weight of the aircraft becomes a problem.

Semi-monocoque construction

The semi-monocoque type of construction overcomes the strength-to-weight ratio problem of monocoque construction. This type of construction uses aluminum alloy and is found on most modern military aircraft. Figure 1–2 illustrates the semi-monocoque fuselage. Notice that, in addition to former rings and bulkheads, the fuselage is constructed with longerons and stringers; the longerons are the longest and strongest members of this type of fuselage. They run the length of the fuselage, providing strength. Primarily, stringers provide cross-sectional strength to the fuselage and attachment points for the skin. In summary, the longerons hold the former rings and bulkheads together; the former rings and bulkheads, in turn, hold the stringers. These components, when joined with the skin, form a rigid fuselage framework.

It is easy to see that the structural design varies from aircraft to aircraft. The reason for this is that each aircraft was built with a particular mission in mind. In general, the larger the structural surface, the more wind it deflects in flight, which translates into more maneuverability.

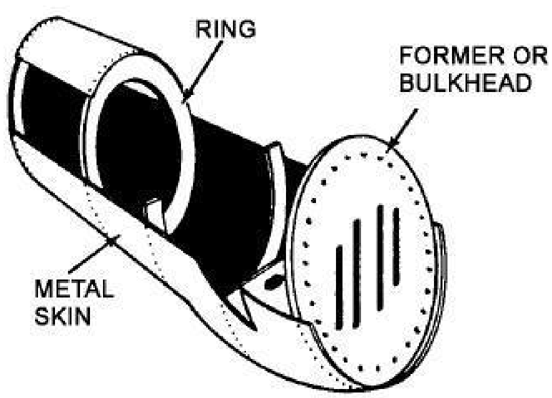


Figure 1–1. Monocoque fuselage construction.

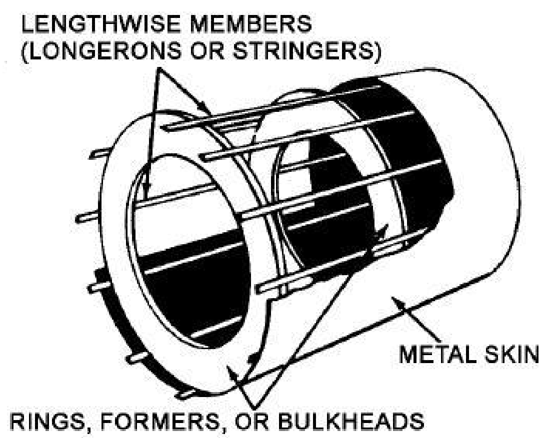


Figure 1–2. Semi-monocoque fuselage construction.

Wings

The wings of the aircraft are surfaces designed to give lifting force when they move rapidly through the air. The wing design for each aircraft depends on factors such as size, weight, airspeed, rate of climb, and aircraft mission.

Most military aircraft use a cantilever design made of aluminum alloy. This design requires the skin part of the wing to carry part of the wing's stress load. The component parts of the wing are broken down as either primary structural members or secondary structural members. The primary members include the spars, the ribs, and the skin. The secondary structural members include the stringers and stiffeners. These parts are riveted or welded together to form the wing's structure. Figure 1–3 shows how the structural members are laid out. Most aircraft have inspection openings and access doors on the bottom and top surfaces of the wing. Some wing designs vary in the angle at which they attach to the fuselage. If the wings angle upward, they are said to have positive dihedral. If the wings angle downward, they have negative dihedral.

Empennage

The empennage is the tail section of the aircraft. It includes the aft end of the fuselage on conventionally designed aircraft. The empennage may include horizontal and/or vertical stabilizers, rudder(s), elevator(s), and trim tabs. The vertical stabilizer maintains the directional stability of an aircraft about its vertical axis and is the attachment point for the rudder. The horizontal stabilizer gives stability to the aircraft about its lateral axis and serves as a base or attachment point for the elevators.

We have discussed the fact that the design of the wings and empennage vary with the mission of our aircraft. There is another design feature that is considered when our aircrafts are made. This is what we call low observables (LO).

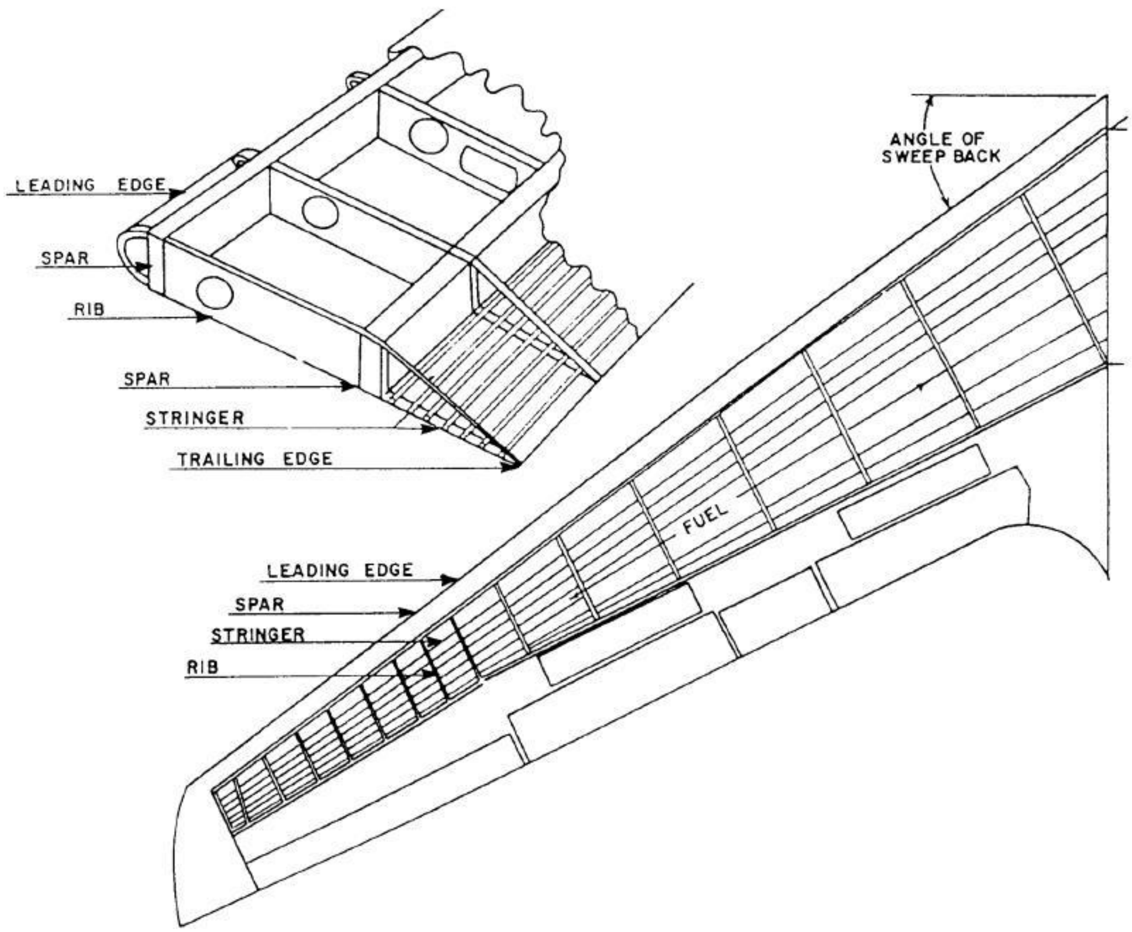


Figure 1–3. Aircraft wing construction.

202. Flight control surfaces and landing gear

A car uses a steering wheel, which is attached to the front wheels to control the movement of the car. Most aircraft use a similar system while on the ground; however, can you see where this system would not work in flight? This is where flight controls come into play.

Flight control surfaces

Flight control surfaces are hinged, moveable surfaces that control the attitude or maneuvers of an aircraft during takeoff, flight, and landing. Flight control surfaces are often categorized as primary, secondary, or auxiliary.

Primary flight controls

These surfaces control the directional movement about the axis of an aircraft. Aircraft directional movement is around three axes—lateral, longitudinal, and vertical—and represents an unlimited number of planes of movement. These planes of movement are illustrated in figure 1–4. Ailerons, elevators, rudders, and stabilizers are examples or primary flight controls that you will find on most aircraft (fig. 1–5). Ailerons are located on the trailing edge near the wing tips. Elevators control the pitch movement of the aircraft and make the aircraft dive or climb. The rudder is a single surface, hinged in a vertical position to the trailing edge of the vertical stabilizer. It controls the movement of the aircraft about the vertical axis. Primary flight control surfaces generally are constructed of aluminum alloy.

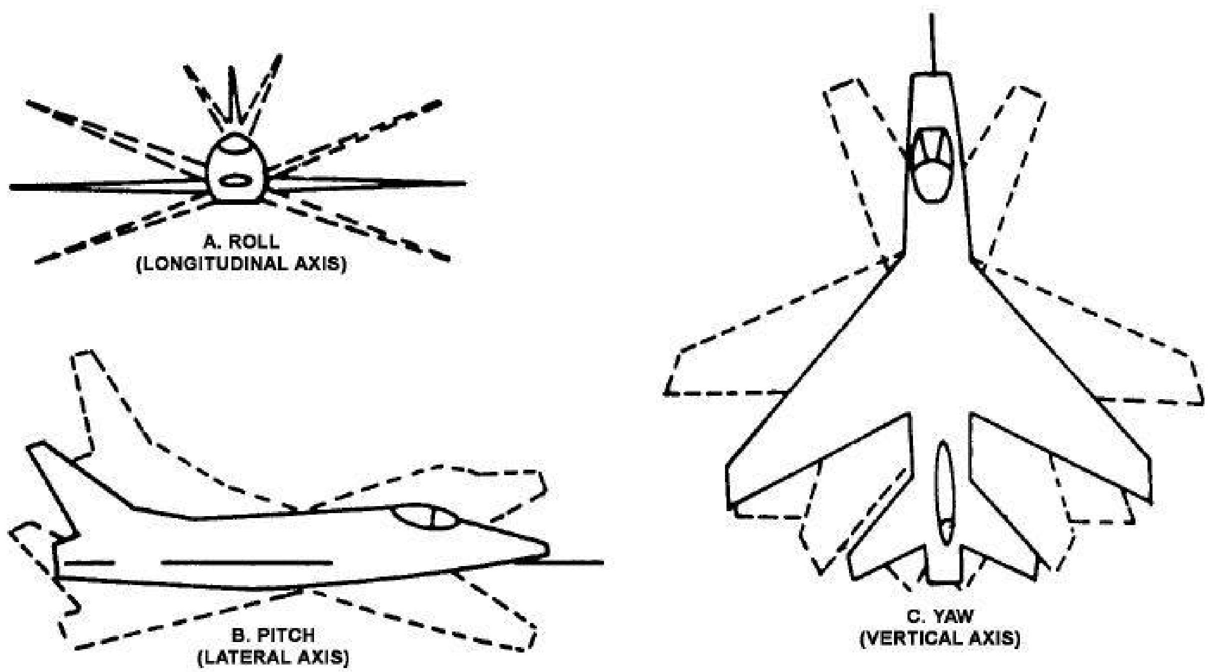


Figure 1–4. Aircraft flight attitudes.

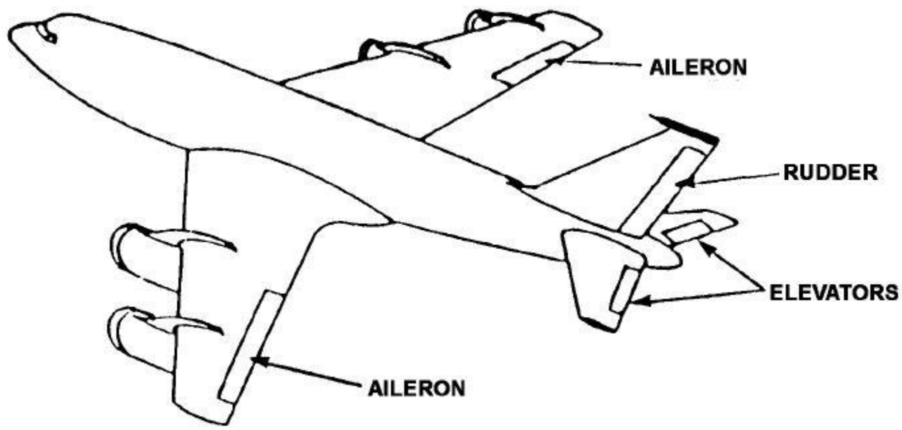


Figure 1–5. Primary flight controls.

Secondary flight controls

Secondary flight controls are trim tabs. They aid the primary flight controls by correcting for any unbalanced condition of the aircraft in flight.

Auxiliary flight controls

Flaps and spoilers are examples of auxiliary flight controls that you will find on most aircraft (fig. 1–6). These flight control surfaces supplement the primary and secondary flight controls. They increase lift during takeoff and reduce speed during landing. Flaps reduce the landing speed and shorten the length of the takeoff or landing run.

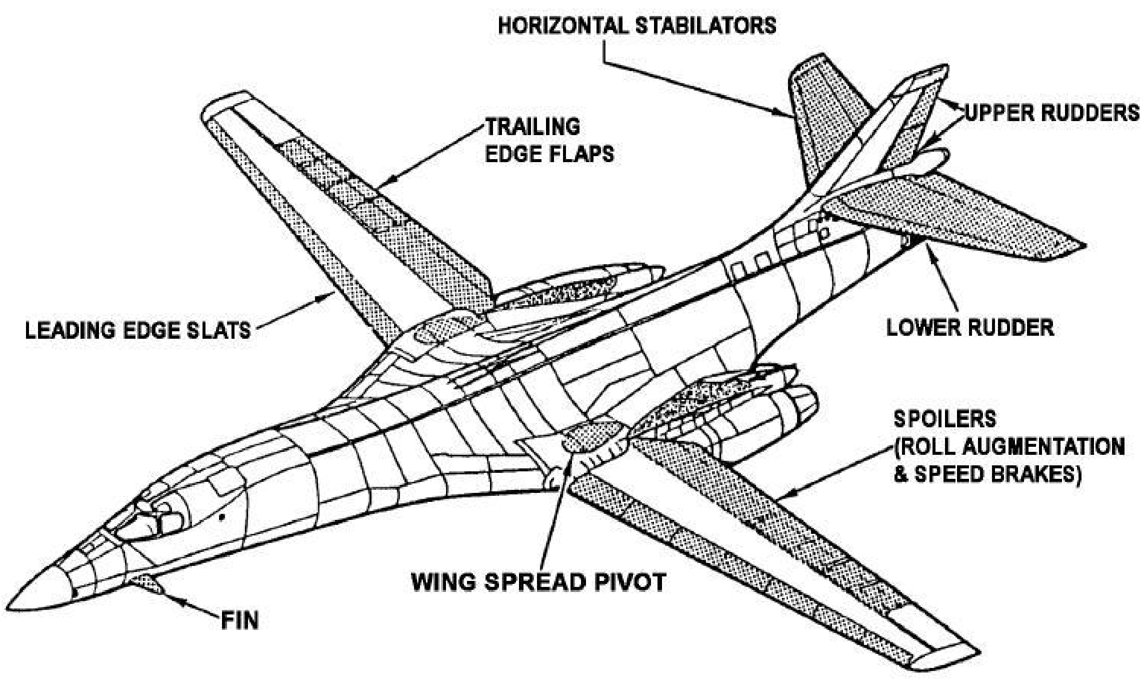


Figure 1–6. Typical flight controls.

Landing gear

The landing gear supports the aircraft during landing, resting, or moving on the ground. It also aids in steering and braking the aircraft while on the ground. The shock struts absorb the shock of landing and taxiing. The landing gear attaches to the aircraft structure and is extended and retracted by a retraction mechanism that may be electrically-, mechanically-, or hydraulically-actuated, depending on the type of aircraft. The landing gear arrangement usually has a tail wheel or a nose wheel design, with the latter being most common. Usually, landing gear arrangements using a nose wheel are equipped for nose wheel steering. Brakes are installed in the wheels to enable the aircraft to be slowed or stopped during movement on the ground.

203. Low observables

Although making an aircraft visually invisible is impossible, applying LO technology gives us the ability to avoid radar detection and increase our surprise attack capability. Our adversaries use multiple techniques to identify potential threats including radar, thermal, acoustical, and visual detection. LO technology, also referred to as stealth technology, is a series of processes that gives an object the ability to defeat radar, thermal, acoustical, and visual detection. The ability to defeat various detection methods increases aircraft survivability.

Exploring the history of low observables

One of the earliest uses of radar absorbent material (RAM) was discovered by mistake. British radar engineers theorized radar cross section of an aircraft in the late 1930s. Due to the Allied Forces taking catastrophic losses during daylight bombing in World War II, the decision was made to begin nighttime raids. The decision paid off until the Germans introduced the first airborne radar. With resources becoming scarce, the British built wooden skin fighters known as “Mosquitoes.” Because the German radar was new and very basic, the Mosquitoes were able to avoid detection. With this surprising discovery, the Mosquitoes became the primary nighttime fighters.

The brothers Reimar and Walter Horten, pioneers of flying wing aircraft, conceived the Horten HoIX, also known as the Go 229. In 1943, they started to design a twin-engine, jet-powered flying wing called HoIX. At the beginning of 1944, the Reichsluftfahrt Ministerium realized the importance of the design, as did Hermann Goering, who gave all his support to the Horten brothers and their novel aircraft.

Using the previous design of the German Horten HoIX, Northup Grumman established a program to put the stealth technology to work. They manufactured the YB–49, which flew from 1941 to 1950, but the program was cancelled for 40 years before being brought back online. This design of the YB–49 evolved into the B–2 Stealth Bomber.

In the late 1950s, Lockheed Martin designed an aircraft that relied on shape, altitude, and speed to help with its stealth capabilities. This company produced the SR–71 Blackbird, which flies in the earth’s atmosphere at altitudes of 85,000 feet and faster than Mach 3.

With the future of aircraft getting smaller and faster, Lockheed Skunk Works developed an aircraft in the late 1970s to adapt to changes in radar. They designed and built a small state-of-the-art fighter called Have Blue. The Have Blue was made a bit stealthier, thus evolving into the F–117A Nighthawk.

As radar systems became more advanced, stealth technology lagged behind. A major advancement in stealth technology was not made until the B–1 bomber utilized advanced composite materials in the late 1970s. The fuselage and empennage sections of the B–1 use an extensive amount of advanced composite material. These advancements in technology led to a more widespread use. These advancements are becoming the standard in modern aircraft such as the B–2 bomber, F–35, and F–22 tactical fighters.

The purpose of low observables

The main purpose of LO technology is to increase the survivability of the weapons platform. The biggest advantage LO aircraft bring to the fight is high survivability. That means that an aircraft is highly likely to successfully complete its mission and be available to fight again. In addition to having a high-survivability rate, stealth aircraft are also highly lethal platforms. They are capable of destroying many intended targets on their first attempts. The combination of survivability and lethality means that one of these aircraft can do the job that required multiple legacy aircraft in past conflicts. This capability makes LO aircraft force multipliers. Stealth systems can penetrate defenses to attack targets denied to conventional aircraft or sustain far fewer combat losses in performing their designated missions. Additional specific advantages of LO technologies are as follows:

- Reduced range at which an enemy can detect or track you.
- Ability to see your enemies before they see you.
- Reduced amount of time the enemy has to react to you.
- Allows you to engage and destroy targets prior to threat lock-on or launch.
- Permits you to evade or deceive hostile forces through covert operations.
- Leads enemy to misidentify you as a non-hostile platform.
- Increased effectiveness of electronic countermeasures.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. Structural features of the fuselage, wings, and empennage

1. What are the three types of fuselage construction?

2. In what type of fuselage construction does the skin carry the primary stress load?

3. For what purpose was the semi-monocoque type fuselage designed?

4. What type of material is used in the construction of the semi-monocoque fuselage?

5. Which members of the semi-monocoque fuselage are the longest and strongest?

6. What function do the stringers serve in a semi-monocoque fuselage?

7. What purpose do the wings serve?

8. What factors determine the design of the aircraft's wings?

9. What kind of wing design do most military aircraft use?

10. What is meant by the term "positive dihedral wing?"

11. What units or components may be included as part of an aircraft empennage?

12. What is the purpose of the vertical stabilizer?

202. Flight control surfaces and landing gear

1. In addition to the primary flight control surfaces, what are two other types of flight control surfaces?

2. What is the function of primary flight controls?

3. Where are the ailerons located on the aircraft?

4. What is the purpose of the rudder?

5. What purpose do the trim tabs serve?

6. What are two examples of auxiliary flight controls?

7. What is the purpose of the aircraft landing gear?

8. Depending on the aircraft, how may the landing gear be extended or retracted?

203. Low observables

1. What is the definition of low observable?

2. What increases an aircraft's ability to survive?

3. What major stealth technology advancement occurred in the late 1970s?

4. What is the main purpose of LO technology?

1–2. Aircraft Hardware

Fastening devices (i.e., bolts, nuts, washers, etc.) are installed throughout the aircraft. They attach components, connect/disconnect assemblies, fasten structural members, allow adjustments, and so forth. The replacement of fasteners with like fasteners is critical. Therefore, you need to become familiar with some basic types of hardware commonly used on aircraft. The next few lessons address the types and usage of bolts, nuts, washers, and screws.

204. Bolts

Most of the bolts used are general-purpose Air Force-Navy (AN) Standard, National Aircraft Standard, internal wrenching, or close tolerance bolts. When dimensional and strength requirements demand special bolts, manufacturers must make them. When a bolt is installed, the grip length (i.e., unthreaded portion) should be a few thousandths of an inch shorter than the thickness of the material being joined. This is to avoid bottoming the nut. A general rule is, "All bolt installations involving self-locking or plain nuts have at least two complete threads protruding through the nut." Because it is not always possible to observe this rule, certain variations are allowed. You can use bolts of slightly greater grip length if you use washers underneath the nut or bolt head. Aluminum alloy washers are used with steel bolts on dual parts (e.g., an alloy of aluminum, copper, manganese, and magnesium), except in the case of high-torque values. Steel washers are used on steel parts to prevent corrosion.

Because some bolts are made for a particular purpose, you must use similar bolts for replacement. The letter "S" stamped on their heads identifies special bolts. Head markings on other bolts may indicate either the bolt type or the material from which they are made. Usually, bolts used on aircraft are made of cadmium or zinc-plated nickel steel, bronze, or aluminum alloy. You can get a working knowledge of special markings only by learning and memorizing their meaning.

Maintenance personnel generally identify the size of a bolt in terms of its length, diameter, and threads per inch. A bolt that is 2 inches long, 1/4 inch in diameter, and has 28 threads per inch is called a 2-inch bolt, 1/4 by 28. Bolts that have a 1/4-inch or greater diameter are specified by actual diameter measurement in inches or fractions of an inch. Bolts less than 1/4 inch in diameter are specified by a number—10, 8, 6, 4, and 2—followed by the number of threads per inch.

Bolts are made in so many shapes and varieties that a clear-cut method of classification is difficult. For the sake of simplicity, they may be roughly classified by the shape of the bolt head; hex head, internal wrenching, 12-point, clevis, eyebolt, and stud (fig. 1–7).

Hex head

The hex head bolt is available as either a drilled or an undrilled head. It is also available in thin heads for use in tight places. Hex head bolts are used where heavy tension or lengthwise stresses must be sustained.

Internal wrenching

This bolt, made of high-strength steel, is used primarily in high-tension applications. The head is recessed for internal wrenching. Never substitute a standard hex head bolt in place of an internal wrenching bolt. Also, never use a standard nut or washer with this type of bolt; special nuts and heat-treated washers must be used.

12-point, external-wrenching

The 12-point, external-wrenching bolt is a high-strength steel bolt used primarily in high-tensile, high-fatigue, and strength applications. A hole is drilled or formed in the head to lighten the bolt. Standard hex head bolts cannot be substituted for these bolts.

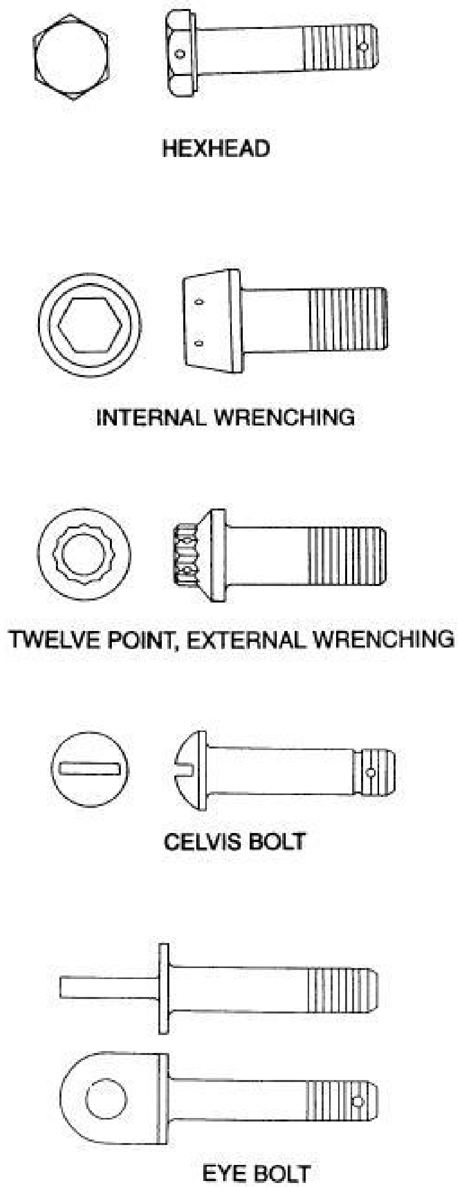


Figure 1–7. Types of bolts.

Clevis

The clevis bolt is a special-purpose bolt used where shearing or sidewise stress occurs. Clevis bolts are never used for tension; however, they are often used as pins in control systems. Clevis bolts are available with either slotted or recessed heads.

Eyebolt

The eyebolt is a special-purpose bolt used where external tension loads are applied. The eye of the eyebolt is used for attaching a turnbuckle fork, clevis, shackle, or tie down rope. Eyebolts are also found in fuel cell cavities, and serve as supporting attachments for fuel cells and tie-off points for lacing cord.

Stud

The stud is used where a standard-type bolt is impractical (e.g., in the mounting of accessories). In most instances, one end of the stud has finer threads than the other end. The nut is put on the end with the fine threads.

205. Nuts, washers, and screws

In addition to bolts, other fasteners commonly used on aircraft include nuts, washers, and screws.

Nuts

Since most types of bolts require nuts, let's look at the nuts that are made to fit them. Nuts, like bolts, come in a wide variety of shapes and sizes. Nuts do not come with the bolts and have no identifying marking or lettering. Furthermore, they can be identified only by the characteristic color (e.g., metal, brass, or fiber) construction, and thread size. Except for a few special types of nuts, nearly all are AN and can be divided into two general groups—non-self-locking and self-locking.

Non-self-locking

Non-self-locking nuts must be secured by external locking devices (e.g., locknuts, cotter pins, or safety wire) to ensure they do not vibrate loose. Some common types of non-self-locking nuts are plain, castellated, castellated shear, and wing nuts. It is important to ensure that the nut is torqued to the proper value before applying the locking device.

Self-locking

Self-locking nuts require no external locking device because they have a locking feature built into the nut. They withstand severe vibration, and they attach to anti-friction bearings, pulleys, accessories, and anchor nuts around inspection holes. Self-locking nuts are not used at joints where the movement of the joint causes the nut to rotate against the surface on which the nut is bearing. On bolts without cotter pin holes, fiber or nylon insert locknuts are used whenever possible. At least 1½ threads must extend through the fiber for maximum locking effect.

Washers

As with other hardware, there are many kinds of special-purpose washers, but generally, most washers you use are plain or lock washers. To provide a smooth-bearing surface, normally plain washers are used under all hex nuts. They permit alignment of the slots of castellated nuts with the drilled cotter pinholes in the bolts. Use lock washers with screws and bolts whenever the self-locking or castellated type of nut is not used. The spring action of the washer provides friction to prevent loosening of the nut caused by vibration. Special washers are used for various purposes (e.g., when the bolt is installed at an angle to the surface or where perfect alignment with the surface is required at all times).

Screws

Screws are the most common form of threaded fastener used on aircraft. Many different types of screws are used in the construction of an aircraft. Some applications that concern us in fuel system maintenance include access doors, panels, components, and integral tank structural components (i.e., stiffeners or braces). Of all the types of screws available, the machine screw is the type that you will use most often. Its type is usually described according to the shape of its head (e.g., flathead, roundhead, fillister head, socket head, pan head, and truss head screws), as shown in figure 1–8.

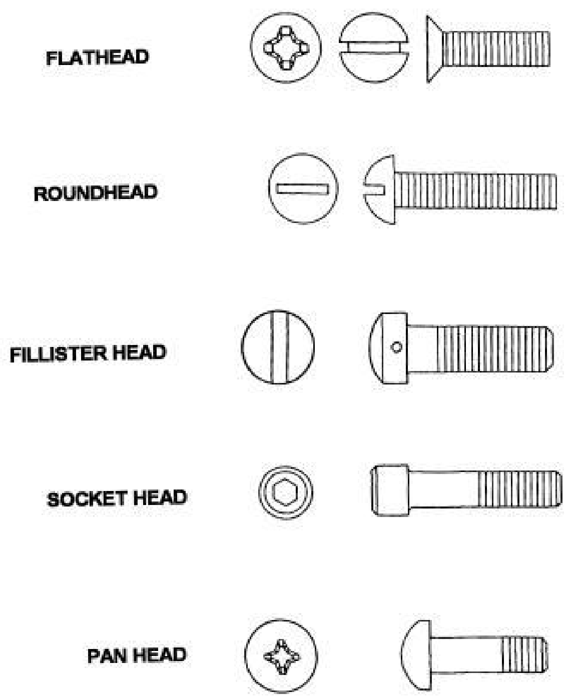


Figure 1–8. Types of screws.

Flathead

Flathead machine screws are used in countersunk holes where a flush surface is desired. These screws have various types of recesses and slots, and are manufactured from various materials (e.g., carbon steel, corrosion-resistant steel, aluminum alloy, and brass).

Roundhead

Roundhead screws are designed for electrical or general-purpose use and are available with slotted or recessed heads. The roundhead screws are commonly used on fuel system electrical components (e.g., cannon plug). They may be fine or course threaded.

Fillister head

These screws are used as general-purpose screws and can be used as cap screws in light mechanics. One common use of these screws is the attachment of motor actuators on shutoff valves. Usually, fillister head screws are drilled for safety wire and are manufactured from steel and brass. They are available with course or fine threads.

Socket head

Socket head machine screws are designed to be driven, by means of internal wrenches (i.e., Allen wrench), into tapped holes. They are used in applications requiring high-strength precision products, compactness of the assembled parts, or sinking of heads below surfaces into fitted holes. Normally, socket head machine screws are manufactured from corrosion-resistant steel.

Pan head and truss head

These are general-purpose screws used where head protrusion is unimportant. They are available with cross-recessed heads only and are manufactured from steel, carbon steel, corrosion-resistant steel, and aluminum alloy.

206. Rivets and other fasteners

Rivets are used in areas of the aircraft that are not subjected to the stress that would require the strength of a nut and bolt combination. There are several types of rivets available, but the most common type used for fastening aircraft structures is the solid-shank rivet. The jo-bolt and hi-lok fasteners are the other types of fasteners used in aircraft that will be discussed in this lesson.

Solid-shank rivet

Generally, solid-shank rivets are made from aluminum alloys. However, in special applications, corrosion-resistant steel, mild steel, titanium, iron, or copper rivets may be used. The choice of materials is dependent on three factors—usage, corrosion resistance, and strength. Solid-shank rivets are available with five head styles—universal head, roundhead, flathead, brazier head, and countersunk.

Universal head

This type of rivet is used for both interior and exterior applications.

Roundhead

Roundhead rivets are used in the interior of aircraft, except where clearance is required for adjacent members.

Flathead

Flathead rivets are used in the interior of aircraft but are used where interference of adjacent members does not permit the use of roundhead rivets.

Brazier head

Brazier head rivets are used on the interior of the aircraft where there is no requirement for a flush surface.

Countersunk

Countersunk head rivets are used on the top skin surface of the wing structure where a smooth aerodynamic surface is desired. Countersunk-head rivets permit dimpling of the structure to provide a higher shear strength.

Other fasteners

Besides nuts, bolts, and rivets, there are other fasteners used in the construction of aircraft for specific applications. These are the jo-bolt and the hi-lok fasteners.

Jo-bolts

Jo-bolt fasteners are used on difficult riveting jobs when access to one side of the work is impossible (fig. 1–9). The fastener consists of three parts—aluminum alloy or alloy steel nut, a threaded alloy steel bolt, and a corrosion-resistant steel sleeve. These parts are factory preassembled. As the jo-bolt is installed, the bolt is turned while the nut is held, causing the sleeve to expand over the end of the nut forming the blind head. When the bolt is installed, the head breaks off from the flush to below the head.

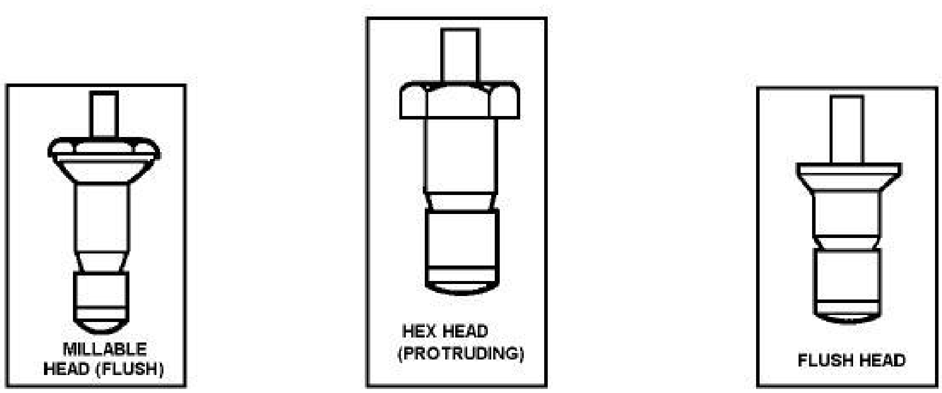


Figure 1–9. Jo-bolts.

Hi-loks

Hi-loks are high-strength threaded fasteners, which combine the best features of a rivet and a bolt. Figure 1–10 shows the installation steps of a typical hi-lok fastener. The hi-lok may be installed with hand tools. The pin part of the hi-lok is inserted into the hole and the collar is threaded onto the pin.

The threaded end of the pin has a hexagon-shaped recess where an Allen wrench is inserted to hold the pin in place. When the collar reaches a preset torque, the protruding part of the collar breaks off completing the installation. When replacing fasteners, it is important to consult the appropriate structural repair manual or other applicable technical data. This will ensure that the fastener you are using is an acceptable replacement.

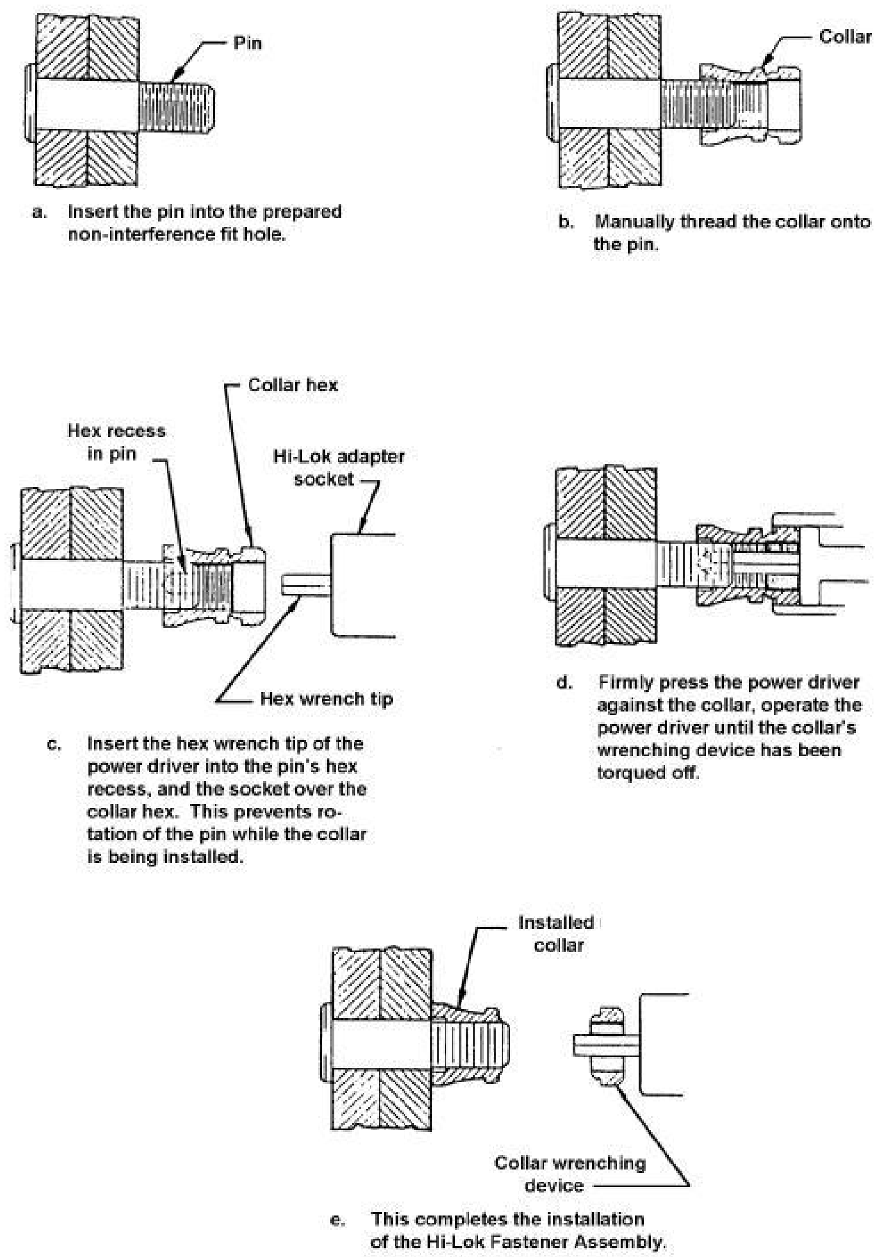


Figure 1–10. Hi-lok installation.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

204. Bolts

1. Regarding grip length, what is the ideal installation of a nut and bolt assembly?

2. Normally, how are special bolts identified?

3. What three factors help maintenance personnel identify the size of the bolt?

4. Normally, where are hex head bolts used?

5. What type of bolt is made of high-strength steel, and used primarily in high-tensile, high-fatigue, strength applications?

6. On an aircraft, where would an eyebolt be used?

205. Nuts, washers, and screws

1. Name the two primary categories of nuts.

2. What type of nut requires an external locking device to ensure the nut does not vibrate loose?

3. List three features of the self-locking type nut.

4. How many threads must extend through the fiber of the self-locking nut?

5. What hardware item is used with screws and bolts whenever the self-locking or castellated nut is not used?

6. What is the most common form of threaded fastener used on aircraft?

7. When would a flathead screw be used?

8. What type of screws is designed for electrical use?

206. Rivets and other fasteners

1. What is the most common type of rivet used for fastening aircraft structures?

2. From what materials may solid-shank rivets be made?

3. What type of rivets is used in the interior of aircraft where a flush surface is not necessary?

4. What rivets are used on the outside wing structure where a smooth, aerodynamic surface is desired?

5. What type of areas would require the installation of a jo-bolt?

6. What is a hi-lok fastener?

1–3. Aircraft Plumbing

Just as the plumbing in a house is used to route water, aircraft plumbing is used to transport various types of fluids or gases (e.g., fuel, hydraulic fluid, and compressed nitrogen). Plumbing for fuel systems normally consists of tubing (manifolds or lines), hoses, fittings, and seals. First, we will cover tubing systems.

207. Tubing systems

Stainless steel and aluminum alloy tubing are used in aircraft to transport or route fuel, oil, coolant, breathing oxygen, hydraulic, and vent lines, as well as for electrical conduits and ventilation ducts. Once commonly used, copper tubing generally has been superseded by aluminum alloy because of aluminum alloy's lighter weight, ease of forming, and resistance to corrosion and fatigue.

Stainless-steel tubing

Corrosion-resistant stainless-steel tubing is used in high-pressure systems, such as the landing gear system, because it can withstand high pressures and is stronger. The high-tensile strength of stainless-steel tubing permits the use of thinner walls than those of aluminum alloy tubing. Therefore, the weight is about the same as thicker walled aluminum alloy tubing. To minimize sleeve and nut cracking, which can result from over torque of “B” nut fittings and vibration, use only stainless-steel nuts when using stainless-steel tubing.

Aluminum alloy tubing

Aluminum alloy tubing is used for general-purpose lines and conduits supporting low fluid pressure such as instrument or drain lines. You will likely find aluminum alloy tubing being used on the sensing line that is routed to a pressure switch or transmitter, any type of drain lines used on the aircraft, and open-type fuel vent manifolds. This type of tubing is the most widely used tubing for general-purpose lines of low and medium pressures. It is flared easily with hand tools. Handle aluminum alloy tubing with care to prevent scratches, dents, and nicks. It is used with two types of connections—the flared joint for mechanical connectors or the beaded end for use with clamps and flexible hose connections. Always consult the applicable aircraft technical data to determine the correct tubing for the particular system.

Identifying tubing damage

Damage such as chafing, galling, or fretting (wearing away) produces mechanical property changes in metal tubing that greatly reduces its ability to withstand internal pressure and vibration. For this reason, it is important for you to be able to identify what is allowable tubing damage.

Chafing

The tubing making contact with a surrounding surface (e.g., another section of tubing or a bulkhead) causes this damage. Always inspect tubing in the area you are working for signs of chafing. Common areas for chafing include the following:

- Dry bay areas.
- Wheel well areas.
- Component parts.
- Integral fuel tanks.

If you see any penetration of the tubing wall surface caused by chafing, correct the condition that caused this damage and replace the tubing assembly, regardless of the type of metal, system, or pressure ranges involved.

Dents

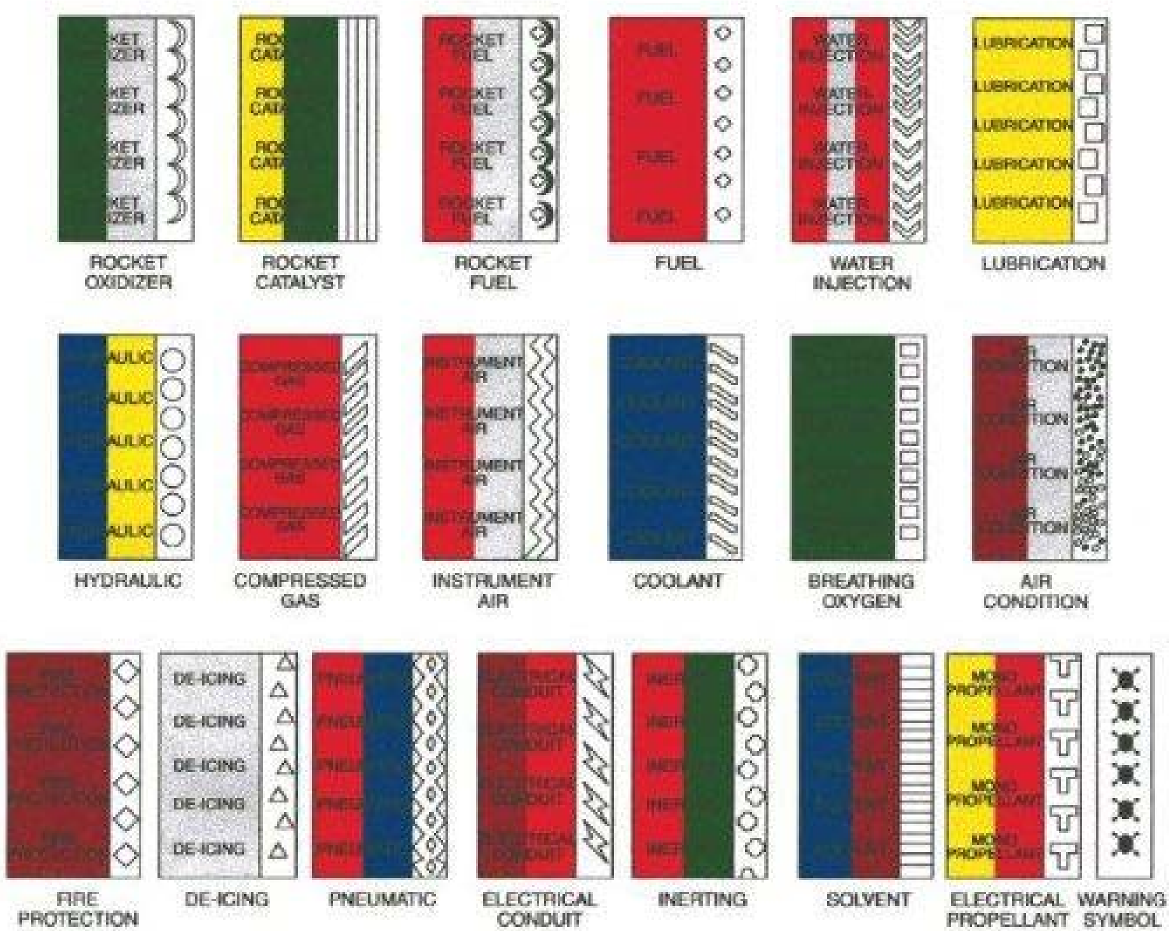
Any dent less than 20 percent of the tube diameter is allowable, unless the dent is on the heel of a short bend radius. For severe damage, replace the tube. For correct bend radius and acceptable limits, refer to Technical Order (TO) 42E1–1–1, *Aviation Hose and Tube Manual*.

Nicks and scratches

Allowable limits for nicks and scratches on tubing bends are contained in TO 42E1–1–1. Scratches or nicks no deeper than 15 percent of the wall’s thickness on straight sections of tubing that are not in the heel of a bend may be repaired. Repair these types of scratches or nicks by burnishing with hand tools. Replace lines with severe damage. Nick and scratch damages can be minimized by using care. Most damage of this kind occurs from careless handling of tools during maintenance of the aircraft.

System coding

Code bands of colored tape are placed around the tubing near the system units and joints at intermediate points along the plumbing to help you identify and trace an individual systems lines throughout the aircraft (e.g., a hydraulic plumbing system is banded with a blue and yellow tape). Figure 1–11 shows the various combinations of color-code bands used to identify fuel and other aircraft systems.



THE ABOVE COLOR CODES REPRESENT DESIGNATION FOR SYSTEMS ONLY. FOR CODING LINES WHICH DO NOT FALL INTO ONE OF THESE SYSTEMS THE CONTENTS SHALL BE DESIGNATED BY BLACK LETTERING ON A WHITE TAPE.

SUBSIDIARY FUNCTIONS OR IDENTIFICATION OF LINE CONTENT MAY BE INDICATED BY THE USE OF ADDITIONAL WORDS OR ABBREVIATIONS WHICH SHALL BE CARRIED ON A SECOND TAPE ADJACENT TO THE FIRST OR ALTERNATELY, INTERPOSED BETWEEN THE WORDS DESCRIPTIVE OF THE MAIN FUNCTION.

WARNING SYMBOL TAPES 3/8-INCH WIDE, SHALL BE APPLIED TO THOSE LINES WHOSE CONTENTS ARE CONSIDERED TO BE DANGEROUS TO MAINTENANCE PERSONNEL. WARNING TAPES ARE TO BE PLACED ADJACENT TO SYSTEM IDENTIFICATION TAPES.

ONE BAND SHALL BE LOCATED ON EACH TUBE SEGMENT, 24 INCHES OR SHORTER. ONE BAND SHALL BE LOCAED AT EACH END OF EACH TUBE SEGMENT LONGER THAN 24 INCHES. ADDITIONAL BANDS SHALL BE APPLIED WHEN THE TUBE SEGMENT PASSES THROUGH MORE THAN ONE COMPARTMENT OR BULKHEAD. AT LEAST ONE BAND SHALL BE VISIBLE IN EACH COMPARTMENT OR ON EACH SIDE OF BULKHEAD.

PRESSURE TRANSMITTER LINES SHALL BE IDENTIFIED BY THE SAME COLORS AS THE LINES FROM WHICH THE PRESSURE IS BEING TRANSMITTED.

FILLER LINES, VENT LINES AND DRAIN LINES OF A SYSTEM SHALL BE IDENTIFIED BY THE SAME COLORS AS THE RELATED SYSTEM.

TAPES SHALL NOT BE USED ON FLUID LINES IN THE ENGINGE COMPARTMENT WHERE THERE IS A POSSIBILITY OF THE TAPE BEING DRAWN INTO THE ENGINE INTAKE. FOR SUCH LOCATIONS, SUITABLE PAINTS, CONFORMING TO THIS COLOR CODE, AND WHICH HAVE NO DELETERIOUS EFFECT ON THE MATERIAL USED FOR THE LINES, SHALL BE USED FOR IDENTIFICATION PURPOSES. IN THESE CASES THE GEOMETRICAL SYMBOLS MAY BE OMITTED.

Figure 1–11. Plumbing system coding.

208. Flexible hose

Normally, flexible hose is used where a great amount of vibration occurs or where flexibility is required (e.g., an engine bay or pylon).

Types of flexible hose

We will limit our discussion to the four types of bulk hose generally used for hydraulic, pneumatic and fuel systems. As you proceed through the lesson, keep in mind that various types of hose assemblies are manufactured locally by the hydraulic shop. The four types of hoses we will discuss are as follows:

1. Military specification-hose (MIL-H)–8794 bulk hose (medium pressure rubber).
2. MIL-H–8788 bulk hose (high-pressure rubber).
3. MIL-H–27267 bulk hose (medium pressure Teflon®).
4. MIL-H–83298 bulk hose (high pressure Teflon).

MIL-H–8794 hose

This is a medium pressure rubber hose for use in hydraulic, fuel, and oil (only petroleum-based systems). The outer surface of the hose has yellow markings. Most hydraulic rubber hoses are marked with the specification number, the size, the quarter and the year of manufacture (this is known as the "cure date"), and a five-digit number identifying the manufacturer. These markings are in yellow-colored letters and numerals that indicate the natural lay (no twist) of the hose. They are repeated at intervals of not more than 9 inches along the length of the hose. The operating temperature range of this hose is –65 to 200 degrees Fahrenheit (°F). The hose consists of a synthetic rubber inner tube; impregnated cotton braid, single-wire braid, and impregnated cotton braid outer covering that has a rough finish.

MIL-H–8788

This is a high-pressure rubber hose for use in hydraulic systems. The outer surface of the hose has yellow markings similar to the medium-pressure hose (MIL-H–8794) previously discussed. This hose is very similar in construction to the medium-pressure hose except for an additional wire braid and a smooth outside covering.

MIL-H–27267

The Teflon hose is used in hydraulic and pneumatic systems, which do not exceed 1,500 pounds per square inch (psi), except as specified in TO 42E1–1–1–1. The operating temperature range of the Teflon hose is approximately –65°F to 450°F. This hose is manufactured with a smooth-bore (firm, waxy feeling) inner-tube covered with corrosion-resistant steel wire braid. The hose identified by a band spaced at 3-foot intervals. The band is marked with the specification number, size (indicated by a dash number such as –10), operating pressure, and the manufacturer's code number. Keep in mind the hose size is designated by a dash number (–4, –6, –8, etc.) stenciled on the size of the hose. This dash number does not denote the inside or outside diameter of the hose itself, but rather the size of the tubing with which it is used. For example, a –8 hose is used with –8 tubing. The reason for this is the inside diameter of both –8 hose and –8 tubing is approximately the same.

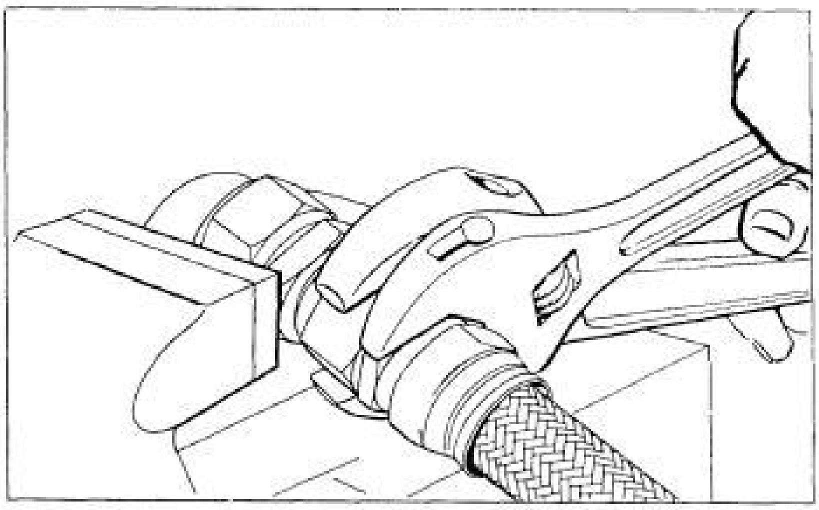
MIL-H–83298

This Teflon hose is intended for use in aircraft high-pressure systems. Bulk hose will be marked at 3-feet intervals with a band containing information similar to the Teflon medium-pressure hose (MIL-H–27267).

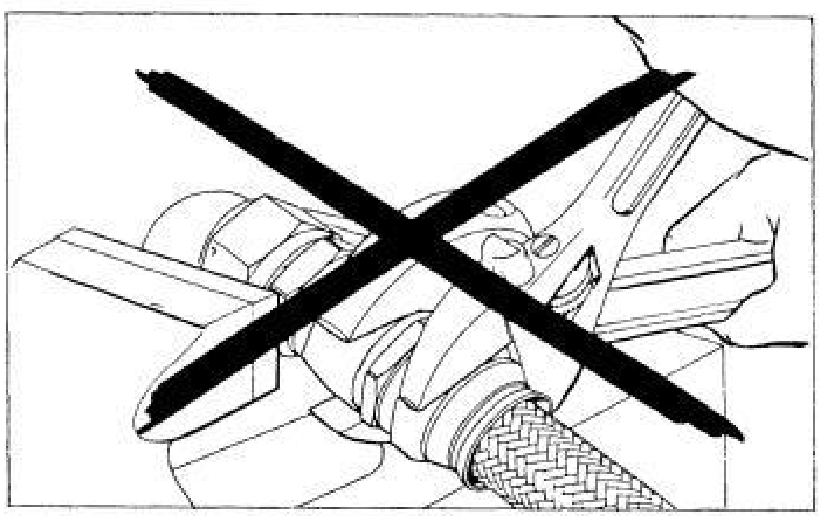
Installation of flexible hose assemblies

Observe the following guidelines when installing a hose assembly.

1. Never use oil on a self-sealing hose to aid installation; the oil may cause the sealant layer to become active.
2. Do not place a wrench on the socket of a hose fitting when installing a hose assembly (fig. 1–12).
3. Install the hose so it will not be subjected to twisting under any conditions. To ensure there will be no twisting, the replacement hose should be an exact duplicate of the one removed.



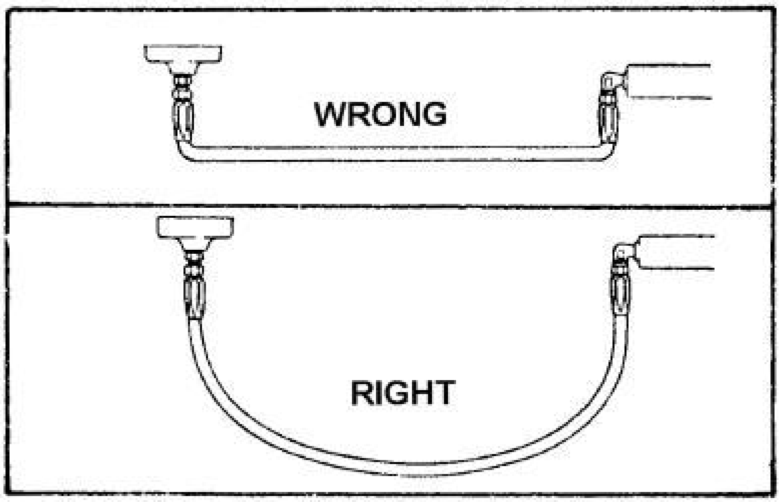
DO ----- Place wrench on nipple hex to hold line while loosening swivel nut.



DON'T --- Place wrench on socket flat to hold line while loosening swivel nut.

Figure 1–12. Hose assembly installation.

4. When bends are required in the hose for installation, maintain the minimum radius at all times. Because each hose may have different requirements, consult TO 42E1–1–1. A radius larger than the minimum allowed is preferred (fig. 1–13).



Keep the Bend Radii of the hose as large as necessary to avoid kinking of line and restriction of flow.

Figure 1–13. Hose installation-bend radius.

5. Do not install clamps so tight that they cause a reduction in the diameter of the hose. A reduction in the diameter would restrict flow.
6. Support hose at least every 24 inches of length; however, closer supports are preferred. A flexible hose used between two rigid connecting lines should never be rigidly supported; its purpose is to allow flexibility of the plumbing.
7. Eliminate chafing by using suitable bulkhead-type grommets or cushioned clamps and ensuring adequate clearance exists between the hose and the surrounding structure.
8. Protect the hose from excessive temperatures. The use of flame-resistant hose is preferred in areas forward of the engine firewall and is often directed by the aircraft TO for certain aircraft.
9. Whenever possible, install the hose so that all markings are visible.
10. Tighten hose end fittings to applicable torque value according to TO 42E1–1–1 or the applicable aircraft TO. Do not over tighten fittings!

Unserviceable hose conditions

Replace hose assemblies when any of the following conditions are found:

1. Separation of the cover or braid from the inner tube or wire braid.
2. Cracks. Hardening or lack of flexibility.
3. Excessive cold flow (i.e., deep, permanent impressions and cracks in the hose cover caused by the pressure of hose clamps).
4. Leaks. Any evidence of abrasion, kinking, or distortion.

209. Couplings used on aircraft plumbing

Several different types of couplings are used in aircraft fuel systems; their design varies with the aircraft manufacturers. Couplings serve to join manifold segments to each other; if manifold segments were too long, you would not be able to remove them from the tank. Some of the more widely used types of couplings include the quick-disconnect (QD), V-band, and Wiggins types.

Quick-disconnect couplings

Advantages of QD couplings include ease and speed of connecting and disconnecting plumbing systems, particularly in congested areas. Some QD couplings incorporate self-sealing valves to eliminate fluid or gas loss when manifold segments are uncoupled and to minimize the introduction of air into the system. Different types of QD couplings are used in aircraft fluid systems, but it is not necessary to cover each type because they all perform the same function.

Proper care and handling of QD couplings must be exercised to prolong life and ensure the integrity of the system in which they are used. Because you will probably be involved in the replacement of these couplings, become familiar with and always observe the following care and handling practices:

1. Do not use gripping tools to connect or disconnect coupling halves. They were designed to be tightened by hand.
2. Avoid dirt or other foreign matter contamination when couplings are disconnected. If contamination occurs, wipe the coupling with a clean, dry, lint-free cloth or use a clean brush.
3. Handle QD couplings as you would any other fine piece of equipment. Do not abuse them by dropping or inflicting other types of abuse.

The procedures to remove a QD are simple. If you have used an air compressor and changed attachments on the end of the hose, then you have used a QD type connection. Simply pull back on the female end (they are spring loaded); when you pull it back, pull the two parts away from each other. To install simply reverse the process. Some QDs can be pushed back on without too much effort; others may require you to pull back on the spring-loaded part in order to re-install it.

V-band couplings

Another type of coupling used on aircraft tubing is the V-band coupling (fig. 1–14). V-band couplings of the QD type require safety wiring to prevent complete separation of the joint in the event of a T-bolt failure. Unless specifically directed by a technical manual, the captive T-bolt type coupling does not require safetying. To remove the V-band type couplings, you must first cut the safety wire; always put safety wire in an approved foreign object container. Next, remove the nut on the coupling. When the nut is removed, the coupling will open up, and you can remove it from the manifold. Always refer to your TO when installing the coupling; as you can see in figure 1–14, there are two ways to safety wire the coupling.

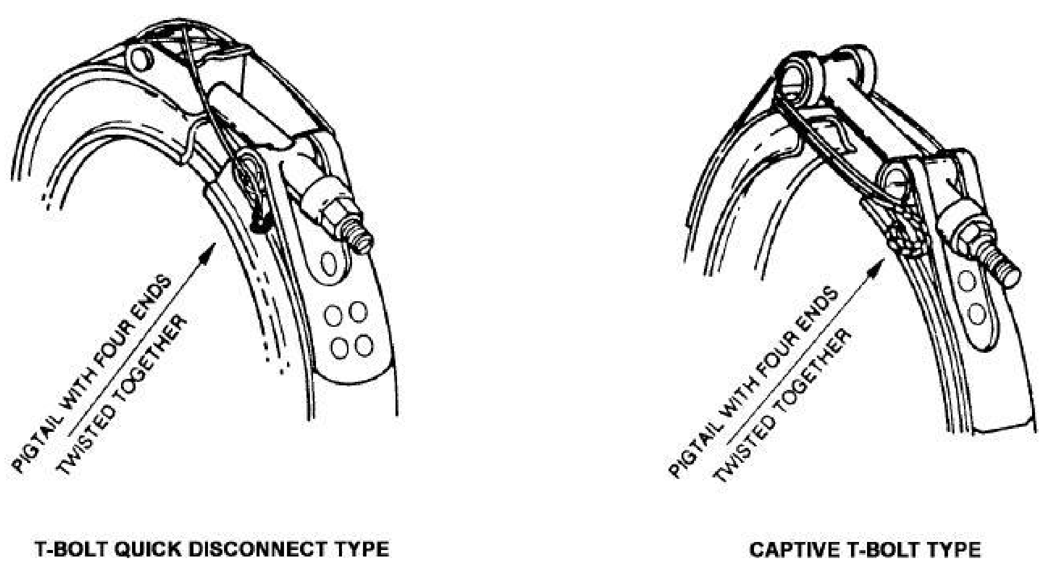


Figure 1–14. V-band couplings.

Wiggins couplings

Several types of Wiggins couplings are used extensively on aircraft fuel systems plumbing. Probably the most popular type is the beaded tube coupling (fig. 1–15), which consists of the body, split washer, nut, two O-rings, and a two-piece retainer (commonly referred to as “half-moons” or “snap-rings”). The O-rings provide the sealing action when the coupling is torqued. Figure 1–16 illustrates the typical installation of a Wiggins coupling to join manifold segments.

On some aircraft, Wiggins couplings may be safety wired. To remove the coupling, you must first cut the safety wire. Using a strap wrench or spanner wrench unscrew the two ends of the coupling. Slide the two ends away from each other to expose the snap rings. Remove the snap rings from the manifold and the manifold will be ready for removal. Always replace the O-rings before reinstalling the Wiggins coupling. For installation, simply reverse the removal procedures.

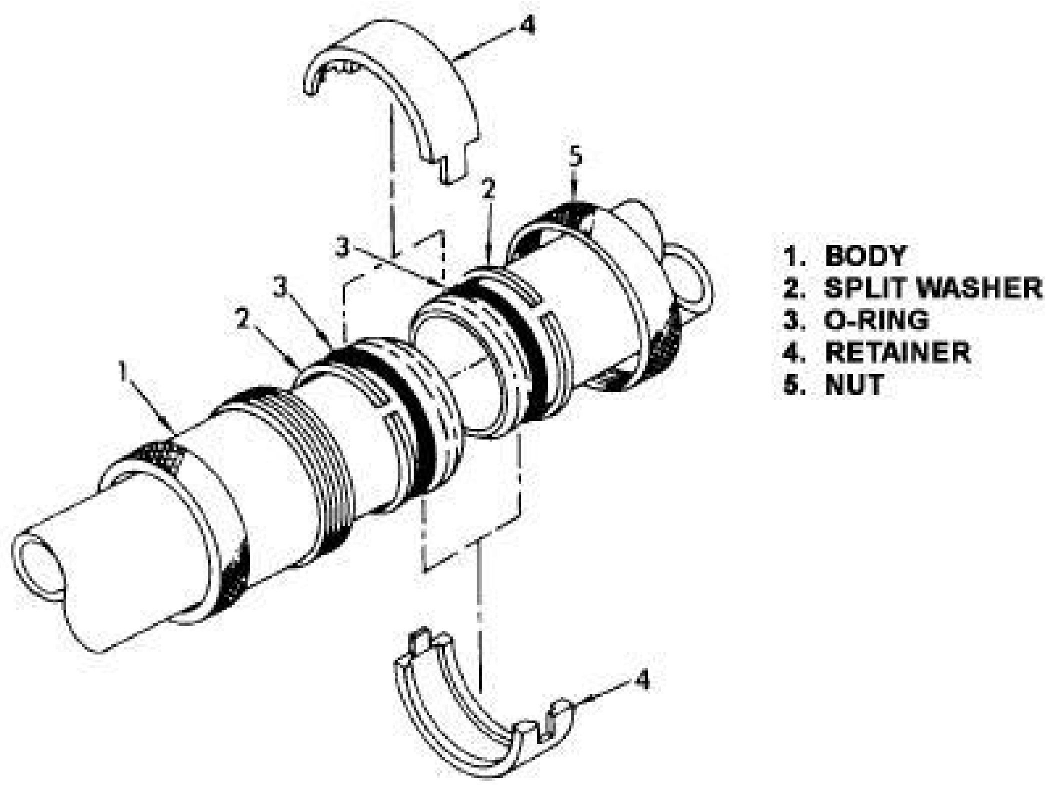


Figure 1–15. Wiggins coupling—beaded tube.

Caps and plugs

After removing couplings, manifolds, or hoses, you are left with a “hole” in the fuel system. This may present a foreign object hazard (FOD) hazard. A good example is a cell replacement. Many manifolds must be removed to facilitate the removal of a fuel cell; to prevent foreign objects from entering the open lines, you need to plug or cap the lines. Some aircraft may have plug kits; if not, you may need to work with your local sheet metal shop to have some made. Always document the aircraft forms with a red X when installing something on the aircraft.

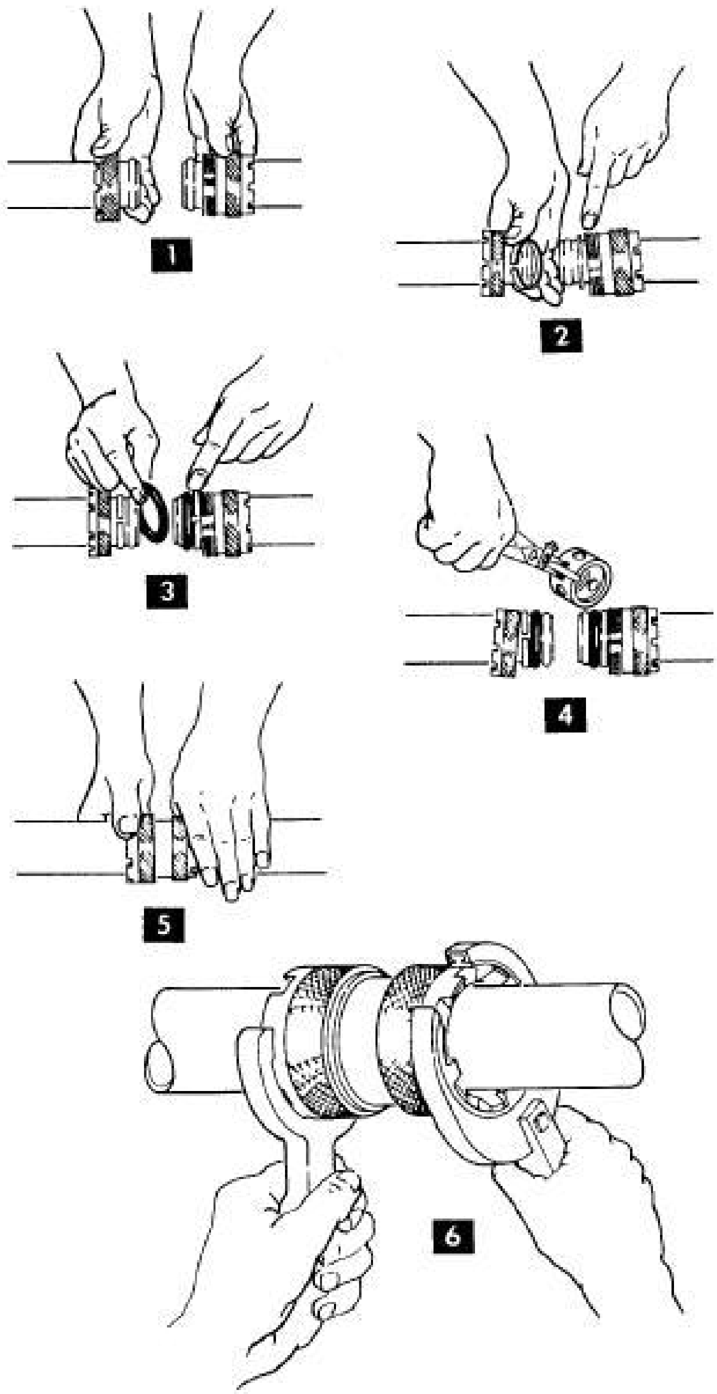


Figure 1–16. Installing a Wiggins coupling.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

207. Tubing systems

1. What are some common uses of tubing systems used on aircraft?

2. What are the advantages of aluminum alloy tubing when compared with copper tubing?

3. What type of tubing is suitable for use in high-pressure systems?

4. Normally, where would aluminum alloy tubing be used on the aircraft?

5. What type of tubing is most widely used for general-purpose applications?

6. What impact would chafing have on a section of manifold?

7. List four areas on the aircraft that are commonly inspected for signs of tubing chafing.

8. What is the allowable limit for a scratch in a straight section of a pressurized fuel manifold?

208. Flexible hose

1. At what locations on an aircraft would flexible hose be installed?

2. Match the hose assembly in column B with its characteristic in column A. Items in column B may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Has an operating temperature of –65 to 450°F.	a. MIL-H–8794.
____ (2) Intended for use in high-pressure systems.	b. MIL-H–8788.
____ (3) Used in medium pressure systems.	c. MIL-H–27267.
____ (4) High pressure for hydraulic systems.	d. MIL-H–83298.
____ (5) Temperature range of –65 to 200°F.	
____ (6) Not to exceed 1,500 psi.	

209. Couplings used on aircraft plumbing

1. What are three types of couplings commonly used on aircraft fuel systems?

2. What are the advantages of QD couplings?

3. What type of V-band coupling requires the installation of safety wire as an added safety measure?

4. What component of a Wiggins coupling provides the sealing action?

1–4. Safetying Devices

Although its use has been decreasing with the introduction of high-tech self-locking fasteners, safety wire is still used in many fuel system applications throughout the Air Force. The improper selection and use of safetying devices could have devastating effects on the safety of an aircraft. The next few lessons address the use of safety wire and cotter pins on aircraft applications.

210. Using safety wire

In addition to non-self-locking nuts, other areas of the aircraft also require safety wire. These areas are subjected to extreme vibrations normally and, therefore, need to be safety wired to ensure the couplings or fasteners will not work loose. We will concentrate on applications you commonly deal with on the aircraft. Aircraft hardware that requires safety wiring is secured with zinc-coated soft steel wire.

Safety wire methods

There are two methods of safety wiring—the single wire method and the double-twist method, which is used the most. The single wire method is used on screws, bolts, and/or nuts in closely spaced closed geometrical patterns (i.e., a triangle, square, rectangle, or circle). The single wire method may be used on parts in electrical systems and in places difficult to reach. Most other applications require the double-twist method because of the increased tensile strength resulting from the two wires being twisted together. Figure 1–17 illustrates various types of double-twist safety wiring.

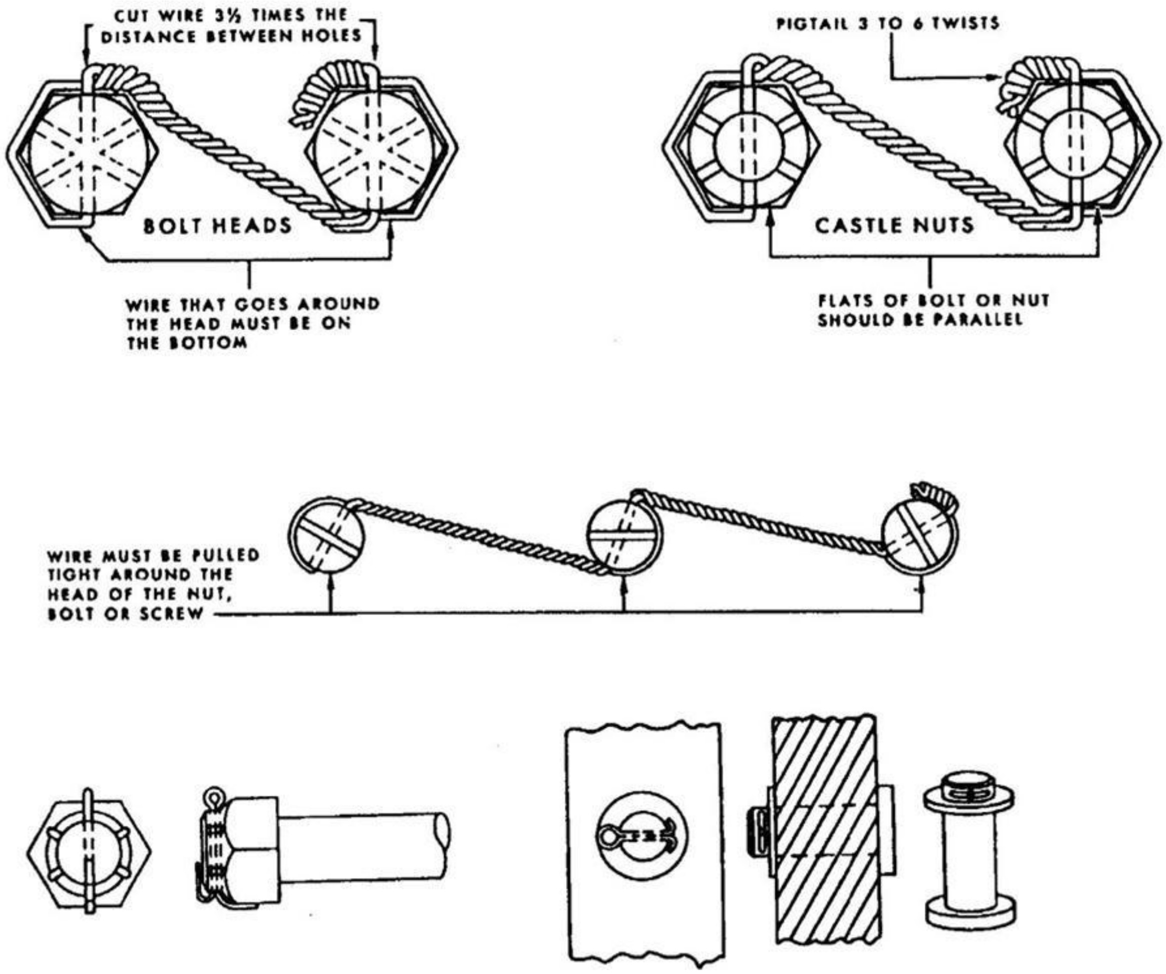


Figure 1–17. Safety wire, double-twist method.

Procedures

Figures 1–18 and 1–19 show some common applications of safety wire. There are many combinations of lock wiring, but all applications have certain basic rules common to them:

1. When drilled head bolts, screws, or other parts are closely grouped, it is more convenient to safety wire them in series to each other.
2. When securing widely-spaced bolts by the double-twist method, the maximum number of bolts that can be wired together is three.
3. When securing spaced bolts using the single wire method, a 24-inch long piece of wire is the maximum length. If the pattern requires a piece of safety wire longer than 24 inches, you need to do two separate patterns.
4. Widely-spaced multiple groups must not be safety wired together when the fasteners are from 4 to 6 inches apart.
5. Lock wiring must not be used to secure fasteners or fittings spaced more than 6 inches apart, unless tie points are provided on adjacent parts to shorten the span of the lock wire to less than 6 inches.
6. Install safety wire so that it tends to tighten and keep a part locked in place; the natural tendency of the part to loosen is counteracted.
7. Safety wire must never be overstressed. It will break under vibrations if twisted too tightly.
8. To prevent injury, bend the pigtails under.

9. Never over torque or loosen units to obtain proper alignment of the safety wire holes. You should be able to align the holes when the units are torqued to the specified limits.
10. When using pliers, grasp the wires at the ends. Safety wire must not be nicked, kinked, or mutilated.
11. When cutting off ends, leave at least three to six complete twists measuring 1/2 to 5/8 inches after the loop. This is known as the pigtail.
12. When removing safety wire, never twist the wire off with pliers. Cut the wire close to the hole, exercising caution.
13. When practical, install safety wire with the wire positioned around the head of the fastener and twisted so that the loop of the wire fits closely to the contour of the unit being safety wired.
14. Most importantly, use eye protection any time you are working with safety wire!

Safety wire sizes

When using the double-twist method, use .032-inch minimum diameter wire on fasteners/parts that have a hole diameter larger than .045 inch. Safety wire of .020-inch diameter (double-strand) may be used as applicable, on parts that have a hole diameter of .045 inch or less, or on parts having a nominal hole diameter between .045 and .062 inches with a spacing between parts of less than 2 inches. A general rule to follow when using the single wire method is, “Use the largest size wire that will accommodate the hole.” If in doubt, consult the applicable technical data.

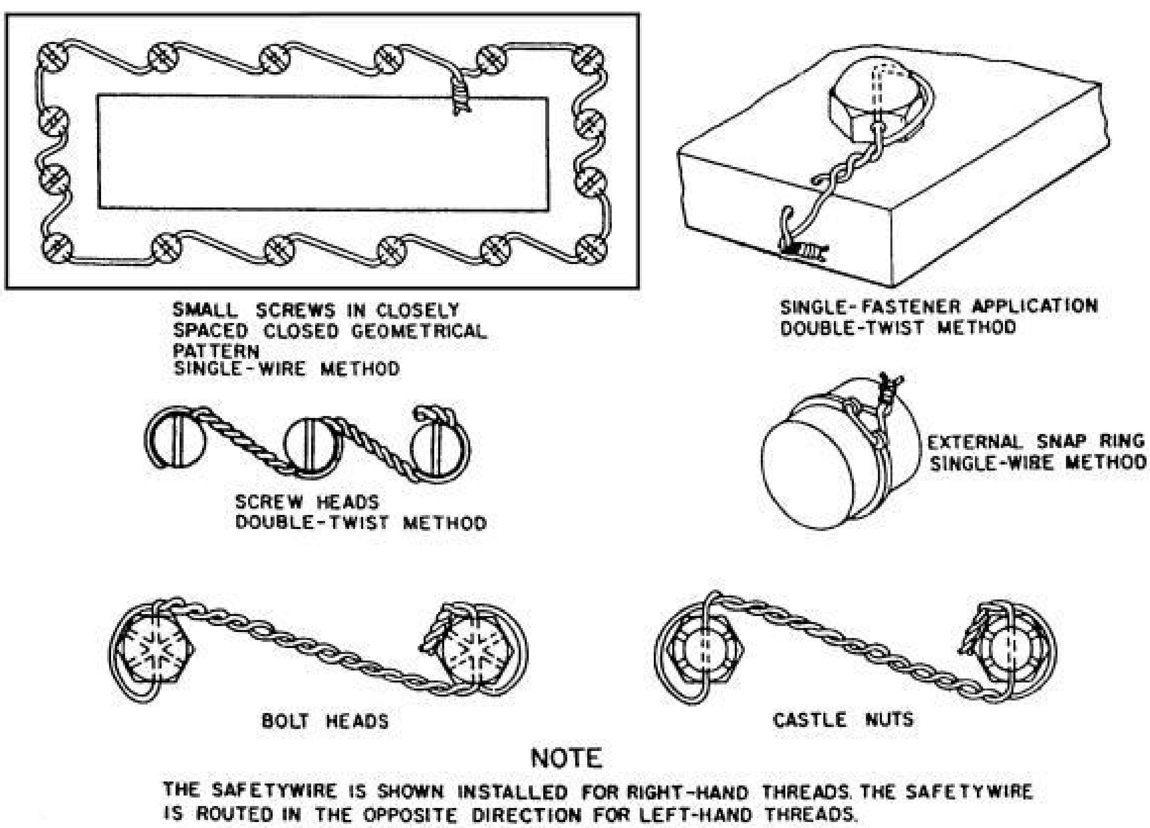


Figure 1–18. Securing screws, nuts, bolts, and snap rings.

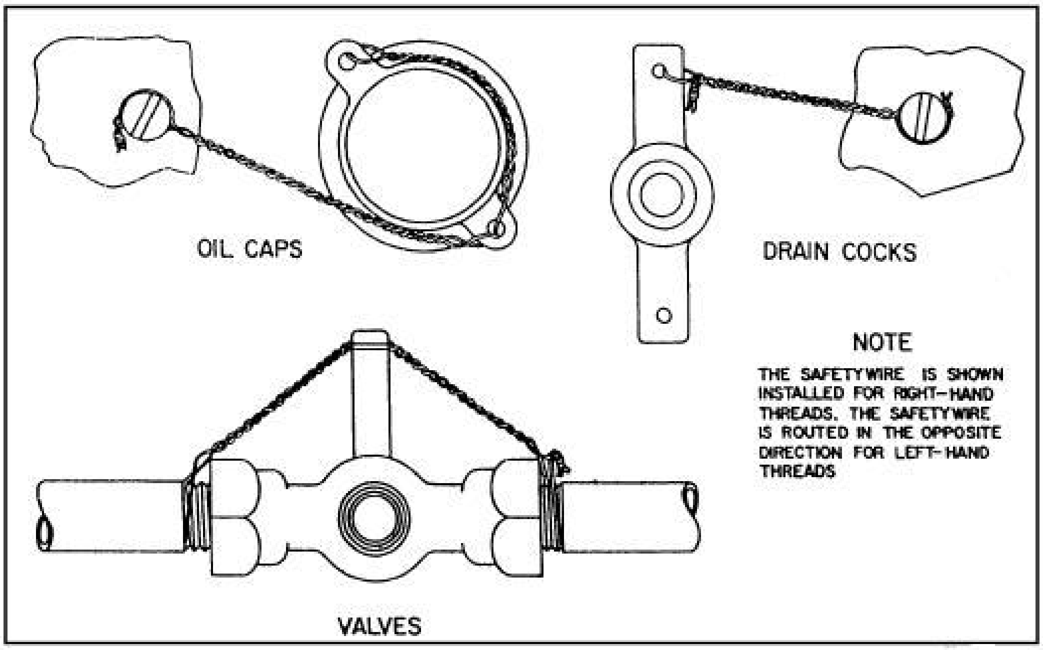


Figure 1–19. Securing oil caps, drain cocks, and valves.

211. Using cotter pins

Cotter pins secure items such as bolts, screws, pins, and shafts. Their use is favorable because they can be removed and installed quickly. The diameter of cotter pins selected for any application should be the largest size that will fit consistent with the diameter of the cotter pin hole and the slots in the nut, unless otherwise specified, in the applicable maintenance or overhaul technical manual for the item or assembly. Do not reuse cotter pins on aircraft.

In using the method of cotter pin safetying as shown in figure 1–20, ensure the prong bent over the bolt is seated firmly against the bolt shank, not to exceed the bolt diameter. Also, ensure the bent prong does not contact the surface of the washer.

REMEMBER: Incorrect installation of a safetying device is the same as no safetying device at all.

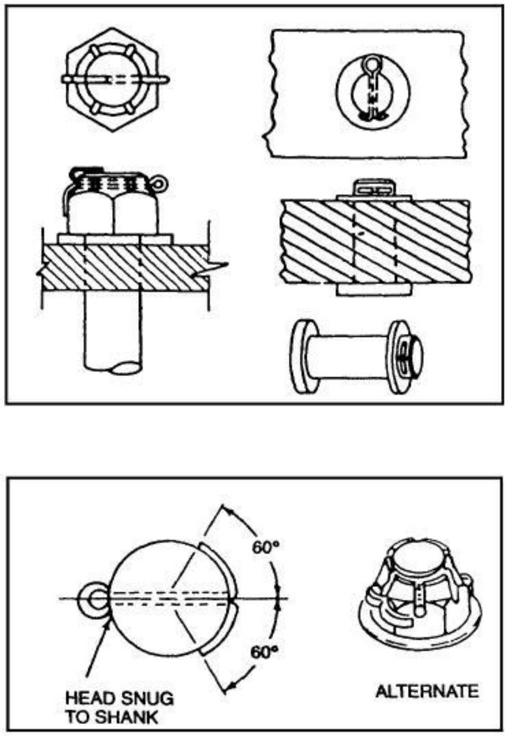


Figure 1–20. Securing with cotter pins.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

210. Using safety wire

1. What type of safety wire is used on aircraft hardware?

2. For which applications would the single wire method normally be used?

3. When securing widely-spaced bolts using the double-twist method, what is the maximum number of bolts that can be safety wired together?

4. How many twists of wire does the “pigtail” require?

5. When using the double-twist method to secure two bolts, under what conditions would .032-inch safety wire be required?

211. Using cotter pins

1. For what purpose are cotter pins used on aircraft?

2. How would you select the proper diameter cotter pin for a given application?

3. When properly installed, what surface should the bent prong of a cotter pin not touch?

1–5. Corrosion Control

One of the many responsibilities of any aircraft maintenance person is the identification and prevention of corrosion on aircraft surfaces. Depending on the situation at your particular unit, you may also have to become involved in the treatment of mild corrosion. Because your profession involves entering an area of the aircraft not normally seen by anyone else (i.e., fuel tanks/cells), fuel systems personnel are in the best position to detect corrosion in these areas. The purpose of the next few lessons is not to make you a corrosion control specialist but to educate you on the prevention of corrosion, as well as treatment procedures for mild corrosion.

212. Corrosion prevention

By this time in your career, you may have noticed that washing aircraft is taken seriously. This is not to make them pretty; it is to aid in corrosion prevention. In addition to washing, there are scheduled inspections to aid in the early detection of corrosion. To illustrate the importance of corrosion detection and prevention, let’s look at the development of corrosion, some degrees of corrosion, and then the prevention of corrosion.

Development of corrosion

All corrosion begins on the surface of metals. If allowed to progress, corrosion could penetrate into the metal. If corrosion begins on an inside surface of a component (i.e., the inside wall of a metal tube), it may go undetected until perforation occurs. When corrosion products form, they often precipitate onto the corroding surface as a powdery deposit. If this film acts like a barrier to electrolytes, the film of corrosion products may reduce the rate of corrosion.

Some metals (e.g., stainless steel and titanium), under the right conditions, produce corrosion products that are so tightly bound to the corroding metal that they form an invisible oxide film (a passive film), which prevents further corrosion. However, when the film of corrosion products is loose and porous (e.g., those of aluminum and magnesium), electrolyte can easily penetrate and continue the corrosion process, producing more extensive damage than surface appearance would show. Figure 1–21 lists various types of metals, the types of corrosion to which they are susceptible, and how the corrosion appears.

Paint coatings can hide the initial stages of corrosion. Since corrosion products occupy more volume than the original metal, frequently inspect paint surfaces for irregularities (i.e., blisters, flakes, chips, and lumps), which may be indications of corrosion beginning under the paint.

Alloys	Type of Attack to Which Alloy is Susceptible	Appearance of Corrosion Product
Magnesium Alloy	Highly susceptible to pitting	White, powdery, snowlike mounds, and white spots on surface
Low Alloy Steel (4000-8000 series)	Surface oxidation and pitting, surface, and Intergranular	Reddish-brown oxide (rust)
Aluminum Alloy	Surface pitting, intergranular, exfoliation, stress corrosion and fatigue cracking, and fretting	White to gray powder
Titanium Alloy	Highly corrosion resistant; extended or repeated contact with chlorinated d solvents may result in degredation of the metal's structural properties	No visible corrosion products at low temperature. Colored surface oxides develop above 700° F (370° C)
Cadmium (used as a protective plating for steel)	Uniform surface corrosion; used as sacrificial plating to protect steel	From white powdery deposit to brown or black mottling of the surface.
Stainless Steels (300-400 series)	Crevice/concentration cell corrosion; some pitting in marine environments; corrosion cracking; Intergranular corrosion (300 series); surface corrosion (400 series)	Rough surface; sometimes a red, brown, or black stain.
Nickel-base Alloy (Inconel, Monel)	Generally has good corrosion-resistant qulities; susceptible to pitting in sea water	Green powdery deposit
Copper-base Alloy , Brass, Bronze	Surface and intergranular corrosion	Blue or blue-green powdery deposit
Chromium (plate)	Pitting (promotes rusting of steel where pits occur in plate)	No visible corrosion products; blistering of plating due to rusting and lifting.

Figure 1–21. Effects of corrosion on metal alloys.

Degrees of corrosion

The degree of corrosion can be broken down into three categories: light, moderate, and severe. Knowing the categories will help you determine what level repair is required.

Light corrosion

At this degree, the protective coating is scarred or etched, and the condition of the metal is characterized by discoloration and pitting to a depth of approximately 1-millimeter (0.001 inch) maximum. This type of damage can be removed by light hand sanding. As a fuel systems maintenance person, it is likely you will be treating light corrosion only. Any corrosion requiring treatment beyond light hand sanding will be reported to and treated by corrosion control specialists.

Moderate corrosion

This looks similar to light corrosion except that there may be some blisters or evidence of scaling and flaking of the coating or paint, and the pitting depths may be as deep as 10 millimeters (0.010 inch). Extensive hand sanding or light mechanical sanding normally removes this type of damage.

Severe corrosion

Its general appearance may be similar to moderate corrosion with severe intergranular corrosion, blistering, exfoliation, scaling, or flaking. The pitting depths are deeper than 10 millimeters. Remove the damage by extensive mechanical sanding or grinding.

Figure 1–21 shows some of the effects that corrosion has on different type's metals. It also tells you how to identify the type of corrosion that is present.

Preventive maintenance

The two most important factors in preventing corrosion are the removal of electrolytes and the application of protective coatings. These are also the only factors that can be controlled by field personnel. Since the extent of corrosion depends on the length of time electrolytes are in contact with metals, you can minimize corrosion by frequent washing. The more frequently a surface is cleaned in a corrosive environment with noncorrosive cleaners, the less the possibility of corrosion occurring. In addition, by maintaining chemical treatments and paint finishes, corrosion can be minimized. You can minimize the degradation of nonmetallic materials by avoiding the use of unauthorized maintenance chemicals and procedures. When repair or replacement of nonmetallic materials is required, use only approved materials. Dedication to proper preventive maintenance practices will maximize equipment reliability.

213. Light corrosion treatment

Though corrosion affects every area of the aircraft, there are certain areas you may work on or near that will require light treatment. Become familiar with the inspection and treatment procedures for these areas.

Steel cables

If the surface of a cable is corroded, relieve cable tension and carefully force the cable open by reverse twisting. Visually inspect the inside of the cable. Corrosion on the inside strands constitutes failure, and the cable must be replaced. If no internal corrosion is detected, you may remove the loose external rust and corrosion with a clean, dry, coarse-weave rag or fiber brush. After thorough cleaning, apply the appropriate corrosion preventive compound liberally and wipe off excess.

Attachment of parts and hardware

When attaching parts, such as nuts, bushings, spacers, washers, screws, studs, clamps, and so forth, you do not necessarily need to paint in detail except when dissimilar metal or wood contact is involved in the material being joined. However, all parts must be installed wet with sealant. For permanent installations, use military specification-sealant (MIL-S)–81733 sealant and coat the entire mating surface of the parts. For removable installations, use MIL-S–8784 or PR–1403G sealant and coat only the lower side of the heads of screws and bolts with sealant. Do not coat the threads and shanks of screws and bolts or the holes into which they are inserted, because it will make removal very difficult. Replace severely corroded screws, bolts, and washers. Accomplish major replacements during scheduled aircraft refurbishment or depot maintenance.

Natural and synthetic rubber parts

Except for fuel cells, do not paint or oil natural and synthetic rubber. As a rule, do not apply grease to rubber parts. However, some parts, such as O-rings, require a grease coating prior to installation. Many types of rubber are subject to fungus growth, which can cause deterioration of the rubber and corrosion of surrounding metal surfaces. If fungus is noted on rubber parts, clean the parts and remove the fungus in accordance with TO 1–1–691, *Cleaning and Corrosion Prevention and Control, Aerospace and Non-Aerospace Equipment*. An integral fuel tank may be a prime location for fungus growth because of condensation buildup, and because the tanks do not stay full of fuel.

Aluminum tubing

Protect aluminum tubing exposed to the outside environment. A replacement fuel drain manifold, for example, should have the exterior finish specified in the applicable maintenance manual. Clean aluminum tubing and remove the corrosion in accordance with TO 1–1–691. After the corrosion is removed from the tubing, it should then have conversion coating—military specification-coating (MIL-C)–81706, Class 1A—applied to all interior and exterior surfaces. Do not apply paint to any interior surface of nonstructural tubing.

Stainless-steel tubing

Protect stainless-steel tubing exposed to the outside environment with the specific exterior finish called for in the applicable TO. Certain stainless steels are highly susceptible to pitting, crevice corrosion, and stress corrosion cracking when exposed to moist, salt-laden air, and when deposits of dirt and debris are allowed to collect on tubing areas covered by metal brackets or parts. If you find corrosion on stainless-steel tubing, clean the area and remove the corrosion according to TO 1–1–691. Immediately before painting, wipe areas to be painted with a lint-free cloth wetted with MIL-C–38736 solvent and dry with a clean cloth. Do not allow the solvent to evaporate since soils will redeposit on the surface. Apply the finish specified in the applicable maintenance manual.

Keep in mind that the procedures previously explained for the prevention and treatment of corrosion are general in nature and may not be applicable to all situations. For additional information concerning corrosion control on weapons systems, consult TO 1–1–691 and the applicable aircraft technical data. If in doubt about a specific area of corrosion on an aircraft, call the corrosion control specialists. As previously stated, corrosion, if left unnoticed and untreated, can virtually bring a weapon system to its knees. Hopefully, these last few lessons have heightened your awareness of the cause, prevention, and treatment of corrosion.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

212. Corrosion prevention

1. Where does corrosion of metals begin?

2. What effect can paint coatings have on initial stages of corrosion?

3. List the three degrees of corrosion.

4. How is light corrosion identified?

5. Normally, what type of corrosion is removed by extensive hand sanding or light mechanical sanding?

6. What degree of corrosion is characterized by pitting in depths of more than 10 millimeters?

7. How is the damage of severe corrosion removed?

213. Light corrosion treatment

1. During a routine inspection of a steel cable for a firewall shutoff valve, you discover corrosion on the outside surface of the cable. What is your next step?

2. When would attaching parts such as nuts, bolts, screws, and so forth require painting in detail?

3. What should be done with severely corroded screws, bolts, or washers?

4. To what type of corrosion(s) are rubber parts susceptible?

5. What type of coating do you apply to a section of aluminum tubing after cleaning and removing the corrosion?

6. What is used to protect a stainless-steel engine feed manifold exposed to the outside environment?

Answers to Self-Test Questions

201

1. (1) Truss.
   (2) Monocoque.
   (3) Semi-monocoque.
2. Monocoque construction.
3. To overcome the strength-to-weight ratio problems.
4. Aluminum alloy.
5. Longerons.
6. They provide cross-sectional strength to the fuselage and serve as attachment points for the skin.
7. Provide the lifting force for the aircraft as it moves rapidly through the air.
8. Size, weight, airspeed, rate of climb, and aircraft mission.
9. Cantilever.
10. It means the wing angles upward from the fuselage.
11. Horizontal and/or vertical stabilizers, rudder(s), elevator(s), and trim tabs.
12. To maintain the directional stability of an aircraft about its vertical axis and is the attachment point for the rudder.

202

1. Secondary and auxiliary.
2. To control the directional movement about the axis of an aircraft.
3. On the trailing edge near the wing tips.
4. To control the movement of the aircraft about the vertical axis.
5. Aid the primary flight controls by correcting for any unbalanced condition of the aircraft in flight.
6. Flaps and spoilers.
7. To support the aircraft during landing, resting, or moving about on the ground.
8. Via a retraction mechanism that may be electrically, mechanically, or hydraulically actuated.

203

1. A series of processes that give an object the ability to defeat radar, thermal, acoustical, and visual detection.
2. The ability to defeat various detection methods.
3. The use of advanced composites in the B–1 bomber.
4. To increase the survivability of the weapons platform.

204

1. A minimum of two threads should be showing through the nut.
2. The letter “S” is stamped on their heads.
3. (1) Length.
   (2) Diameter.
   (3) Threads per inch.
4. Where heavy tension or lengthwise stresses must be sustained.
5. The 12-point, external-wrenching bolt.
6. Where external tension loads are applied.

205

1. Self-locking and non-self-locking.
2. Non-self-locking.
3. (1) It has a locking feature built into the nut.
   (2) Some have a nylon or fiber insert.
   (3) It is designed to withstand extreme vibration.
4. 1½ threads.
5. Lock washers.
6. The screw.
7. In countersunk holes where a flush surface is desired.
8. Roundhead screws.

206

1. The solid-shank rivet.
2. Generally aluminum alloys but may also be made from corrosion-resistant steel, mild steel, titanium, iron, or copper for special applications.
3. Brazier head rivets.
4. Countersunk rivets.
5. Where access to one side of the work is impossible.
6. It is a high-strength threaded fastener, which combines the best features of a rivet and a bolt.

207

1. To route fuel, oil, coolant, breathing oxygen, hydraulic and vent lines, as well as electrical conduits and ventilation ducts.

2. Aluminum tubing is lighter than copper, can be easily formed, and has better corrosion/fatigue resistance than copper tubing.
3. Corrosion-resistant stainless steel tubing.
4. For general-purpose lines, conduits supporting low fluid pressure, such as instrument lines and drain lines, sensing lines, any drain lines, and open-type fuel vent manifolds.
5. Aluminum alloy tubing.
6. It would produce a mechanical property change in the metal that would greatly reduce its ability to withstand internal pressure and vibration.
7. (1) Dry bays.
   (2) Wheel wells.
   (3) Component parts.
   (4) Integral fuel tanks.
8. No deeper than 15 percent of the tubing wall thickness.

208

1. Areas where a great amount of vibration occurs or where flexibility is required (e.g., an engine bay or pylon).
2. (1) c.
   (2) d.
   (3) a.
   (4) b.
   (5) a.
   (6) c.

209

1. (1) QD.
   (2) V-band.
   (3) Wiggins couplings.
2. Ease and speed of connecting and disconnecting plumbing systems, particularly in congested areas and some QD couplings have self-sealing valves to eliminate fluid or air loss when disconnected.
3. QD V-band couplings.
4. The O-rings.

210

1. Zinc-coated soft steel wire.
2. On fasteners in a closely spaced or closed geometrical pattern, on electrical parts, and in places difficult to reach.
3. Three.
4. Three to six.
5. On fasteners/parts that have a hole diameter larger than .045 inch.

211

1. To secure bolts, screws, pins, and shafts.
2. Select the largest diameter cotter pin that will fit in the drilled hole and/or the slots in the nut, unless otherwise specified in the applicable technical data.
3. The surface of the washer.

212

1. On the surface of metals.
2. They can hide initial stages of corrosion.

3. (1) Light.
   (2) Moderate.
   (3) Severe.
4. The protective coating is scarred or etched, and the condition of the metal is discolored and pitted to a depth of approximately one millimeter (0.001 inch) maximum.
5. Moderate corrosion.
6. Severe corrosion.
7. By extensive mechanical sanding or grinding.

213

1. Relieve cable tension and carefully force the cable open by reverse twisting. Visually inspect the inside of the cable for signs of corrosion.
2. Only when dissimilar metal or wood contact is involved in the material being joined.
3. Replace them.
4. Fungus growth.
5. Conversion coating, MIL-C–81706, Class 1A.
6. The specific exterior finish called for in the applicable TO.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

Please read the unit menu for unit 2 and continue ➔

Unit 2. Special Tools and Equipment

AN AIRCRAFT IS A PRECISION FLYING MACHINE, but to remain useful, it must be maintained by the skillful hands of various maintenance personnel. Your skill as a mechanic depends not only on your ability to diagnose and correct malfunctions but also on your ability to select, use, and care for tools and equipment.

There is a great deal of self-satisfaction in using tools properly. It is great to know that you are working as competently with a tool as anyone can. A toolbox full of good, clean tools seems almost to say, “Pick me up and go to work, carefully and correctly.” Sometimes, you may prefer a particular wrench. Somehow, that wrench almost has a “personality” of its own.

Even if you think of a tool as just a cold piece of steel, you know that steel needs to be cared for and used correctly. Remember, you may immediately exchange a damaged tool for a usable one. However, it is better to protect tools through proper use than to continually exchange one tool for another because you never learned how to use them properly.

2–1. Hand Tools and Special Tools

Good mechanical work in maintenance and repair of aircraft and equipment depends largely on the correct use of tools. It is impossible to do your best work with the wrong tool or with tools in poor condition. Take care of your tools and keep them in good condition! Exchange damaged tools for serviceable ones. This is very important to efficiency in job performance.

In this section, we discuss some of the tools you will use in your work to maintain fuel systems. Remember, the tools you use cannot do the work alone; take pride in your work and use your hand tools correctly.

214. Using common hand tools

Common hand tools are the most widely used instruments when performing aircraft maintenance. While some of them may seem familiar to you, others may not. Do not let that worry you. As you become more familiar with your job, the names and uses for these hand tools will become second nature to you.

Screwdriver

The screwdriver is a tool for installing and removing screws. Do not use a screwdriver for prying, for opening boxes, or as a chisel. If used as a chisel or as a pry bar, as shown in figure 2–1, the handle or blade may bend or break. The three types of screwdrivers used most often are the common, the cross point, and the offset. To prolong the life of a screwdriver and prevent damage to the screw head, use the correct screwdriver. Figure 2–1 shows how an offset screwdriver can be used to reach a screw that is located in a recessed position where a straight screwdriver cannot be used.

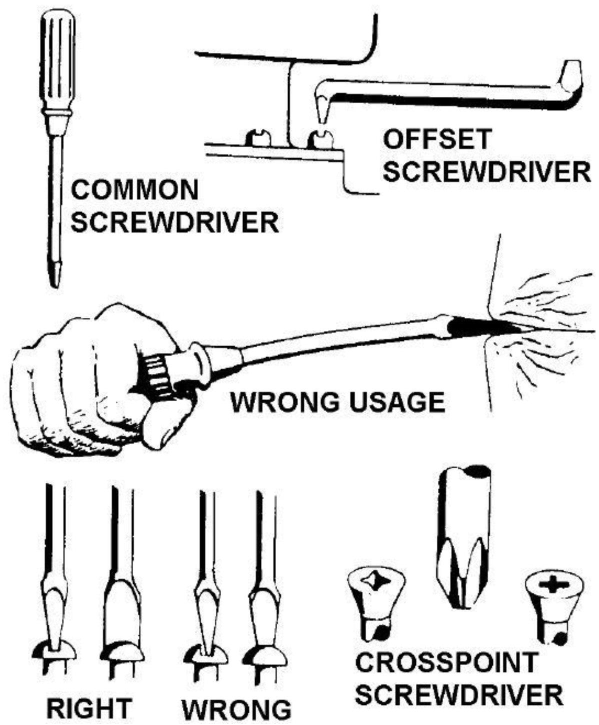


Figure 2–1. Screwdrivers.

Hammers

Keep the faces of hammers and mallets in their original shape and free from chips, dents, and dirt. Most accidents using hammers and mallets are caused by loose handles, a sweaty palm, or an oily handle. Figure 2–2 shows two types of hammers you probably use—the ball-peen hammer and the soft-faced mallet.

Ball-peen hammer

The ball-peen hammer is used by mechanics for general-purpose work, which in your case is around aircraft. The flat striking surface is used for driving punches and chisels, and the rounded surface is used as a peening tool.

Soft-faced mallet

Mallets with soft faces of plastic, rubber, or leather are used when it is necessary to hammer a metal surface without scratching or marring the metal. The mallet, shown in figure 2–2, has a removable plastic striking surface that can be replaced with one of softer or harder material when needed.

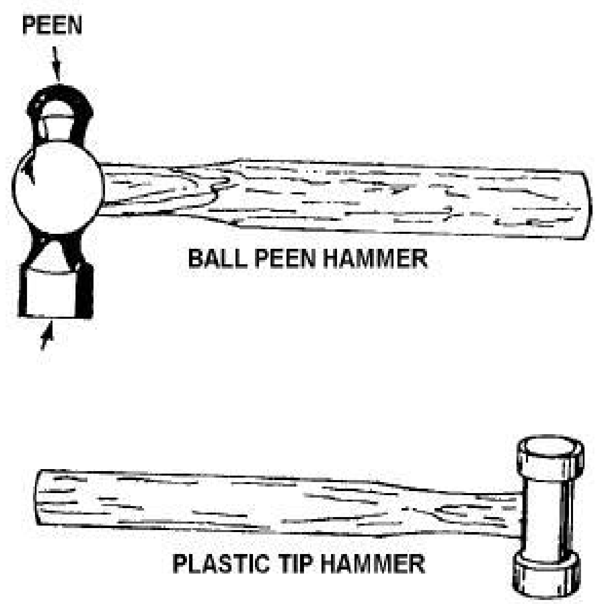


Figure 2–2. Hammers.

Pliers and punches

Pliers are used when the grip of the hand alone is not sufficient to do the job, when you are holding something hot, or when light cutting is to be done. A common tendency among inexperienced mechanics is to use pliers as an all-purpose tool. Pliers are made to aid the mechanic when installing and removing safety wire and cotter pins, to hold materials when his or her hand alone is not strong enough to hold them, and to hold hot materials (e.g., connections that are being soldered). They are not to be used as wrenches. If so used, they will unquestionably damage the material and may, if they slip, injure you.

Pliers are made in a variety of shapes and sizes. The three most common types are the diagonal-cutting pliers, the long-nose pliers, and the slip-joint pliers (fig. 2–3).

Pliers	
Type of Pliers	**Description**
Diagonal-cutting pliers	They cut safety wire, remove cotter pins, and do similar work.
Long-nose pliers	These pliers reach where the fingers alone cannot and bend small pieces of metal.
Slip-joint pliers	They grip wires and bend small pieces of metal to the desired shape. A pair of such pliers is a general-purpose tool.

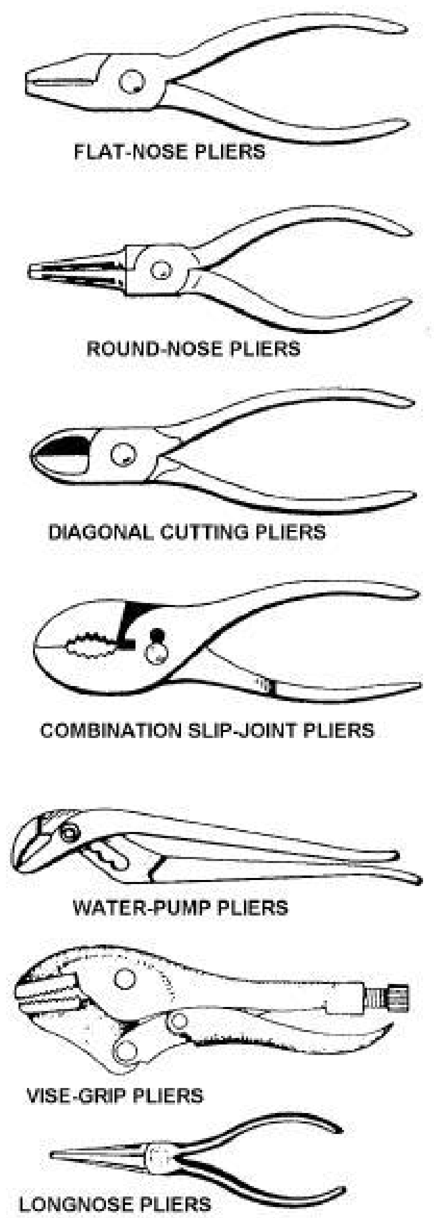


Figure 2–3. Types of pliers.

Many types of hand punches can be used in mechanical work; however, the punches illustrated in figure 2–4 are used more often than others are. Keep their heads and points in good condition.

Types of Punches	Description
Center punch	The center punch makes a small depression in metal prior to drilling a hole. This depression prevents the twist drill from “walking” during the drilling operation.
Prick punch	The prick punch establishes location points or scribing marks on metal surfaces.
Starting punch	The starting punch is tapered and has a blunt tip. It loosens tight-fitting pins that are to be removed from holes. The starting punch is heavier and stronger than the drift punch.
Pin punch	The pin punch has no taper. It drives out rivets, which have had the heads drilled off and drives pins out of holes that are too deep for the starting punch or the drift punch. The starting punch, drift punch, and pin punch have blunt tips.
Drift/alignment punch	A drift punch loosens tight-fitting pins, although its slender taper is not as strong as the starting punch. Often, the drift punch aligns holes in two pieces of metal prior to screw or bolt installation.

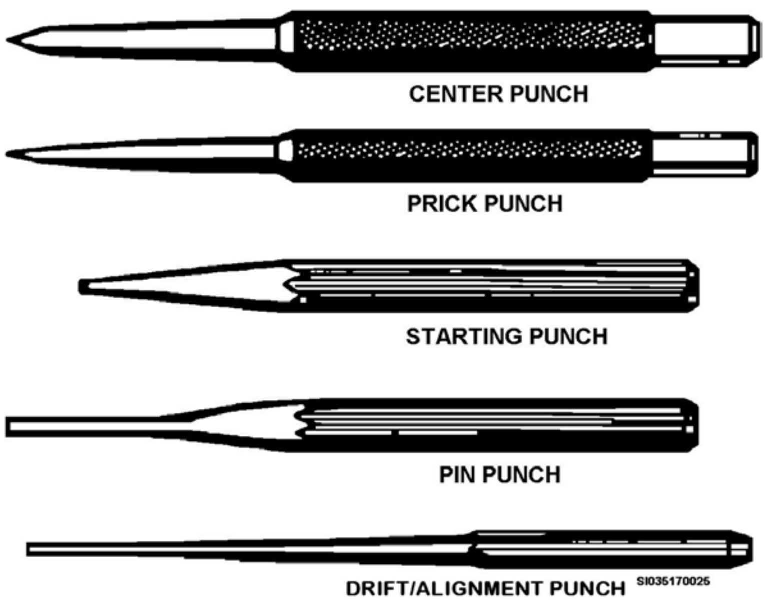


Figure 2–4. Types of punches.

Wrenches

A wrench is not a hammer! Not all people seem to realize this. Occasionally, you will see someone banging away with the business end of a wrench. Soon that end is not good for anything else. Keep in mind that a wrench is made to fit a certain size nut. If you file the jaws of a wrench to make them fit a larger nut, you have weakened the jaws. In addition, you will confuse the next person to pick up the wrench because he or she will expect the wrench to fit a nut for which the wrench was made.

Common wrenches

The wrenches most often used in aircraft maintenance are shown in figure 2–5. They include the open-end, adjustable-jaw, box-end, socket, and Allen wrenches. The Allen wrench, though not often used, is indispensable for one special type of internal wrenching nut. The ratchet handle, sliding offset handle, hinge handle, speed handle, and extension bar increase the usefulness of sockets.

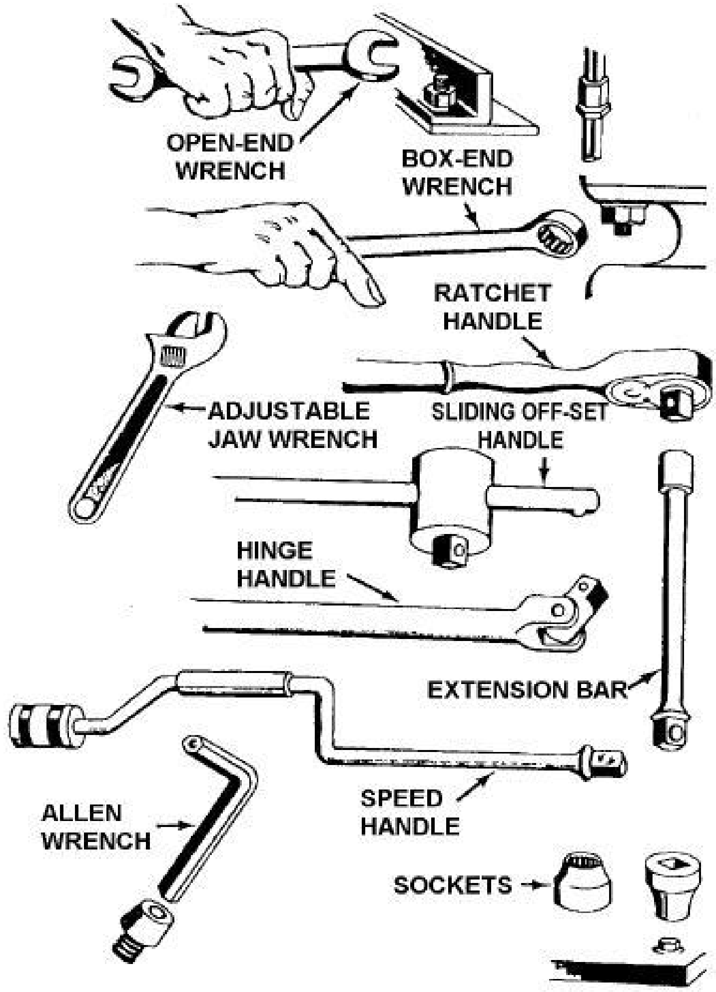


Figure 2–5. Types of wrenches.

Spanner wrenches

Spanner wrenches aid in the installation of manifold fittings and couplings. Two types of spanner wrenches are the hook-type and the pin-type, as shown in figure 2–6. Hook-type spanner wrenches are either fixed or adjustable and are used to tighten manifold couplings normally, which have a protruding lip. Pin-type spanner wrenches have pins protruding from the handle, which fit into holes in the coupling or plate to be tightened or loosened. Hook-type spanner wrenches remove or install couplings with protruding rims or edges (e.g., the Wiggins coupling). Spanner wrenches are special-purpose wrenches and are to be used only for their intended purpose.

Strap wrenches

Strap wrenches have a leather or canvas strap attached to the handle (fig. 2–7). The strap is looped around the manifold and back through the handle to grip the manifold. The strap wrench is designed so that it should not damage the surface of the manifold.

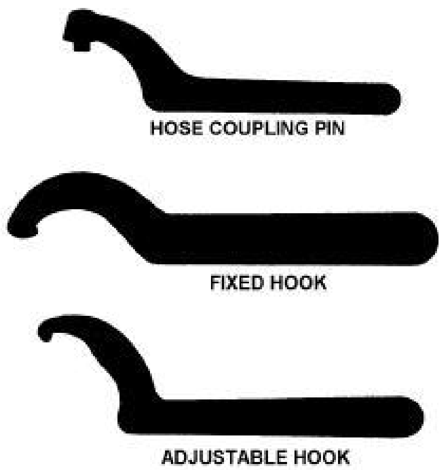


Figure 2–6. Spanner wrenches.

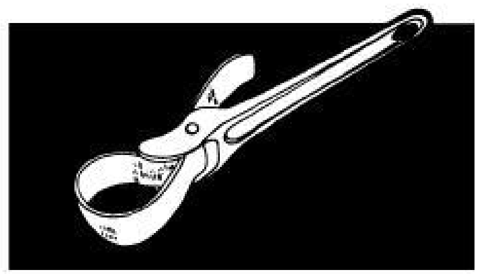


Figure 2–7. Strap wrench.

215. Caring for hand tools

Always choose and use the correct hand tools regardless of the type of job to be done. This is a requirement if you are to do a job quickly and accurately. Furthermore, your efficiency in using hand tools is determined largely by the way you care for your tools. Keep the following tips in mind as you care for and use your tools:

- When you perform work while you are standing on ladders, scaffolds, platforms, and work stands, use tool-carrying bags that contain *only* the tools you need for that job.
- Do not lift the heavy toolbox to any height.
- Be particularly careful not to drop a tool on a worker below.
- When you are not using a tool, do not keep it in a coverall pocket. Carrying tools in this manner can cause injury not only to you but also to others.
- Do not use tools that are greasy and grimy. The grease and grime may cause you to lose your grip on a tool, and you can injure yourself or damage the aircraft.
- Whenever you use tools that may cause flying particles, wear eye protection.
- Be aware that when you work in an area where a fire hazard is present, a spark created with a metallic tool can cause a fire or explosion.
- A good mechanic has a place for every tool and keeps every tool in its place. When not using your tools, store them in the racks, shelves, or toolbox provided to you.
- Carefully wipe your tools clean and dry before putting them away. If you do not expect to use a tool again for some time, coat the tool surface with lubricant to prevent rusting.
- Turn in tools that are damaged or defective for replacement. The price of a new tool or screwdriver bit is insignificant compared to the monetary loss due to, for example, screw damage and the time consumed in removing damaged screws.
- Ensure you have the tools you need and that they are in proper condition. The composite tool kit manager in your unit will periodically conduct inspections. You are responsible for the tools issued to you.

Remember the following guidelines when cleaning your tools:

1. Clean tools that are extremely greasy and grimy using an approved-cleaning solvent.
2. Use a wire brush to clean dirt from locations such as serrated jaw faces.
3. Eliminate rust by using crocus cloth or fine aluminum oxide abrasive cloth.
4. Lubricate hand tools using a lightweight lubricating oil or preservative lubricating oil.

Accidents involving hand tools are usually the result of misuse. Many people are under the impression that hand tools are simple devices that can be used by anyone with little or no training. That idea is untrue. Hand tools are precision instruments, capable of performing many jobs when used properly and safely. The prevention of accidents involving hand tools is a matter of proper instruction and adequate training in a safe working environment. An important precaution to observe in the safe use of hand tools is to make sure the tools are in good condition and adequate for the job at hand.

216. Using torque wrenches

Applying the correct amount of force to hardware is important to all mechanical operations. However, it is extremely important when you are working on aircraft. If too much force is placed on an item, the stress will tend to weaken it; if too little force is placed on an item, the item may loosen itself. This is why it is very important to use a torque wrench when tightening any aircraft hardware.

What is torque?

The purpose of tightening a screw or a nut on a stud is to place the screw or stud under tension. The amount of this tension is critical in some assemblies. If a nut is left too loose, it does not hold securely. If it is tightened too much, it may pull the bolt apart, strip the threads, or put an unnecessary and possibly dangerous strain on the members being held together. If a set of nuts on a unit are not all tightened with the same torque, internal stresses are set up in the unit. These stresses may cause eventual failure of the unit. Check after check has shown that improper tightening of nuts and bolts cause structural failure and rapid wear.

Torque exerted by the mechanic while using the wrench is an approximate measure of this tension. However, torque, as a measure of screw or stud tension, is approximately accurate only if the proper technique is applied while the torque wrench is being used.

When using the torque wrench for assembling nuts, tighten the nut or screw. Keep the nut or screw moving with a steady sweep of the wrench until the specified torque is reached.

NOTE: A fast or jerky motion will result in an improperly torqued fastener.

If the torque is being used for retightening and checking screws or nuts, a slightly different technique is used. Because of the adhesion or "set" that takes place between the threaded and other mating surfaces if motion is stopped, even briefly, the torque indication is valid only when the nut or screw is moving. Even when a screw is under less-than-desired tension, more than the specified torque is usually required to start it turning. Therefore, when a torque wrench is used for retightening or checking, the nut or screw must be started before the torque readings are taken. Back off the screw or nut so that less-than-specified torque is required to start it in the proper direction. When the specified torque is approached, the nut or screw must be kept moving with a steady sweep of the wrench until the required torque is reached. In all torque requirements, the desired torque value is predetermined. These values can be found in the appropriate TO 1–1A–8, *Structural Hardware*.

The torque wrench, shown in figure 2–8, is the automatic release or breakaway type. The torque handle is designed in such a way that when the set amount of torque is reached, the handle automatically releases or breaks.

Types of torque wrenches

You will usually use two types of torque wrenches—the breakaway and the T-handle. The breakaway is most commonly used; however, some maintenance shops still use the T-handle. The breakaway has adjustable torque, but the T-handle does not have adjustable torque.

Using the breakaway type

When the handle releases, it has approximately 15 to 20 degrees of free travel. Make the desired torque setting by turning the knurled section of the handle clockwise to raise the torque and counterclockwise to lower the torque. Figure 2–8 identifies the parts of a torque wrench discussed in this paragraph. The numbers on the micrometer (shaft) scale and grip markings represent foot-pounds or inch-pounds, according to the size of the handle being used. When the grip lock is unlocked, the handle, or grip, can be turned to any given setting within the range of the scale. As the grip is turned, it moves along the micrometer scale. One revolution of the grip moves the grip end through a 10-foot-pound range or from one number to the next. The grip markings are used to obtain a setting that falls between two consecutive numbers on the scale. Two reference lines must be considered when setting the handle to a given torque. First, the grip end is the reference line for reading numbers on the micrometer scale. Second, the grip scale line is the reference line for reading numbers on the grip end. If you want to set the torque-indicating handle to 20 foot-pounds, turn the grip until the grip end is on the 20 mark of the reference line and the 0 on the grip end is in line with the micrometer scale line.

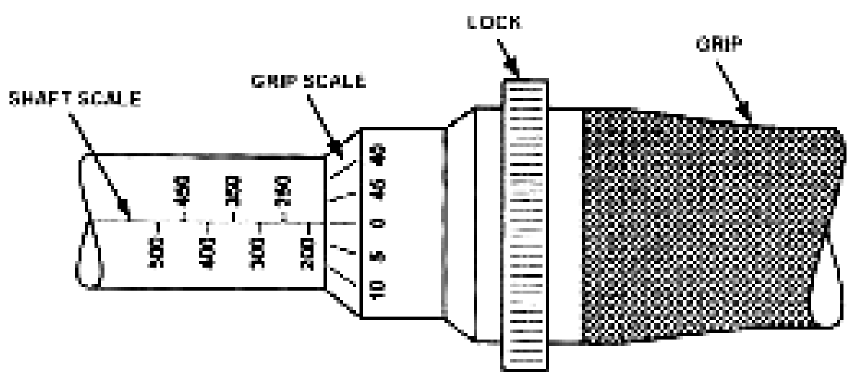


Figure 2–8. Parts of a torque wrench.

NOTE: Always approach a setting from the lower end of the scale. If the handle is already set for a reading above 20, back the handle off until the grip end is below 20 on the scale before making the above setting. If a setting of 24 foot-pounds is required, turn the grip until the grip end is aligned with 20 on the scale as before. Then, continue to turn the grip until the 4 on the grip markings are in line with the micrometer scale line.

Using the T-handle wrench

The T-handle-type torque wrench, shown in figure 2–9, is shaped like a T, as the name implies. It has a preset torque and cannot be adjusted like the other types. When a nut or hose clamp has been tightened to the set torque, the handle ratchets, and your turning the handle further does not continue to tighten the nut.

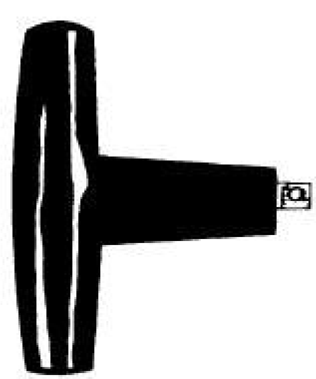


Figure 2–9. T-handle torque wrench.

Converting torque values

From time to time, it may be necessary to convert from inch-pounds to foot-pounds or foot-pounds to inch-pounds. Divide the figure to be converted by 12 to convert from inch-pounds. For example, 600 inch-pounds divided by 12 equals 50 foot-pounds. Multiply by 12 to convert foot-pounds to inch-pounds. For example, 10 foot-pounds multiplied by 12 equals 120 inch-pounds.

Using adapters

In many torque wrench applications, it is necessary to use an extension or adapter to gain access to an object. An extension or adapter that extends parallel (i.e., on a line) with the torque handle affects the predetermined torque value. To refigure torque value when this type adapter is used, follow the formula listed in the applicable aircraft TO.

217. Using powered tools

In addition to hand tools, you will be required to use a few power tools during the process of performing maintenance, whether in-shop or out on the flight line. These tools will be driven electrically or pneumatically. For safety reasons, pneumatic tools are usually used during aircraft fuel systems maintenance. The powered tools you will commonly use are drills, impact wrenches, bench grinders, and pneumatic buffers.

Drills

Drills vary in size and capabilities, but all operate basically the same. Portable power drills are usually equipped with pistol grip handles. Larger “industrial” drills have an extra handle so they may be held with both hands during drilling. Ordinarily, a straight shank, twist drill bit is used in the power drill. Secure the bit in a key-type gear chuck and the chuck automatically centers the drill bit in the drill (fig. 2–10).

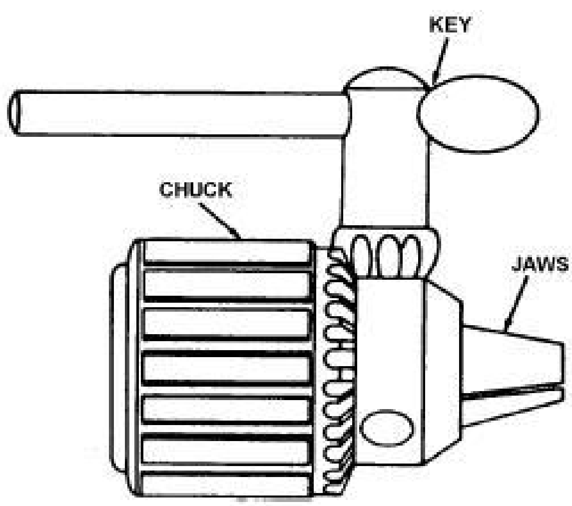


Figure 2–10. Drill chuck and key.

Before using the drill, be sure to mark the area for the hole using the center punch. Then, with the drill bit turning, insert the point of the bit into the depression created by the punch and start drilling. Make sure you hold the drill steady at the correct angle so your hole will be straight. Continue drilling while exerting light pressure. If you are drilling a hole through your work, ease up on your pressure when the point of the drill bit breaks through the surface. Otherwise, you may fall right into your work! After you drill the hole, remove the drill by pulling straight back while the drill is still operating. Do not turn off the drill until you have completely cleared the drill bit from your work.

Impact wrenches

Using impact wrenches increases the efficiency of any fuel systems maintenance shop by decreasing the time it takes to complete a task. Impact wrenches, more commonly referred to as “impact guns,” are commonly used to remove fuel cell and tank-access door fasteners, internal braces in integral tanks, and any other applications having a multitude of fasteners. As previously stated, the pneumatic type of impact wrench is preferred for our use. Although these tools can prove to be invaluable to maintenance person, they are often used incorrectly.

One such occasion is the installation of access doors and panels for integral tanks. I have seen several broken nut plates on a single door caused by someone attempting to torque access door fasteners with an impact wrench. The correct method of using an impact wrench is to set the pressure of the wrench to a point that will result in the fasteners’ requiring a final tightening with a torque wrench. Do not ever use the statement “feels pretty tight to me” as an acceptable measure of torque. Always use a torque wrench for final tightening.

Bench grinder

With very few exceptions, most fuel systems repair facilities have a bench grinder. Bench grinders are used in maintenance shops for sharpening tools, fabricating authorized sealant scrapers, and grinding twist drill bits. The typical grinder is equipped with two grinding wheels, a medium-coarse wheel for rough grinding and a fine wheel for finishing work. To remove carbon and rust from metal parts, use a wire wheel that you have installed on the grinder.

Always keep safety in mind

When using the grinder, always use goggles or a face shield to protect your eyes. Also, test the wheel by tapping it with a plastic or rubber hammer or mallet. A ringing sound indicates a satisfactory wheel. After installing a wheel, stand to one side as the wheel comes up to speed. This way, you will not be in line of flying pieces if the wheel disengages.

Two other important safety precautions to remember when using a bench grinder are: (1) make sure the work rests are in place and correctly adjusted and (2) never use the grinder if the wheel guards are missing. The work rests allow you to keep the work steady so you will not run your fingers into the wheel. The wheel guards are there to protect you if the wheel comes off or disintegrates.

Pneumatic buffers

The fuel cell pneumatic buffer (fig. 2–11) buffs lightweight fuel cells and for final buffing work on a fuel cell patch. A heavier buffer is also made for fitting flange repairs and buffing self-sealing cells.

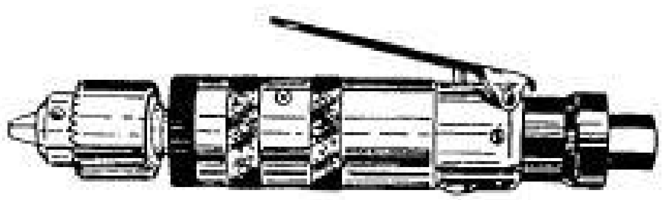


Figure 2–11. Pneumatic buffer.

The fuel cell buffer arbors are used with the heavier buffer (fig. 2–12). The arbors are made in several sizes. Usually, you will use either a 0 to 2-inch or 2- to 3-inch arbor. The buffing bands fit over the arbors and come in various grits (fig. 2–13).

The buffing stones (fig. 2–14) are used to buff the bladder fuel cells and flanges. These stones can be used with both sizes of fuel cell buffers.

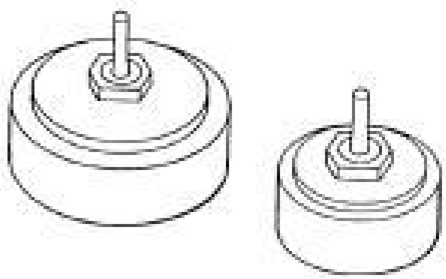


Figure 2–12. Buffing arbors.

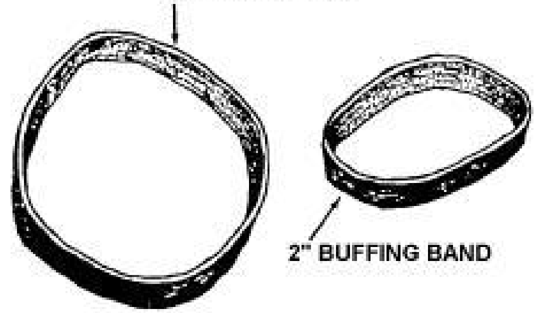


Figure 2–13. Buffing bands.

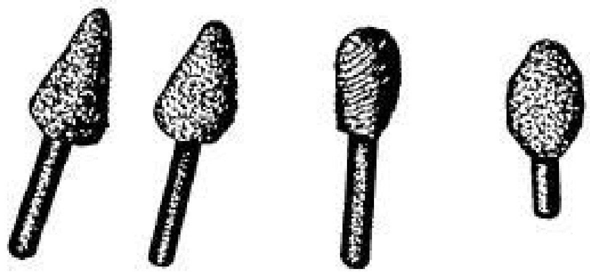


Figure 2–14. Buffing stones.

218. Using the two-part sealant injection gun (curing)

The two-part sealant injection gun forces two-part sealant into voids and channels, and the filleting gun (fig. 2–15) can furnish other areas where a higher pressure is required. The injection gun is larger and heavier than the filleting gun, but it uses the same type disposable cartridge used in the filleting gun. The cartridge plunger (C) has a removable plug that lets the gun plunger (D) pass into the cartridge. The injection gun uses an injection tip (B) that attaches to the gun barrel instead of the cartridge. When the trigger (A) is pressed, sealant comes out of the gun with a force that is about 50 times greater than the air pressure being used. Therefore, the ratio of input to output pressure is 50 to 1. With air supply line pressures from 25 to 125 psi, the gun puts out sealant pressures between 1,250 and 6,250 psi. Injection tips are commonly available in 3/16-, 1/8-, and 3/32-inch orifice size. They must be completely cleaned after each use, before the sealant on the tips cures, with cleaner rods of the same size as the tip orifice, using cleaning solvent. Certain special tips are used for some aircraft, and these tips are made specifically for use on that aircraft. The tips can be found in the manufacturer’s list of special tools or tool kits for each aircraft.

You must always be aware of the pressure-multiplying characteristic of the injection gun. If you use an air supply line pressure of 125 psi, the total force on a void having 10 square inches of area (i.e., about the area of the palm of your hand) is over 52,000 pounds. This pressure can cause structural damage if you are not careful. You must operate the gun intermittently to allow it to refill and to relieve the pressure between the structural members of the aircraft. To prevent damage, provide a bleed hole to relieve the high pressure developed in voids or channels.

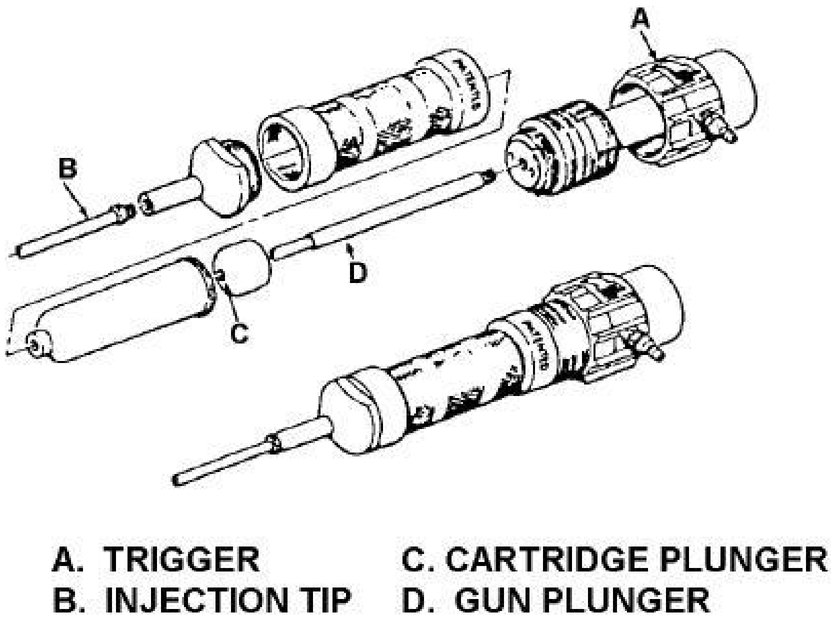


Figure 2–15. High-pressure injection gun (curing sealant).

219. Using the sealant-filleting gun

Use a sealant-filleting gun to apply fillet seals. Always use a sealant mixer to mix the sealant properly prior to inserting the cartridge into the filleting gun. Prior to mixing the sealant, you should select your nozzle. Filleting nozzles are available in various sizes. The size of the nozzle orifice controls the thickness of sealant fillet during application. Mix the sealant and insert the cartridge in the gun; next, screw the nozzle into the sealant cartridge. Connect air hose and regulate the air pressure in accordance with the manufacturer's instructions. It is a good idea to test the gun prior to starting the actual fillet seal. By squeezing the trigger on the filleting gun, you can release a small amount of sealant; this releases any trapped air and tells you that the sealant is properly mixed. Put the nozzle on the structure where the new fillet is required, squeeze the trigger, and move the gun along the area in order to apply the fillet to the entire area. After you are finished using the filleting gun, always clean any residual sealant off the gun.

220. Operating the one-part sealant injection gun (non-curing)

This type high-pressure sealant injection gun injects one-part sealant into channels under the wing skin. Figure 2–16 shows one model of the gun. You fill the gun with sealant by removing the baffle (D) from the gun assembly and packing one-part concurring sealant into the barrel with a spatula. It is important to keep trapped air to a minimum and prevent foreign matter from getting into the sealant. Adjust the regulator (C) to the correct pressure for proper operation of the gun. The air pressure applied at the baffle assembly moves the sealant into the path of piston travel. Depress the trigger (B) to move the piston forward. Piston movement can be noted by observing the stop in the slot (A) of the gun. Releasing the trigger returns the piston to its original position. This can be seen by the position of the piston stop. The barrel assembly can be replaced with the cartridge adapter kit (fig. 2–17). This permits you to use prefilled cartridges and eliminates the entrapment of air and foreign matter in the sealant. Using this kit saves time because you do not need to hand-pack sealant into the baffle.

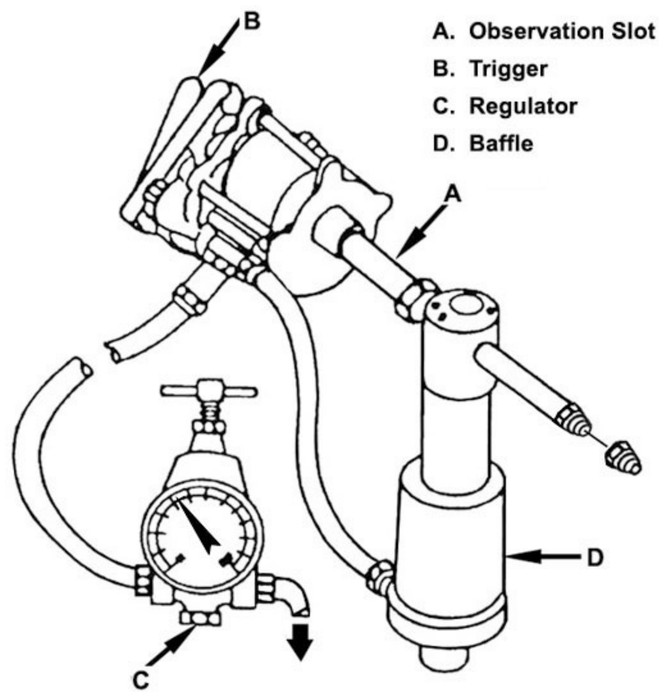


Figure 2–16. Injection gun (noncuring sealant).

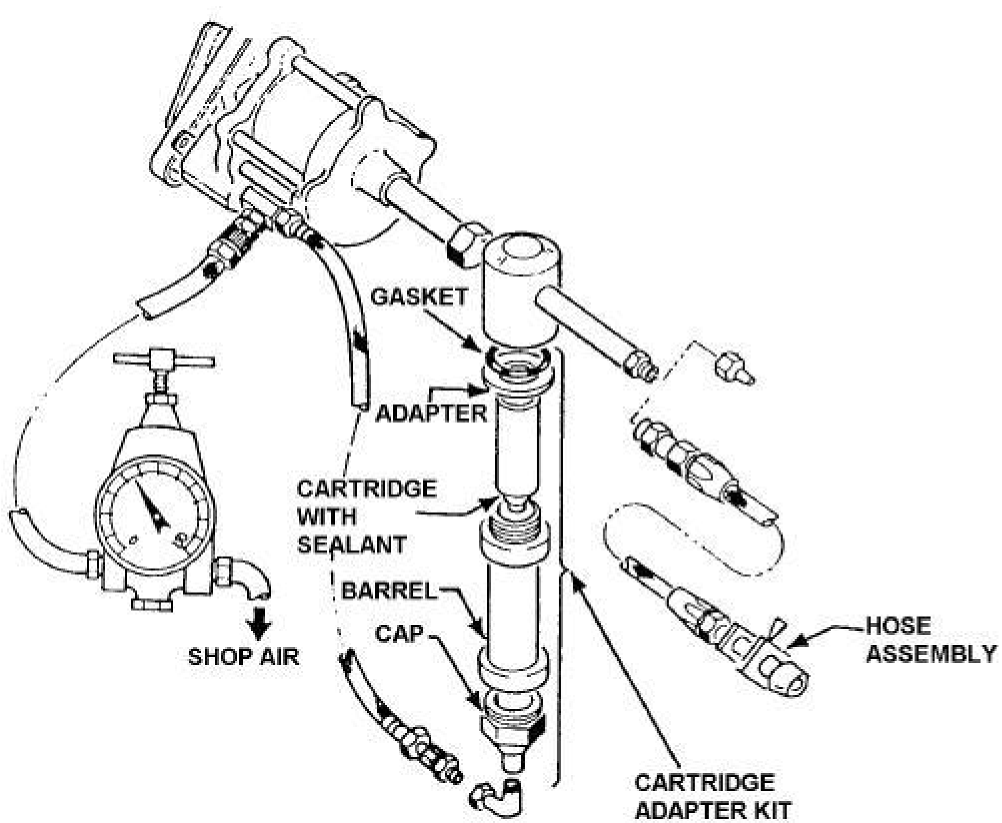


Figure 2–17. Cartridge adapter kit.

We have all heard the old adage, "If a little pressure will do a little good, a lot of pressure will do a lot of good." Damage, destruction, or injury would be better fitting words instead of "a lot of good." Increasing the pressure to the sealant gun will not result in a more efficient repair, nor will it result in a satisfactory fix. A pressure increase of 50 psi will cause a force of 3,500 psi on a sealant gun since the ratio of input to output pressure is 70 to 1. The structure may not be able to withstand this extreme pressure. The increased pressure may damage the airframe. It can also cause the gun assembly to explode while you are operating it and cause serious injury or a possible fatality.

221. Using pneumatically-powered tools with caution

This lesson gives you some simple precautions you should observe to realize the greatest efficiency from pneumatic-powered tools.

Air hoses

First, do not abuse air hoses. If you step on a hose or run over it with heavy equipment, the fabric cords that give the hose its strength to resist pressure will break and the hose will rupture. If it is necessary to roll equipment over the hose because you cannot raise the hose over the equipment, then place simple bridges over the hose. Second, nearly all air hoses in use now are coated and sealed with synthetic rubber that is not affected by oils and fuels. Even when the hose you are using does have fuel- and oil-resistant properties, it is to everyone's advantage to keep the hose clean. An oil-covered hose collects dirt that can be carried into the fuel tank if the hose has to be taken inside the tank. A dirty, messy hose is a nuisance to handle, and you should never allow one in a properly organized fuel system shop. Third, you also must exercise special care when using an air hose during cold weather, because a cold hose is more apt to crack or rupture when bent too sharply.

Use correct pressure

Make sure the operating air pressure of pneumatic-powered tools is within the limitations of the tool specifications; otherwise, you can damage the tool. If you operate a pneumatic tool at a pressure higher than specified, it may explode and injure you. If specifications call for an air pressure lower than the hangar or compressor airline pressure, install a pressure regulator in the line and adjust it to the proper pressure.

The compressed air must be free of all foreign materials, which could cause damage to a high-speed pneumatic motor. The air must also be free of excessive moisture, which could cause tool corrosion, tank contamination, or "freeze up" problems in cold weather.

Control static electricity

Air that passes through a hose and out of the tool motor can generate static electricity and may build up an electrical charge in your body as you operate the pneumatic tool. A spark may result when you touch a metal object such as the aircraft. Static discharge sparks constitute a fire hazard in the presence of fuel vapors. To eliminate any possibility of a body static charge, bond the pneumatic tool and make frequent use of the personnel-static-discharge plate.

222. Using special tools

This lesson discusses a number of tools used during fuel systems maintenance that are unique to our job. We will discuss some procedures and safety items when using some of the tools. Serviceability and safety are paramount.

Lights

Lights, to include flashlights, lamps, and lanterns, used in fuel systems repair facilities/areas shall be intrinsically safe or listed for National Fire Protection Agency (NFPA) 70, Class 1, Division 1, hazardous areas, before they can be used for fuel systems repair. Check lights for serviceability prior to use. As a minimum, ensure they are not cracked and have no broken lenses, missing/damaged seals, or defective cords.

Rubber buckets

Approved buckets are used to drain small amounts of fuel from aircraft. These containers have a 3-gallon capacity and are antistatic, so they do not need to be grounded. When draining fuel, keep free fall to a minimum. As fuel drains, the further it travels it will start to disperse and the stream will spread out. This is important on a windy day. A bucket is not a storage container; they have to be emptied right away to prevent a safety or spill hazard. Do not forget your safety gear, gloves, goggles/face shield, and an apron or coveralls.

Electric knife

The electric knife is equipped with a tungsten carbide cutting edge and is used for carving polyurethane foam material. The knife is not explosion proof; it is used for cutting new foam that has not been in a fuel tank. First, make sure the knife is serviceable. Then ensure the power cord is in good condition with no frays or cut wires. Ensure the blades are installed properly and look for cracks in the body of the knife. If the blades come out during use, they could cut you. Any defects deem the knife unserviceable and, therefore, not usable. After you inspect the knife and find it free of all defects, you can begin cutting the foam.

Sealant scraper

Use the scraper to remove damaged sealant from an aircraft structure. It is a non-spark-producing cutting tool. Use scrapers made only from plastic, wood, phenolic, or aluminum material. It may sound monotonous, but always check your scrapers for serviceability. A bad scraper can damage the structure. Scrapers should have a smooth beveled edge with no nicks or gouges on the beveled edge. Damaged scrapers can easily be repaired using a bench grinder. After you have performed your inspection, you can then begin scraping sealant.

CAUTION: NEVER use steel, copper, or brass to make a scraper that will be used on an aircraft structure. Scrapers made from these metals can cause damage or corrosion to the structure.

Sealant filleting gun

Use the sealant-filleting gun to apply a smooth, continuous fillet seal or to apply a low-pressure injection seal (fig. 2–18). The gun is composed of a hose, handle, trigger, knob, and valve assembly. You can select the size of the sealant cartridge and steel retainer required for the job. The disposal polyethylene cartridges and plungers used in the gun are furnished as Semkits. The size of the applied fillet is determined by the size and cut of the nozzle used.

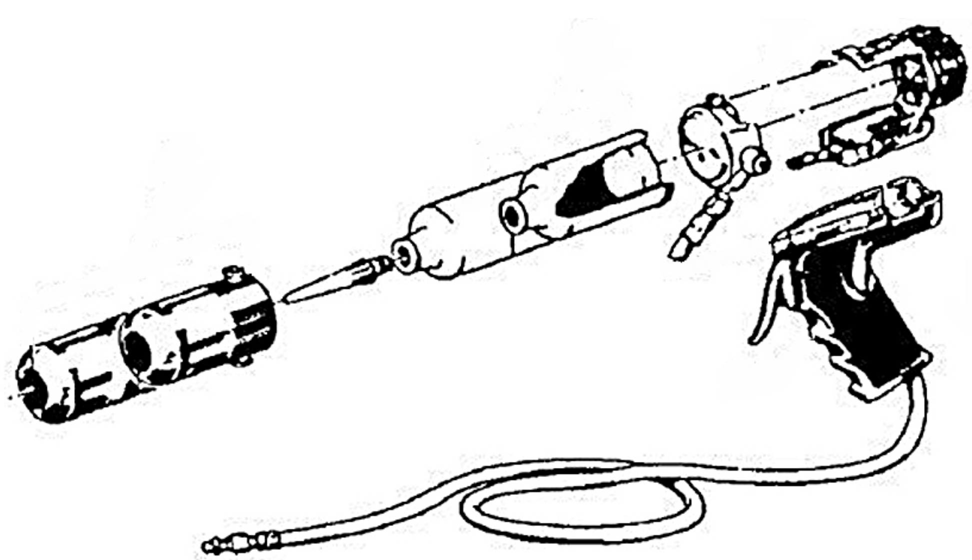


Figure 2–18. Sealant filleting gun.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

214. Using common hand tools

1. Name three types of screwdrivers.

2. Why is using the correct size screwdriver so important?

3. What two types of hammers were discussed in the text?

4. Name the striking surfaces of a ball-peen hammer and explain their uses.

5. Should pliers be used to tighten fittings? Why or why not?

6. Name the three most common types of pliers.

7. What are the uses of the three most common types of pliers?

8. Name five hand punches and describe their uses.

9. What tools are used to loosen tight-fitting pins?

10. What are five common types of wrenches?

11. What tool tightens a Wiggins coupling?

215. Caring for hand tools

1. When you are performing work that requires the use of a work stand, how do you carry your tools up on the work stand?

2. What do you do with hand tools that you do not expect to use for some time?

3. Normally, what do you do with a damaged tool?

4. What care do you give hand tools that are extremely dirty and grimy?

216. Using torque wrenches

1. Describe the technique used to torque a loose bolt and compare it to the technique to torque a bolt that is already tight.

2. What type of torque wrench has a preset torque and cannot be adjusted?

3. How do you convert inch-pounds into foot-pounds?

4. What is the result of using an extension or adapter on a torque handle that increases its length?

217. Using powered tools

1. What do you do before using a drill to bore a hole?

2. What type of power tool may be used to speed the removal of access door fasteners?

3. When using an impact wrench to install access door fasteners, what must you *never* do?

4. What tasks may require the use of a bench grinder?

5. What procedure do you use to check the integrity of a grinding wheel?

6. What two safety precautions must always be observed when using a bench grinder?

7. For what purpose is the pneumatic buffer used?

218. Using the two-part sealant injection gun (curing)

1. What is the purpose of the two-part sealant high-pressure injection gun?

2. What is the ratio of the output pressure of the injection gun to the input pressure?

3. How and when do you clean the gun?

4. Why must you provide a bleed hole for the sealant injection with this gun?

219. Using the sealant-filleting gun

1. For what should the sealant-filleting gun be used?

2. What controls the thickness of the fillet during application?

220. Operating the one-part sealant injection gun (non-curing)

1. What is the purpose of the one-part sealant injection gun?

2. Explain the operation of the one-part sealant injection gun.

3. What could happen if the air pressure used to operate the one-part sealant injection gun were too high?

221. Using pneumatically-powered tools with caution

1. What are four precautions to observe concerning the use of pneumatically powered tools?

2. Why must air hoses be kept clean?

3. What do you do to prevent the buildup of static electricity when using a pneumatic tool?

222. Using special tools

1. What requirement must lights meet before they can be used for fuel systems maintenance?

2. Why is it important to keep the bucket as close as possible to the drain?

3. Why should a scraper never be made from brass or steel?

2–2. Test and Measurement Equipment

Have you heard the story about the mechanic who blew the wing off of an aircraft, or maybe the one about some poor mechanic getting injured when something went wrong while he or she was "checking out" a leak or malfunction on an aircraft? Most of us have heard a few of these stories. The problem is that not all of these are just stories. Some are based on actual accidents. They happened because test equipment was being used improperly or was not used at all. The proper use of test equipment in aircraft maintenance is critical. The next few lessons cover the purpose and proper use of test equipment commonly used during fuel systems maintenance.

223. Using the water manometer

The water manometer is used when a fuel tank is either positive- or negative-pressure tested (fig. 2–19). It is also used during fuel-cell testing. The purpose of the manometer is twofold. First, it provides a means to relieve excess positive or negative fuel tank pressure. Second, it serves as a pressure gauge. Water manometer types are U-shaped or vertical. The only fluid authorized for use in the manometer is a mixture of 50 percent water and 50 percent ethylene glycol. Fuel systems related accidents have resulted from the improper use of or failure to use a manometer. The water manometer is omitted when pressurizing the aircraft with the weapon specific Tank Pressurization System, in accordance with TO 33D2–3–56–21, *Tank Pressurization System, Part Number Det-Tps–8000*.

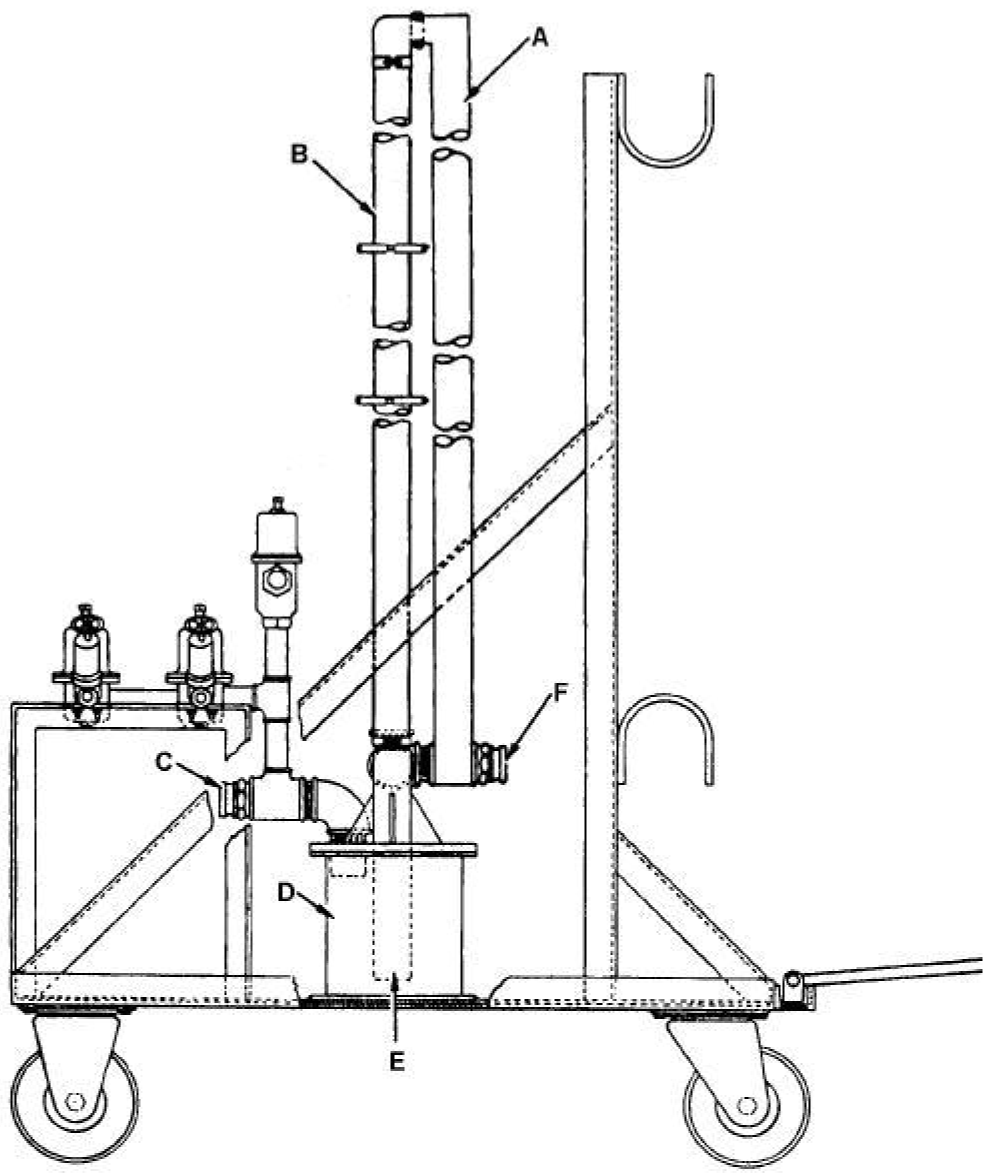


Figure 2–19. Water manometer.

Negative pressure

When the fuel tank is to be under a negative pressure, connect the water manometer hose to the negative pressure connection (F) to show the fuel tank pressure reading. Uncap (leave open) the positive pressure connection (C). As the fuel tank negative pressure builds up, the resulting lower pressure in tubes A and B cause water to be sucked into the tube at point E and up the clear plastic tube (B). Determine the fuel tank pressure by comparing the water level to the indicator mark on the clear plastic tube. If the water rises in excess of the clear plastic tube, the water will be sucked into the fuel tank by way of the metal tube (A) and the connection (F). Air will enter the fuel tank after all of the water is sucked from the reservoir (D). This will relieve the excess negative pressure.

If the positive pressure connection is not left open, air will not enter the reservoir. This will cause a negative pressure above the fluid level in the reservoir during test and an erroneous reading on the clear plastic tube (B). For example, the reading on the tube may only indicate 2 psi, and, yet, the tank may be under a negative pressure of 5 psi. The tank may not be able to withstand this amount of pressure, which could cause structural damage or an implosion (bursting inward).

Positive pressure

Connect the positive pressure connection (C) to the fuel tank when the tank is to be given a positive test. Unplug the negative pressure connection. Once again, be sure both connections are unplugged, preventing over pressurization and damage to the aircraft. Mechanics have attempted to use the manometer without unplugging both connections. In some instances, the mechanics observed and corrected the trouble before any damage occurred. In other instances, the mechanics were not so observant, and the fuel tank exploded. When the manometer is not in use, install rubber plugs in both the positive and negative connections. Before operating the manometer, check the following items and correct any discrepancies:

1. Check both the positive and negative pressure connections for obstructions.
2. Check the manometer hose for obstructions.
3. Check the fluid level in the manometer.
4. Check the applicable aircraft TO to determine the maximum pressure you may apply to the tank.
5. Check the length of the plastic tube on the manometer to ensure that it does *not* exceed the maximum pressure range. The sections of tubing may be increased or decreased, depending on the required pressure range.

224. Operating, inspecting, and maintaining atmosphere measuring equipment

Probably the most distinguishing factor in your job as a fuel systems mechanic is that you will be required to enter fuel tanks. That is why it is very important that you know how to measure the atmosphere inside a fuel tank. The photo ionization detector, or PID, is the detector of choice. In this lesson, we will discuss the operation, inspection, and maintenance of the PID. The goal of this lesson is to enhance your familiarization with the PID. This lesson is by no means a substitute for the information you will find in the owner’s manual for this particular equipment.

Operation

To turn on the PID, press the MODE button. This starts the 90-second warm-up sequence. During this warm-up, read the digital screen display to ensure your alarm settings are correct. If they are *not*, refer to the owner’s manual and reset them. These are your warning signals telling you that the tank atmosphere is unsafe. At the end of the warm-up sequence, the PID is ready for use. Now you simply take a reading at various parts of the tank starting at the entrance and moving toward the area where you will be working. Take a reading at the top, middle, and bottom section of the tanks to ensure you get a good sample. You should sample each area for 60 seconds, plus one second for every foot of hose used, if you are using the remote sampling hose. Refer to TO 1–1–3, *Inspection and Repair of Aircraft Integral Tanks and Fuel Cells*, for guidance on the current acceptable levels for tank entry. The PID is capable of reading in percent lower explosive limits (LEL) or parts per million (ppm). If you hear an alarm during sampling, exit the tank and find out what caused the alarm. You may need to recalibrate your PID or purge your tank longer. Be sure to record your reading on the entry permit. The PID can be left on for continuous monitoring or turned off and used for periodic sampling; refer to TO 1–1–3 for guidance on whether or not you require continuous monitoring or periodic sampling. When you are finished with the PID, push the MODE button and hold it for five seconds. This turns the PID off. When not in use, charge the batteries, ensuring the PID is ready for its next use.

Inspection

As with any piece of equipment, inspect the PID prior to use. The first thing you want to check is the calibration date to make sure the PID is current on its calibration. Check the outer case for damage. This is especially important because any damage to the outer case could cause the unit to become unsafe for use in a fuel systems repair area. You should also inspect the external filter to ensure it is not discolored or clogged prior to each use, if one is installed.

Maintenance

Most of the time, charging the batteries will be the extent of the maintenance you will be involved in with the PID. However, you should be aware of some components that require periodic maintenance. There are several sensors in the unit that may require replacement because they lose their sensitivity over time. Their expiration date can be viewed during the warm-up sequence. You should be aware of these dates and make sure replacement sensors are on hand. Some models have a charcoal filter that must be replaced every 4 to 6 weeks depending on use. Again, it is a good idea to keep some of these on hand so your PID is serviceable at all times.

Toxicity indicator

This equipment is designed to detect toxic chemicals and is not required for day-to-day use in fuel systems maintenance. The local bioenvironmental engineering flight (BEF) should conduct periodic sampling to detect and measure toxic substances in the work area.

225. Using the bonding meter

The movement of fuel through a manifold or component can cause the buildup of static electricity. To prevent this buildup, critical components are bonded together. This means they are connected in such a manner that electricity would have a continuous path to flow through them. This is essential to prevent the chance of a spark caused by static electricity occurring inside of our fuel tanks. Therefore, whenever parts that have a need to be bonded together are separated, it is imperative that you check to see if they are bonded when you reinstall them. This is why you need to be familiar with a bonding meter.

Meter description

The model T477W bonding meter is a precision instrument used to identify the integrity of electrical connections by measuring and displaying small values of resistance (less than 2 ohms). The range of measurement is .2 to 2000 milliohms. The meter is supplied with three sets of probes having four wire connections. In addition, a separate power supply is provided for charging the batteries. Underwriter Laboratories certify the bonding meter as an intrinsically safe device for use in hazardous locations, Class I, Group A, B, C, or D. Therefore, the meter may be used inside the fuel systems repair area or facility.

Cables used with the meter

Three sets of cables are supplied with the meter. The use of a particular cable depends on the size and shape of the two bonded materials near the bond. One set of cables consists of four test probes, another set consists of a probe on one end and a clamp on the other, and the third set consists of dual compass-type probes.

The set consisting of four test probes is used on tubing and where edges are exposed. The set consisting of a probe on one end and a clamp on the other is used where edges are exposed and on tubing. The use of this probe allows the operator to take a measurement while monitoring the meter. The third set of cables is used where the connections have to be made on the surface of the two bonded materials.

Meter operation

To use the meter, select one of the three probes and connect it to the front panel. When taking a measurement, ensure the probe tips penetrate any nonconductive film that may be present. Briefly press the TEST button located on the front panel. The TEST button turns on the display and changes the meter range. The meter display can be illuminated by pressing the LAMP button located on the front panel. To conserve battery power, a built-in timer automatically shuts off the display after 52 seconds of operation.

Using the meter

The meter is used by connecting a probe to the input connector, turning the meter on, and connecting the probe across the resistance or bond to be measured. All meter displays are in milliohms. The decimal point is positioned for each range automatically. If a display is over range, as indicated by flickering digits, select a less sensitive range by pressing the TEST button.

The bonding meter is used primarily to ensure electrical continuity exists between a component and a manifold, between two sections of manifold, between a component and the tank structure, and so forth. If continuity does not exist, static electricity may result and present a potential hazard. Consult the applicable aircraft technical data for specific resistance values when using the bonding meter.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

223. Using the water manometer

1. What is the two-fold purpose of the water manometer?

2. Why must both connections of the water manometer be unplugged?

3. What items do you inspect before using a water manometer?

224. Operating, inspecting, and maintaining atmosphere measuring equipment

1. What atmosphere measuring equipment measures the atmosphere of fuel tanks?

2. Which button is pressed to turn on the PID?

3. When is the PID ready for use?

4. How long should you sample each area of the tank?

5. When inspecting the PID, what is the first thing you should check?

225. Using the bonding meter

1. What is the purpose of the bonding meter?

2. Can the meter be used inside the repair area or facility? Why or why not?

3. Which set of test probes should you use when you need to monitor the meter while taking a measurement?

4. Which button turns on the meter display?

5. How does the meter conserve battery power automatically?

2–3. Aerospace Ground Equipment

Powered and non-powered support equipment is instrumental in performing fuel systems maintenance. Aerospace ground equipment (AGE) *supports* maintenance by providing a source of compressed air for pneumatic tools, fresh air for fuel tank and cell purging, filtered air for breathing, and a number of other important functions. This section covers some important and widely used AGE items, both powered and non-powered.

226. Operating air compressors

Air compressors supply air for several purposes (e.g., the operation of pneumatic tools, blowers, and pumps). They are needed also for ground checking and servicing some aircraft. The Air Force uses several types of air compressors, but the three most widely used to support fuel systems maintenance are the MC–2A, MC–7 and the A/M 32A–95 compressors.

A portable cart mounted air compressor can be used for fuel cell/tank maintenance when a compressed air source is required. Non-explosion proof air compressors are kept outside the fuel systems repair area. When used as an air supply to personnel entering a fuel cell/tank, it is connected directly to the air purifier cart that removes air contaminants. Explosion proof compressors are in the MB–1 series.

MC–2A, low-pressure air compressor

The MC–2A “lo-pac” is a two-wheel, portable, gasoline engine-driven compressor (fig. 2–20). It is designed to operate small pneumatic tools and other small pneumatic devices (e.g., the air mover or sealant gun). This compressor can compress 15 cubic feet per minute (cfm) at a maximum of 200 psi. The centrifugal clutch engages when the engine reaches 300 revolutions per minute (rpm).

Most of the valves, along with operating instructions and instruments, are on the operator’s panel. The service hose is stowed on brackets welded to the storage tank. The drain valves provide a means to remove moisture from the system during use and for draining the storage tank upon shutdown.

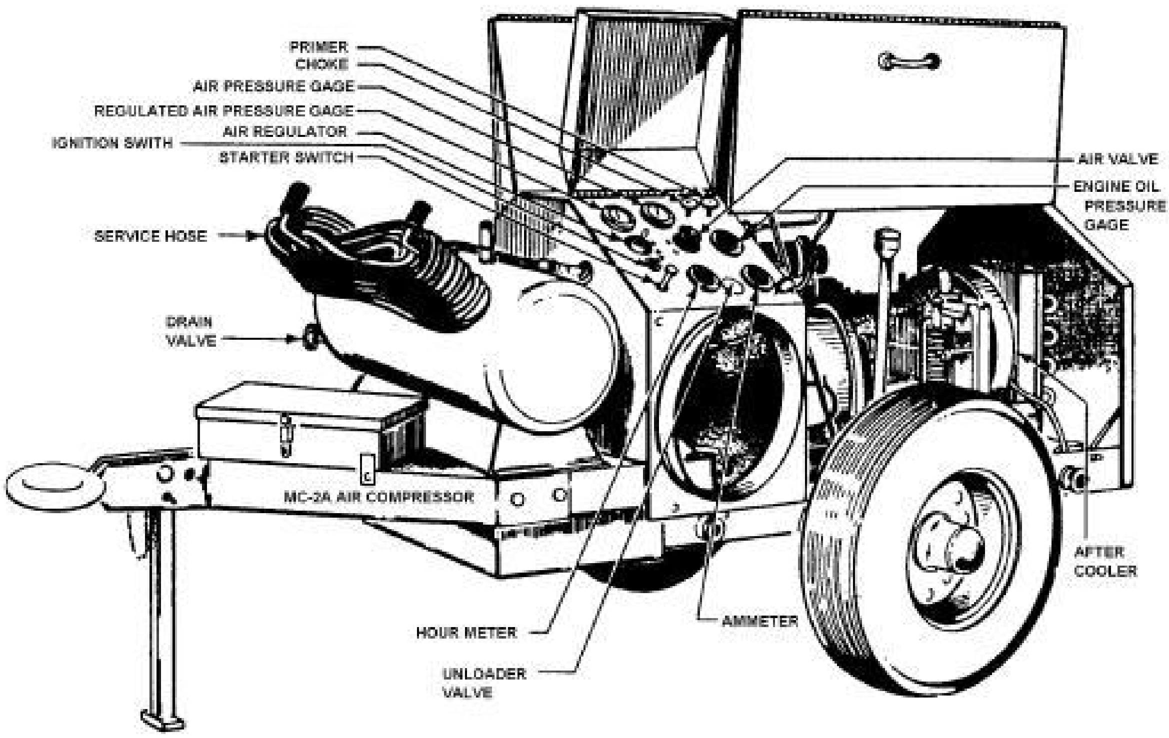


Figure 2–20. MC–2A air compressor (lo-pac).

MC–7 high-volume air compressor

The MC–7 is a diesel engine-driven rotary air compressor, capable of producing 125 cfm of airflow at a maximum of 100 psi. The compressor is self-contained and, under normal conditions, is capable of continuous operation for eight hours without refueling. The MC–7 is often used to provide compressed air for the operation of pneumatic tools and equipment. The unit is equipped with two 50-foot hose reels, which may be used simultaneously. When using the MC–7 or any other air compressor, observe the following precautions:

1. Keep the housing side doors closed during operation.
2. Follow the operating instructions on the unit.
3. Set the parking brake when the unit has been positioned.
4. Always wear ear protection when the unit is in operation.

A/M 32A–95 air compressor

The A/M32A–95 compressor cart is a four-wheeled, towable vehicle consisting of an enclosure assembly, turbine engine assembly, fuel system, electrical system, lubrication system, frame and running gear and air delivery system. The compressor is intended to be used in furnishing pneumatic power for ground support of aircraft systems. Its primary mission is to start engines for a variety of aircraft. The cart's air delivery hose connects to the aircraft and delivers compressed air for starting the aircraft's turbine engine(s) and performing other functions that require a large volume of compressed air.

227. Using the explosion-proof pneumatic vacuum

The vacuum cleaner used for fuel systems maintenance is an explosion-proof, air operated unit. It depuddles residual fuel that will not drain during normal drain procedures. The vacuum cleaner is also suitable for cleaning the cavity or tank to make certain all foreign matter has been removed. Handle the vacuum cleaner as a fuel collection container. The vacuum must be grounded and bonded to the aircraft before and during use. Do not modify the hose with metal extensions or other spark producing materials. The vacuum is not a fuel storage container and needs to be emptied after use. Before using the vacuum, check the structural condition, including the wheels. Next, check for fuel leaks. Lastly, make sure the vacuum is not full to capacity.

To operate use the following steps:

1. Position vacuum ground and bond to aircraft.
2. Use hangar air supply or an approved air source.
3. Drain any condensation from air supply system.
4. Attach compressed air supply line to vacuum.
5. Adjust air supply in accordance with TO.
6. Open air supply shutoff valve on vacuum.
7. Hold recovery hose at surface of fuel to allow mixture of air and fuel to enter recovery hose.
8. Close air supply shutoff valve on vacuum.
9. Elevate recovery hose to allow residual fuel to flow into recovery tank.
10. Bleed off air pressure before disconnecting air supply line.
11. Drain fuel from recovery tank through drain valve into an approved safety container.
12. Consult manufacturer's instruction manual for maintenance.

228. Operating heaters

There are a few heaters available in the Air Force that are used for several purposes (e.g., providing heat for comfort, curing sealant, and purging a fuel tank) in a cold environment. Heaters are classified into two types—explosion-proof and non-explosion-proof. Most of the heaters used to support fuel systems maintenance are the explosion-proof type, and there are presently two heaters authorized for use—the HDU–13/M and the rapid curing device (RCD).

HDU–13/M heater

The HDU–13/M heater is specifically designed for fuel systems maintenance, and as such, safety features are incorporated throughout the unit (fig. 2–21). The exterior panels, including the wheel covers, are made of aluminum so they will be non-sparking. The electrical circuitry is encased in an explosion-proof steel box. The heater is completely sealed, making it explosion-proof.

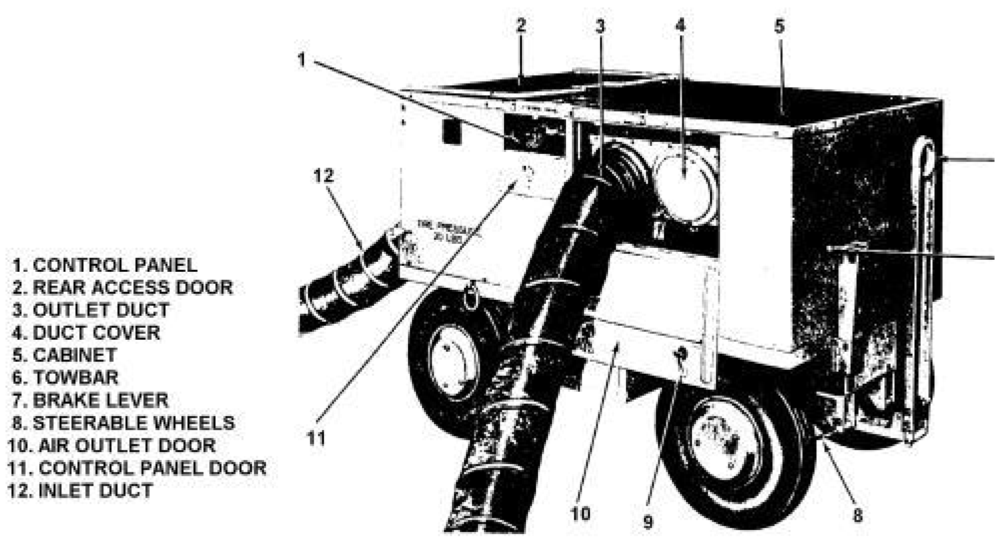


Figure 2–21. HDU–13/M heater.

The HDU–13/M heater is designed for safe operation in atmospheres containing explosive mixtures of aviation gasoline, jet fuels, and air. It can provide heated air and/or ventilating air for purging fuel tanks and cells. It can also be used to cure sealants and coatings. The temperature range for the HDU–13/M is 40 to 200° F. The heater is an electrically powered unit mounted on a four-wheel trailer, with its two front wheels steerable by a tow bar.

To start the HDU–13/M, hold both the BLOWER START switch and the HEATER START switch for 4 seconds. The heater will blow air. If heated air is desired, press the HEATER START switch a second time. The desired temperature can be selected by using the temperature control switch.

Rapid curing device

The RCD is a 28-volts direct current (VDC) thermoreactor system; it is explosion proof and may be operated inside the fuel systems repair area. The RCD may be placed directly inside the tank opening. Before placing the RCD in the tank, you must first ensure the system is serviceable. Do a general prior to use inspection. Check the case for cracks and any defects. Ensure wires are not frayed or the connection to the RCD is broke. After you have completed your inspection, turn the RCD on and then put it in the fuel tank opening.

HDU–43 heater or new generation heater

The new generation heater (HDU–43) is designed to burn multi-fuels (JP–8, DL–1, DL–2, JP–4, and JP–5) to produce heat for maintenance personnel, ground vehicles, maintenance shelters, and portable hangars. It utilizes an electric power transmission with no direct mechanical contact between the engine and the heating unit.

These heaters are not explosion proof and shall remain outside the open fuel systems repair area. Their combustion chambers are sealed from the ventilation chambers. They may be connected through a plenum chamber to the open tank using the ducts provided with the unit.

229. Using air blowers and air conditioners

Heaters are one way you can purge fuel tanks. Other explosion proof equipment can also be used. Blowers, fans, and climate control units are considered explosion proof (fig. 2–22). We will also talk about air conditioners that are not explosion proof.

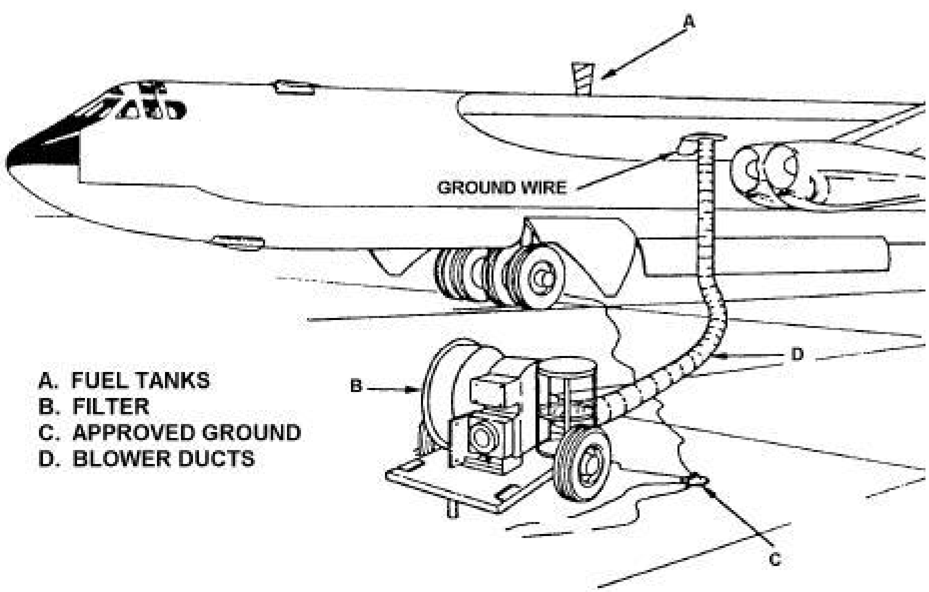


Figure 2–22. Typical blower set-up.

Pneumatic-powered fan

The pneumatic-powered fan is a 12-inch fan powered by an air pressure source and used to blow purge or exhaust purge a fuel tank. It is portable and may be used inside the repair area. A regulator on the fan varies the airflow output. The fan is presently available from Rhine Air, Inc., and is often referred to as the "Rhine air fan."

Eight-inch pneumatic-powered blower

This blower is similar to the 12-inch fan and used to ventilate one or more fuel tanks at once. It is also portable and is connected to a compressed air source for operation. The drawback to using pneumatic fans and blowers appears to be the noise generated by their operation.

The 8-inch pneumatic blower, referred to as the blower unit, consists of a variable output, vane-type motor, which directly drives a one-piece blade. The blower is non-spark producing and equipped with an air pressure regulator, relief valve, 0 to 60 psi pressure gauge, and an air exhaust muffler. Some precautions must be observed when using this blower:

1. To prevent premature wear of air motor vanes, set the blower air pressure gauge at or below 22 psi if blower is operated for more than 3 hours at a time.
2. Do not exceed 34 psi on the blower unit pressure gauge.
3. Add 1/2 ounce of 10-weight oil after every day of use.

Air conditioners

Trailer-mounted electric-, gasoline-, or diesel-powered air conditioners—listed in TO 1–1–3—can be used for fuel systems maintenance when conditioned, temperature-controlled air is required. This equipment is *not* explosion-proof and must remain outside the repair area.

The typical air conditioner is a portable, four-wheel, trailer-mounted unit (fig. 2–23). It can be engine-driven or electrical-driven to conduct the cooling air through flexible ducts stored in the duct storage compartment. To assist in positioning and moving the unit short distances, the trailer has a rear axle differential powered by an electric motor. The unit also has a tow bar for towing long distances. If your shop is located in a warm climate area, you are probably very familiar with this equipment item.

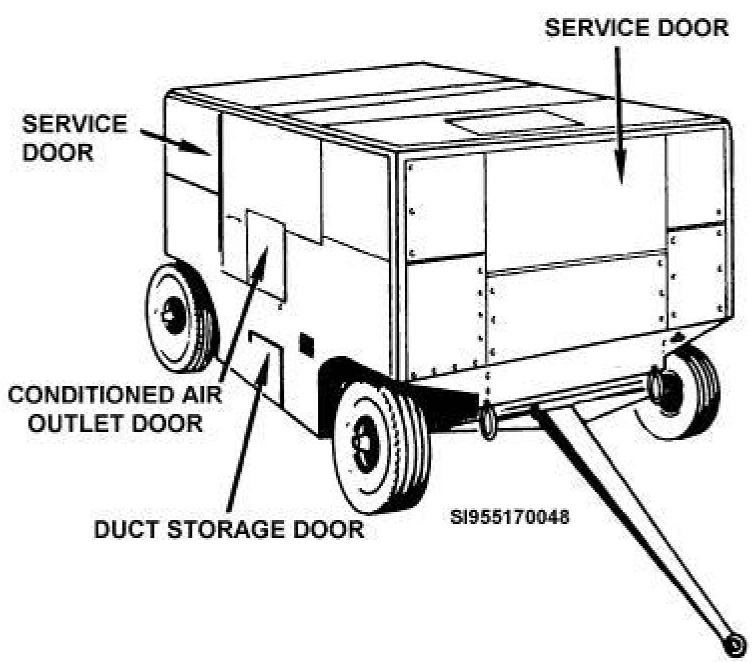


Figure 2–23. Typical air conditioner.

Climate control units

Climate control units are installed in your hangars to provide environmentally stable air for purging, sealant cure, and general repair. These systems are required in new and existing facilities. As the name implies, they can provide hot air for curing sealant and warmth in the wintertime and cooler air in the summertime.

230. Operating breathing air supply equipment

As with other types of support equipment we have covered, there are several different types of equipment used to supply filtered breathing air to workers inside a fuel tank or toxic environment. This equipment includes the fuel cell/tank servicing cart, air purifier cart, ambient breathing air pump, and electric breathing air pump.

Fuel cell/tank servicing cart

Once used extensively, this cart has steadily been replaced by equipment that is easier to operate, quieter, and smaller. The unit is portable and may be used inside the repair area.

By the use of an air compressor (e.g., the MC–1A or MC–7), air can be filtered, regulated, and delivered to five respirator connections ready for use by the worker. The system is designed so that in the event of an air compressor failure, an emergency breathing air supply bottle incorporated in the servicing cart will supply breathing air to the workers long enough for them to evacuate the cell/tank in which they are working.

The fuel cell/servicing cart is used as a central point for breathing air supply bottles, regulators, respirator hose, and connections. It may also be used to store certain materials (e.g., ducting and bonding/grounding cables). Each time a tank entry is made using cylinder breathing air from a cart, a standby person must be at the cart to monitor the breathing air supply system continuously.

Fuel cell ventilation and personnel respiration system (ventilation trailer)

The ventilation trailer is a relatively new equipment item that provides rapid purging of the fuel tanks and cells during maintenance, and can supply breathing air for three fuel systems personnel. Commonly, the system is referred to as the ventilation trailer (fig. 2–24).

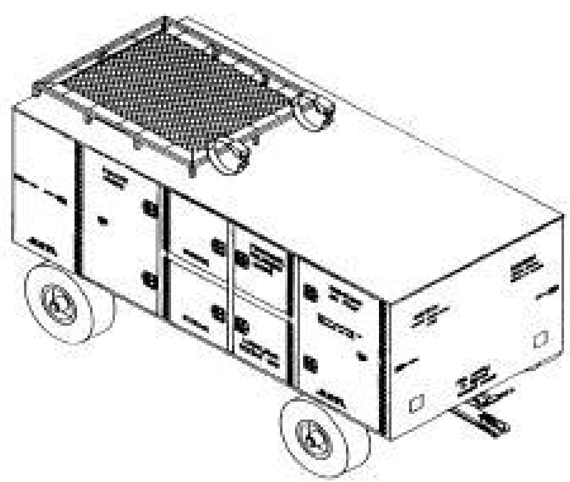


Figure 2–24. Fuel cell ventilation trailer.

Ambient breathing air pump

This equipment item is a portable, oil less, pneumatic-powered pump, which supplies low-pressure ambient air for up to three National Institute for Occupational Safety and Health-approved respirators at once (fig. 2–25). The typical breathing air pump has a manually adjusted air regulator, automatic oiler for the air motor, color-coded pressure gauge, pop-off relief valve, storage mount for detachable inlet filter snorkel, inlet dust cover, and quick-disconnect couplings and an exhaust muffler. The unit's self-contained filters permit the use of respirators without the need for additional filters.

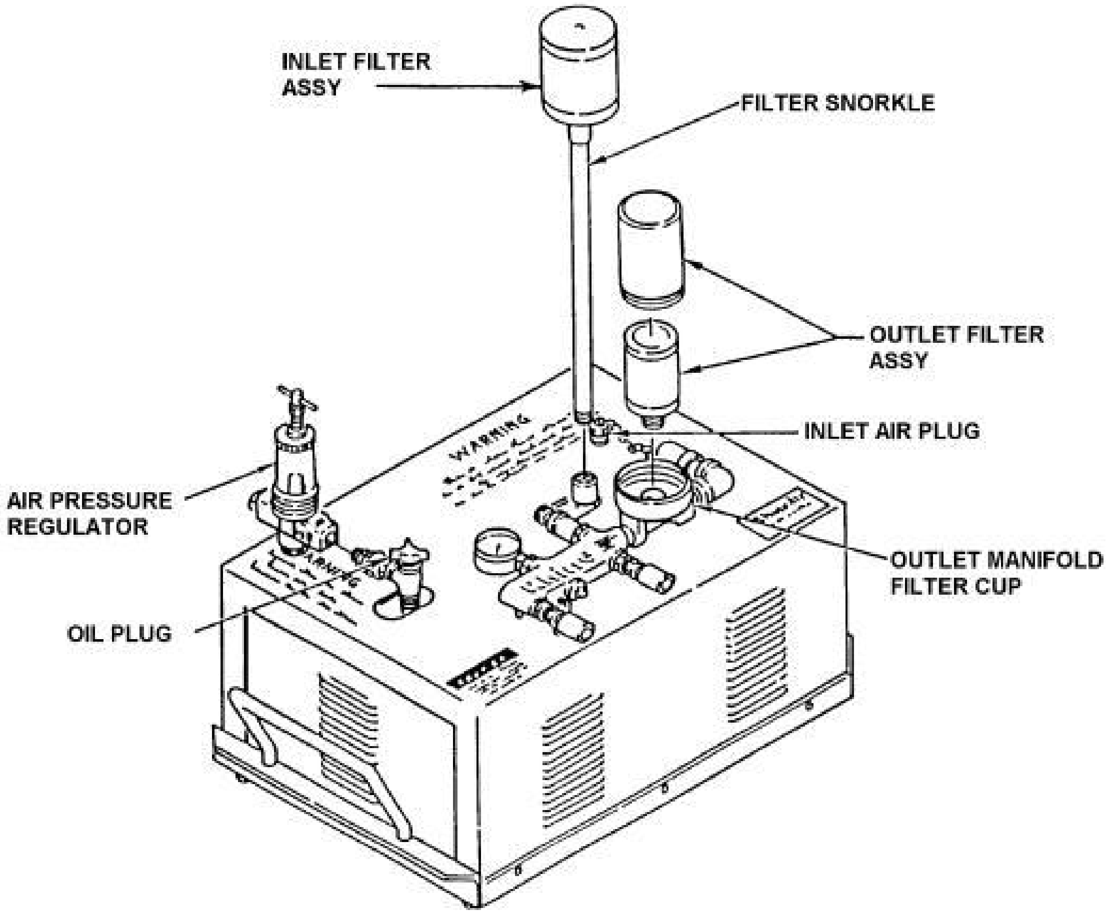


Figure 2–25. Ambient air breathing pump.

The unit draws clean air from any remote source where its air intake snorkel is located. The snorkel may be extended up to 100 feet or more from the actual location of the pump. Model NF15–3 is presently available and is used at many fuel systems shops. Several precautions must be observed when using this pump:

1. Ensure the snorkel is placed in an area free from fumes. The air from this area will be used to supply the respirators.
2. Ensure the hose length from the pump to the respirators is a minimum of 50 feet.
3. Ensure that the inside diameter of the breathing air hose is a minimum of 3/8 inch.
4. Use only class C constant flow respirator equipment with the pump. Avoid *demand type*.
5. Do not run the unit with all three air outlets closed. Be sure that at least one outlet port has the hose and respirator connected before starting the unit.
6. The inlet filter extension is the only component on the pump that can be lengthened or modified.
7. The air motor must be lubricated. Add 1/2 ounce of 10-weight oil for every day's operation. Always check the oil level before operating the unit.

Electric ambient air breathing pump

This electrical-driven breathing unit is similar to the pneumatic-driven pump except that an explosion-proof motor directly drives an oil less rotary vane pump. The unit also draws clean air from any remote source where its air intake filter snorkel is located. The precautions previously listed also apply to this unit. Model NF 23–1 is a newer version of this pump.

Hangar air

The equipment we just discussed can be used to supply breathing air at open areas or in your hangar. Some fuel shops may be equipped with hangar breathing air systems. These systems are easier to use. They should be 100 percent automated, all you need to do is plug in the breathing air hoses, run them to the aircraft, and plug in the respirator. The hangar air system should always be your first choice.

231. Operating other powered support equipment

In addition to the categories of support equipment previously covered, other equipment may also be required to support maintenance. Three of these equipment items are the nitrogen cart, the portable floodlight set, and the diesel generator.

Nitrogen cart

The nitrogen cart supplies nitrogen to a fuel system when inerting is required. Presently, there are two nitrogen carts approved for use—the MB–2 and MB–3. These carts contain various valves, pressure gauges, regulators, and safety devices, which provide a means of relieving pressure when it becomes too great. Pressures involved in the use of the nitrogen cart may reach beyond 1,000 psi, so it is important that you become familiar with the operation of the cart prior to using it. Always open valves slowly to prevent rapid pressurization of a tank or system. Also, to prevent rapid bleeding of trapped gas, disconnect the servicing hose slowly from the aircraft fitting.

Portable floodlight set (light-all)

Light-alls are mobile lighting units. Model NF–2, shown in figure 2–26, has been around for many years. The unit has two mercury vapor floodlights mounted on a tower assembly that can be adjusted with a hand crank. This set furnishes light for maintenance during hours of darkness. An alternator driven by a gasoline engine furnishes electrical power for the unit. To facilitate connection of accessory equipment (e.g., a sealant mixer or droplight), the unit is also equipped with a 110-volt alternating current (VAC) power receptacle.

Diesel generator (–86)

The typical diesel generator is a self-contained unit capable of supplying aircraft electrical outputs compatible to the aircraft systems (fig. 2–27). The purpose of the generator is to provide 400 hertz, 115/200 volt, three-phase power to an aircraft for the operation of the aircraft's electrical equipment when the onboard generators are not running. The engine, generator, and controls are designed into a compact unit mounted on a trailer.

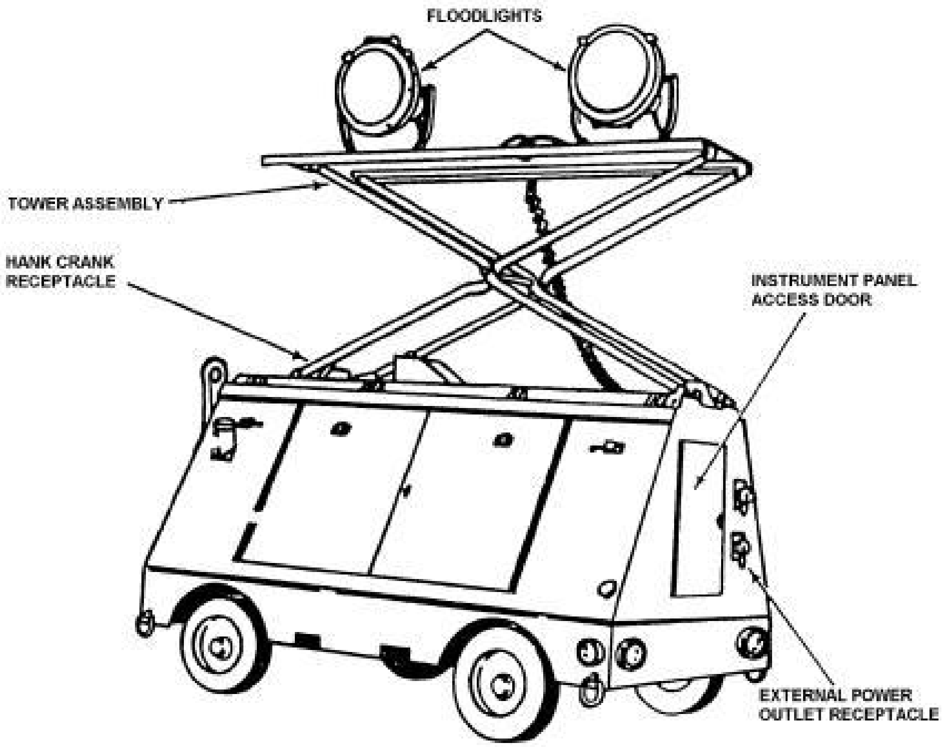


Figure 2–26. Portable floodlight set.

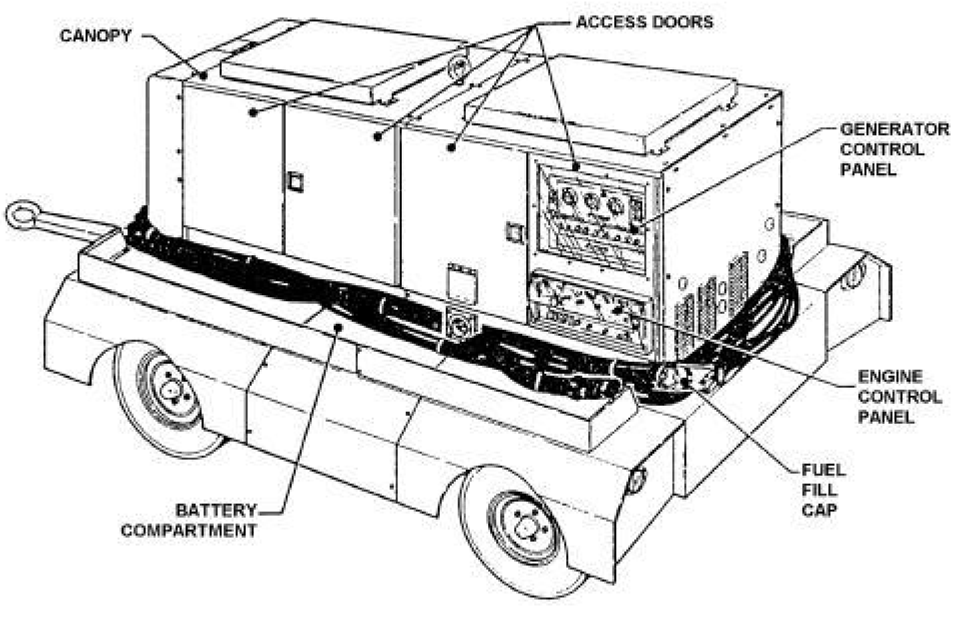


Figure 2–27. Typical diesel generator.

A/M32A–60 gas turbine generator

This gas generator, turbine-equipped generator produces high volume low-pressure air and 120/208 VAC and 28 VDC electrical power. The air may be used for starting aircraft engines. You can also connect it to another piece of equipment to provide cooling air to aircraft systems during troubleshooting or power on maintenance. When the fuel level gets low, a warning horn will sound.

This lets you know that you may be about to lose power. Remember the –60 is a jet engine on wheels, double hearing protection is required at all times.

Although there are a few different models, generators are operated in basically the same method. Push the unit to an area convenient to the aircraft and stretch the power cord out to the aircraft's external power receptacle, where you connect it. After verifying all applicable switches in the aircraft, start the motor part of the unit. When the motor is operating at sufficient rpm, start the generator. If you made the proper connections and the generator is operating correctly, a light inside the aircraft will illuminate. Always follow the specific operating instructions on the unit when operating the equipment. Two general safety precautions to observe are these: (1) *Never* attempt to push or pull the unit by yourself. It is extremely heavy and should not be moved without the proper number of people necessary to ensure safe movement. (2) *Always* wear ear protection when you are in the area of an operating generator or any loud equipment.

232. Using maintenance stands, platforms, and safety

At this point in your career, you have undoubtedly used maintenance stands of one type or another. There are several different types of maintenance stands available, depending on the type of aircraft or equipment being worked. Become familiar with the different types in order to select the proper one for each job. Let's look at the most widely used maintenance stands.

B–1 maintenance stand

A hand-operated hydraulic pump raises and lowers the B–1 stand (fig. 2–28). The platform height can be adjusted to between 3 and 10 feet. Two base locks bolted to the forward end of the frame prevent movement of the stand when the locks are in the *down* position.

B–2 maintenance stand

This maintenance stand has a stand permanently mounted on a base extension structure of fixed height (fig. 2–29). The base of the stand has four locking, pivot-type casters mounted at the corners and four adjustable, screw-type pads to level and immobilize the unit. A ladder with steel steps and handrails provides access to the upper portion of the stand. The B–2 stand is also raised and lowered using a hand-operated hydraulic pump, and has an adjustable height of 13 to 20 feet.

B–4 maintenance platform

This platform is a scissors-type, variable height platform, mounted on a caster-equipped base (fig. 2–30). Each wheel has a brake. The brake can be locked at each 90-degree position. A hydraulic actuator near the bottom of the platform varies the height of the platform from 3 to 7 feet. A reservoir with a hand pump and control valve is mounted on the platform near the ladder.

B–5 maintenance platform

This platform is similar to the B–4 platform in that it is also a scissors-type, variable-height platform (fig. 2–31). However, it is mounted on a long-legged, caster-equipped base. A hydraulic actuating cylinder near the bottom of the platform can be used to vary the height of the platform from 7 to 12 feet. A hand pump supplies pressure to the actuating cylinder. The hand pump and control valve are mounted near the top of the ladder. As a note of caution, never raise or lower this platform while standing on the ladder! You could seriously injure your feet.

Figure 2–28. B–1 maintenance stand.

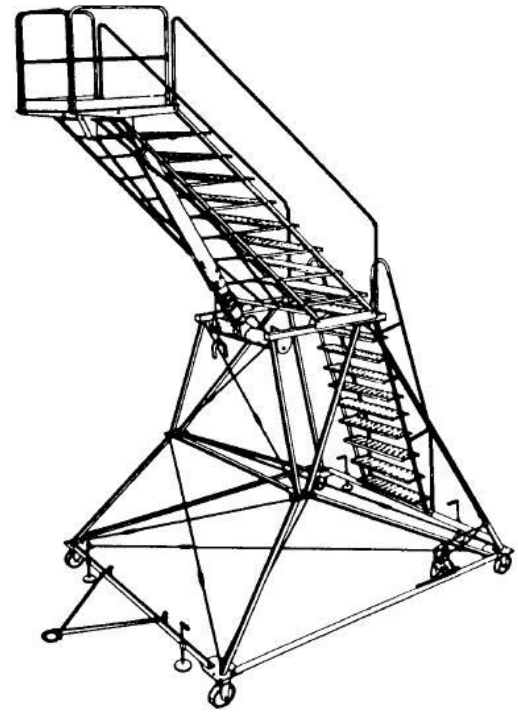


Figure 2–29. B–2 maintenance stand.

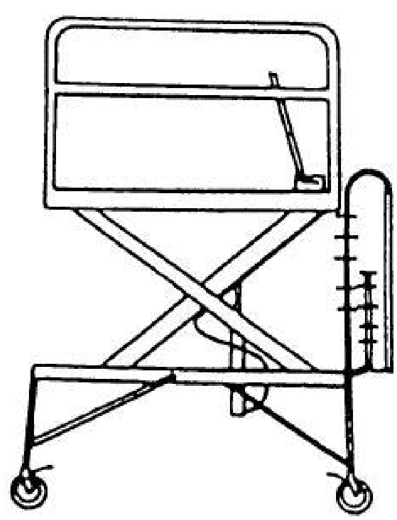


Figure 2–30. B–4 maintenance platform.

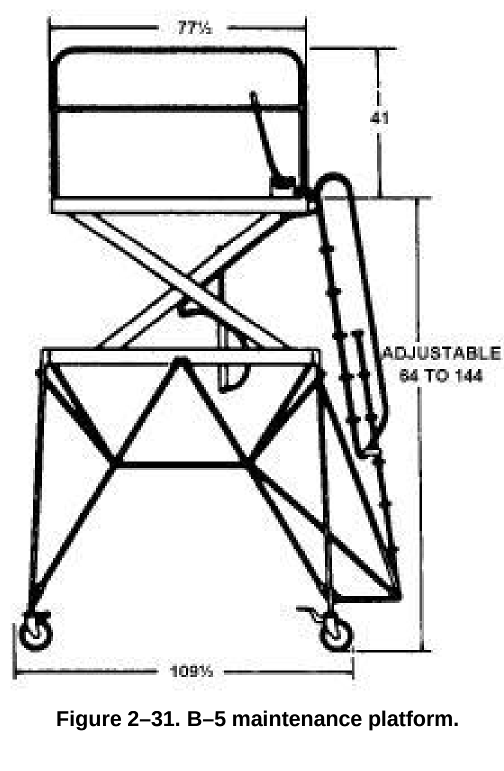


Figure 2–31. B–5 maintenance platform.

B–7–16 maintenance platform

This platform (fig. 2–32) is similar to but larger than the B–1 stand. It is raised or lowered by a hand-operated hydraulic pump. The platform provides a working surface of 4 by 7 feet and the height can be adjusted to between 7 and 15 feet. Its articulating stairs stay parallel at any height within its 7- to 15-feet platform floor range. Its fixed front and swivel rear casters offer ease in maneuverability.

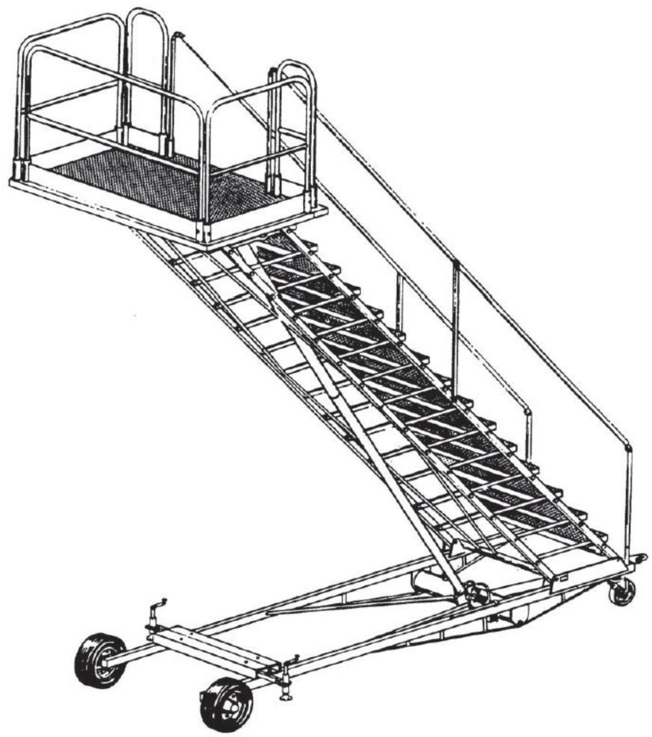


Figure 2–32. B–7–16 maintenance platform.

Maintenance stand safety

Using a maintenance stand correctly is not rocket science. However, many injuries have been caused by the improper use or disregard of safety practices related to the use of these stands. Let's look at some common safety practices that must be observed when using maintenance stands.

1. All maintenance stands are equipped with wheel locks or chocks. *Use them*! Do not assume that the stand will not move while you are working.
2. Do not try to position a large maintenance stand by yourself. Larger maintenance stands (e.g., the B–1 and B–2) are heavy and should be positioned by at least two people. There have been more than a few ground mishaps related to maintenance stands "getting away" from an individual on a windy flight line and ramming into an aircraft.
3. *Never* stand on the handrails of a maintenance stand! If the stand will not reach the area you are working, get a different stand.
4. Adjustable-platform stands have a safety feature that prevents the stand from lowering in case of a hydraulic system failure. On the B–1, B–2, and B–7–16 stands, engage a safety lock after the stand is adjusted to the required height. The safety lock is simply a lock ring assembly turned by hand, causing a cam-like assembly to insert locking fingers into groves or slots, thus locking the hydraulic cylinder. In most cases, the cylinder is painted red where the locking ring goes to indicate that the stand is locked. White indicates a locked condition; red indicates the lock is not engaged.
5. Always remove stands or platforms from under the wings of an aircraft when transferring fuel.
6. Stands maintained specifically for fuel systems maintenance should have static discharge plates made of copper, zinc, or zinc-coated material. The plate is mounted or attached to the handrail at the entrance to the stand, unless a static discharge plate already exists (as per the stand's TO). The plate is marked "PERSONNEL STATIC DISCHARGE PLATE." When

used inside the repair area, they must be bonded to the aircraft; therefore, they must have grounding/bonding reels installed on them.

These are only some of the safety precautions to observe when using a maintenance stand or platform. As with any equipment you use, keep safety a priority.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

226. Operating air compressors

1. What are the uses of air compressors used in fuel systems maintenance?

2. What unit is commonly used to supply air pressure for the operation of pneumatic tools?

3. What is the maximum pressure available from the MC–2A air compressor?

4. Briefly describe the MC–7 air compressor.

5. What are the four safety precautions discussed in the text that you always follow when using any air compressor?

227. Using the explosion-proof pneumatic vacuum

1. For what is the explosion-proof pneumatic vacuum used?

2. Which part of the vacuum is not allowed to be modified?

3. What must be done to the vacuum after use?

228. Operating heaters

1. At present, what are the two heaters authorized for use inside the fuel systems repair area?

2. What are the safety features incorporated into the HDU–13/M heater that make the unit explosion-proof?

3. For what purposes is the HDU–13/M mainly used?

4. What is the operating temperature range of the HDU–13/M?

5. How do you start the HDU–13/M if you were to use it for curing sealant inside a fuel tank?

6. What heater is not explosion proof and must remain outside the repair area?

229. Using air blowers and air conditioners

1. On the 12-inch fan, what varies the airflow output?

2. When using a pneumatic powered blower, what is the maximum pressure the unit is regulated to if it is to be used for more than three hours?

3. How would you ensure a pneumatic blower is adequately lubricated?

4. What type of air conditioners, if any, should be used inside the repair area for ventilating a fuel tank?

5. What system is installed in new facilities and can be used for purging fuel tanks?

230. Operating breathing air supply equipment

1. What equipment must be used to supply air pressure to a fuel cell/tank servicing cart?

2. What safety feature of the fuel cell/tank servicing cart supplies breathing air to workers inside a fuel tank in the event of an air compressor failure?

3. Briefly describe the ambient breathing air pump.

4. Where is the snorkel of the ambient breathing air pump placed?

5. What minimum length of air hose is required from the air pump to the respirators?

6. What is the only component on the breathing air pump that may be modified?

231. Operating other powered support equipment

1. What purpose does the nitrogen cart serve?

2. What support equipment item furnishes lighting during hours of darkness?

3. For what other purpose can the unit in the previous question be used?

4. What is the purpose of a typical diesel generator?

5. Which generator is a jet engine and requires double hearing protection?

6. How do you know if the diesel generator has been properly connected to the aircraft and is operating sufficiently to generate voltage?

232. Using maintenance stands, platforms, and safety

1. Which maintenance stand would you use if you needed the platform height to reach 3 feet?

2. Which maintenance stand has an adjustable height from 13 to 20 feet?

3. Which scissors-type maintenance platform can be adjusted from 7 to 12 feet?

4. What safety feature is used on some maintenance stands to prevent the platform from lowering in case of hydraulic system failure?

5. What items are installed on maintenance stands or platforms when they are used specifically for fuel systems maintenance?

Answers to Self-Test Questions

214

1. (1) Common.
   (2) Cross point.
   (3) Offset.
2. To prolong the life of and to prevent damage of the screw head.
3. Ball-peen and soft-faced mallet.
4. The flat striking surface is used for driving punches and chisels, and the rounded surface is used as a peening tool.
5. No; they'll damage the material.
6. (1) Diagonal-cutting.
   (2) Long-nose.
   (3) Slip-joint.
7. (1) Diagonal-cutting pliers—Cut safety wire and remove cotter pins.
   (2) Long-nose pliers—Reach where the fingers cannot and bend small pieces of metal.
   (3) Slip-joint pliers—Grip wires and bend small pieces of metal.
8. (1) Center punch—Makes small depressions in metal prior to drilling a hole.
   (2) Prick punch—Establishes location points and scribing mark on metal surfaces.
   (3) Starting punch—Loosens tight-fitting pins.
   (4) Drift punch—Loosens tight-fitting pins and aligns holes in two pieces of metal.
   (5) Pin punch—Drives out rivets that have the heads drilled off and drives pins out of holes that are too deep for a starting or drift punch.
9. A drift punch or starting punch.
10. (1) Open-end.
    (2) Adjustable-jaw.
    (3) Box-end.
    (4) Socket.
    (5) Allen wrenches,
11. Spanner wrench.

215

1. Use tool-carrying bags.
2. Coat tools with lubricant.
3. Turn it in for replacement.
4. Clean with an approved-cleaning solvent.

216

1. Keep the nut or screw turning with a steady sweep of the wrench until the specified torque is reached. To retorque a screw or nut, back off the screw or nut so that less-than-specified torque is required to start it turning in the proper direction. Continue the motion until the proper torque is reached.
2. The T-handle type.
3. Divide the inch-pounds by 12.

4. The predetermined torque will be affected.

217

1. Mark the area to be drilled using a center punch.
2. Impact wrenches.
3. Never use an impact wrench to apply final torque.
4. Sharpening tools, fabricating sealant scrapers, and grinding drill bits.
5. Tap the wheel with a plastic or rubber mallet; a ringing sound will indicate a good wheel.
6. (1) Ensure that the work rests are in place and correctly adjusted.
   (2) Never use a grinder if the wheel guards are missing.
7. It is used to buff lightweight fuel cells, and for final buffing work on a fuel cell patch. A heavier buffer is also made for fitting flange repairs and buffing self-sealing cells.

218

1. To inject two-part sealant into voids, channels, and other areas where a higher pressure is required than can be furnished by the filleting gun.
2. 50 to 1.
3. Clean after each use, before the sealant cures, with cleaner rods the same size as the tip orifice using cleaning solvent.
4. To relieve the pressure between the structural members of the aircraft to prevent damage.

219

1. To apply fillet seals.
2. The size of the nozzle orifice.

220

1. To inject one-part sealant into channels under the wing skin.
2. Put one-part sealant into the barrel with a spatula while keeping trapped air and foreign matter to a minimum, adjust regulator to the correct air pressure (air pressure pushes sealant into path of piston travel), push the trigger and the piston will move forward and force sealant out of the nozzle.
3. The high air pressure could damage the airframe or cause the gun assembly to explode while you are operating it.

221

1. (1) Do not abuse air hoses.
   (2) Operate air pressure with the limitation of the tool specifications.
   (3) Keep compressed air free of all foreign matter and moisture.
   (4) Prevent static electricity buildup on tools and personnel.
2. Because dirt will be carried into the fuel tank if the hose has to be taken inside the tank.
3. Bond the pneumatic tool and make frequent use of the personnel-static-discharge plate.

222

1. NFPA–70 Class 1, Division 1, hazardous areas.
2. Keep the fuel from dispersing/spreading out.
3. Because it could cause corrosion or damage to the aircraft structure.

223

1. It provides a means of relieving excess positive or negative fuel tank pressure, and it is used as a pressure gauge.
2. Because the fuel tank could be over pressurized and cause damage to the aircraft.
3. (a) Obstructions in the positive and negative connections.
   (b) Obstructions in manometer hose.

(c) Fluid level of manometer.

(d) Maximum pressure used.

(e) Length of the plastic tube.

224

1. PID.
2. Press the MODE button.
3. At the end of the warm up sequence.
4. For sixty seconds, plus one second for every foot of hose used.
5. The calibration date.

225

1. To identify the integrity of electrical connections by measuring and displaying small values of resistance (less than 2 ohms).
2. Yes; because the meter is intrinsically safe.
3. The set consisting of a probe on one end and a clamp on the other.
4. The TEST button.
5. A built-in timer automatically shuts off the display after 52 seconds of operation.

226

1. Operation of pneumatic tools, blowers, and pumps, as well as for the ground-checking and servicing some aircraft.
2. MC–2A (low-pac).
3. 200 psi.
4. It is a diesel engine-driven rotary air compressor, which is capable of producing 125 cfm of airflow at a maximum of 100 psi.
5. (1) Keep the housing side doors closed during operation.
   (2) Follow operating instructions on the unit.
   (3) Set the parking brake.
   (4) Wear ear protection when the unit is operating.

227

1. For depuddling residual fuel that will not drain during normal drain procedures.
2. The hose.
3. It needs to be emptied.

228

1. HDU–13/M heater and the RCD.
2. Exterior panels are made of non-sparking aluminum, the electrical circuitry is encased in an explosion-proof steel box, and the heater is completely sealed, making it explosion-proof.
3. To provide heated air or ventilating air for purging fuel tanks or cells and to cure sealants and coatings.
4. 40 to 200°F.
5. Hold both the blower start switch and the heater start switch for 4 seconds, and then press the heater start switch a second time.
6. HDU–43, new generation heater.

229

1. A regulator on the fan.
2. 22 psi.
3. Add 1/2 ounce of 10-weight oil after every day’s use.
4. Air conditioners are not explosion-proof and are not authorized inside the repair area.

5. Climate control unit.

230

1. An air compressor, such as an MC–1A or MC–7.
2. An emergency breathing air supply bottle incorporated in the servicing cart.
3. It is a portable, oil less, pneumatic-powered pump that supplies low-pressure ambient air for up to three respirators at once.
4. In a fresh air area free from fumes.
5. 50 feet.
6. The inlet filter extension.

231

1. Supplies nitrogen to a fuel system when inerting is required.
2. Portable floodlight set (light-all).
3. As a power source for equipment such as a sealant mixer or droplight.
4. To provide 400 hertz, 115/200 volt, three-phase power to an aircraft for the operation of the aircraft's electrical equipment when the onboard generators are not running
5. The A/M32A–60 gas turbine generator.
6. An indicator light inside the aircraft illuminates.

232

1. B–1 stand.
2. B–2 stand.
3. B–5 stand.
4. A safety lock.
5. Static discharge plates and bonding wire reels.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

Please read the unit menu for unit 3 and continue ➔

Unit 3. Fuel Systems—Electrical

IN THIS UNIT, we will cover some basic fundamentals of electricity. We will look at the functions and components of a circuit, and the procedures for interpreting a fuel systems schematic. We will also look at the use of test equipment for conducting voltage and resistance checks. Our objective is not to make you an electrical expert; however, we want to provide you with enough information to be able to use test equipment and an electrical schematic to check for voltage or resistance at various points in a fuel systems circuit.

3–1. Basic Circuits and Components

To give you the information you need to build a foundation for understanding a basic circuit and its components, we will cover the following two major subject areas:

- Elements of an electrical circuit.
- The characteristics and parts of a circuit.

233. Elements, characteristics, and parts of an electrical circuit

The foundation of any electrical system is the circuit. In this lesson, we build on that premise and provide you with the basic information you need to work with the electrical portions of the fuel systems you are responsible for maintaining. The subjects we cover are numerous and varied.

Definition of a circuit

A circuit is a complete and continuous path for current to flow. In order to be considered a circuit, the following three conditions must be present:

- A power source.
- Connecting wires or conductors.
- A device, often called a load, which uses the energy provided by the source to accomplish some purpose.

Electrical flow requirements

Before electricity will flow in a circuit, the following three things must exist:

- Current.
- Voltage.
- Resistance.

Current

Current is the flow of electrons through a conductor (flow of electricity). The ampere is the most commonly used unit of measurement for current.

Voltage

To establish a current flow, there must be some form of external force to push the electrons. This external force is called electromotive force or voltage. Voltage is simply a difference of potential between two points in the circuit. The standard unit of measurement for voltage is the volt. One volt is defined as the force required to push one ampere of current past a given point in one second. A battery or a generator provides voltage to an aircraft electrical system.

Resistance

Resistance is defined as the opposition to current flow. The unit of measurement for resistance is the ohm. The resistance of a conductor is usually too small to control the current in a circuit so a resistor is added to the circuit. A resistor is simply a device used to control current.

Circuit characteristics

A circuit may have as few as three or as many as thousands of components to make it work. Remember, we said a circuit is a complete and continuous path for current flow. We also said a circuit must have a power source, connecting wires or conductors, and a load device to use the energy. If you were to connect a battery, a light bulb, and some wires together, the bulb would stay lit and you would have a circuit. These three parts represent the three essential functions of any circuit—power source, conductor, and load device (resistor). Without one of these three, the circuit would not exist.

Basic functions of the circuit parts

A circuit has five basic parts/functions:

- Power source.
- Load device (resistance).
- Conductor.
- Control device.
- Protective device.

Power source

A power source supplies voltage to the circuit. This source could be an aircraft battery, generator, or external power unit. Remember, voltage is the force or pressure that causes electrons to flow (current flow) in a circuit. The aircraft electrical system uses both alternating current (AC) and direct current (DC) voltages.

Load device (resistance)

A load device is one that uses current to perform a function. This can be a motor on a shutoff valve, a light bulb, a resistor, or any other component that performs a function in the circuit. You now have a power source and a component to use that power, but how do you get the power routed to the component?

Conductor

A conductor forms a path through which current flows. Of course, the most common conductor is the wire. A ground is also considered a conductor. Multiple grounds are used extensively on aircraft in an effort to reduce weight. The aircraft chassis (frame) often serves as this multiple ground location.

At this point, you have enough components to make a circuit. However, you cannot turn the circuit on or off. To do this, another part or function is needed.

Control device

A control device, as the name implies, controls the operation of the circuit. Without a control device, the circuit would continuously be in operation. Control devices may be manually or electrically operated by either a switch or relay. Probably the most common types of switches are manually operated toggle switches.

It now appears that you have all the parts necessary for an aircraft circuit. No! There is nothing to protect the circuit from overloading.

Protective device

A protective device protects the circuit against excessive current flow. Two types of protective devices are the fuse and circuit breaker. However, like modern homes, fuses are steadily being replaced by circuit breakers, and it is unlikely that you will find any fuses on any aircraft today. An exception to this would be a thermal fuse in a component such as a boost pump.

Electrical system components

The five parts or functions we just discussed can be found in any aircraft electrical circuit. Most components in a circuit fall under one or more of those functions. Now let’s look at the following seven frequently used electrical system components:

- Resistors.
- Relays.
- Solenoids.
- Toggle switches.
- Circuit breakers.
- Diodes.
- Cannon plugs.

Resistors

Figure 3–1 illustrates the most common electrical symbols you may encounter on the job. The symbol for the resister is in the lower right-hand corner of the figure. A resistor is one type of device that can be used to control current flow in a circuit. In this manner, a resistor can be considered a protective device or a load device. Resistors can be constructed by using many turns of fine wire or by using carbon compounds. You will encounter the following two types of resistors: fixed and adjustable (variable).

Fixed resistors

Fixed resistors are constructed so that the resistance value will not change drastically under normal operating conditions.

Adjustable resistors

Adjustable resistors, sometimes called rheostats or potentiometers, are placed in circuits where there is a need to vary or change the resistance in the circuit. Have you ever seen a dimmer-type light switch in a house? This is an example of an adjustable resistor. The switch adjusts the brightness of the light in the circuit. Resistors have a color code stamped or stenciled on the body that identifies their value.

Diodes

A diode is a solid-state component that allows current to flow through it in only one direction. It is often used to change AC to DC electrically. Symbols for a unidirectional and Zener diode are shown on the lower right-hand corner of figure 3–1. Current always flows against the direction of the arrow shown on the symbol.

Circuit breakers

The electrical symbols for circuit breakers are illustrated in the upper left-hand portion of figure 3–1. These devices protect a circuit from excessive current flow. Normally, circuit breakers are rated above the component/circuit they are protecting. This means if a shutoff valve is designed to use 3 amperes of electrical current for normal operation, the circuit will have a 5-ampere circuit breaker installed. If the valve motor is weak, it will draw more current in order to operate. If the circuit used more than 5 amperes, the breaker would open (pop) to protect the shutoff valve and the rest of the circuit from excessive damage.

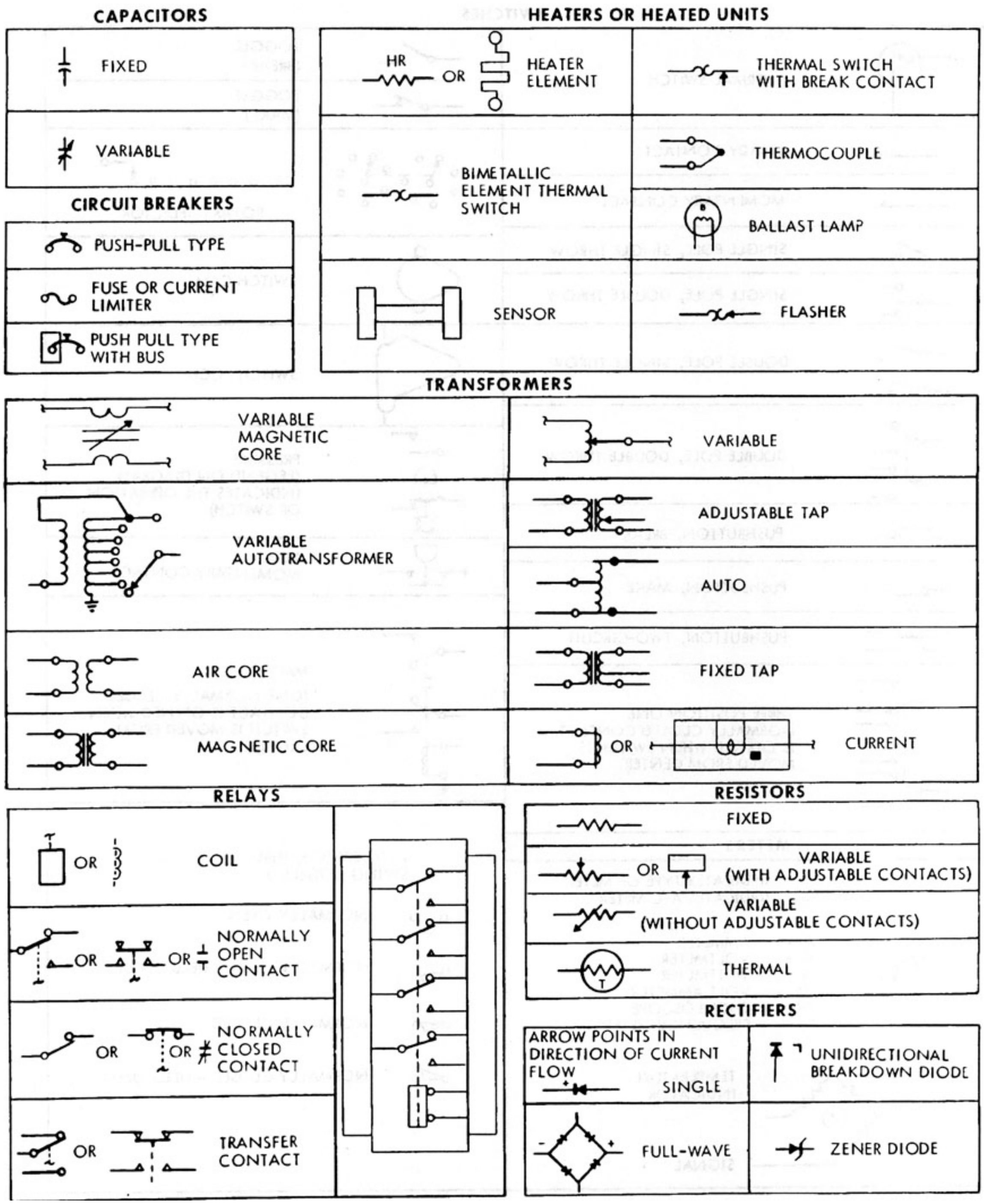


Figure 3–1. Typical electrical systems.

Relays

A relay is an electrically operated switch that normally opens or closes a circuit with contacts. A schematic illustration is shown on figure 3–1. The operation of a relay is based on electromagnetic principles. When power is applied to the coil, an electromagnetic field attracts the movable armature and pulls it toward the coil. When the armature moves, the contacts either open or close.

Some relays are constructed so that specific contacts will open while others will close at the same time. The schematic diagram containing the relays normally shows the position of each contact with the circuit de-energized. When power is applied to the circuit, the contacts will change positions.

Contacts are classified as either normally open or normally closed. Figure 3–1 shows the schematic symbol of both types.

Solenoids

Solenoids are constructed in the same manner as relays. In a solenoid, the armature is drawn into the center of the core. The armature is attached to contacts that either open or close. The most common use of solenoids is as a means of manually controlling a fuel level control valve. In other applications, a solenoid may be used to open or close a shutoff valve or, through a mechanical linkage, perform some other mechanical function.

Toggle switches

Toggle switches fall into several categories. The “poles” and “throws” of the switch identify them. Figure 3–2 illustrates the following four common examples:

- A single-pole, single-throw (SPST) toggle switch can complete only one electrical circuit.
- A single-pole, double-throw (SPDT) switch can complete two individual circuits but only one circuit at a time.
- A double-pole, single-throw (DPST) switch can complete two individual circuits at the same time.
- A double-pole, double-throw (DPDT) switch can complete four individual circuits but only two circuits at a time.

Some toggle switches have a spring-loaded positioning mechanism that places the switch to a normally OFF position. This would be an SPST-type switch and would have to be held to the ON position.

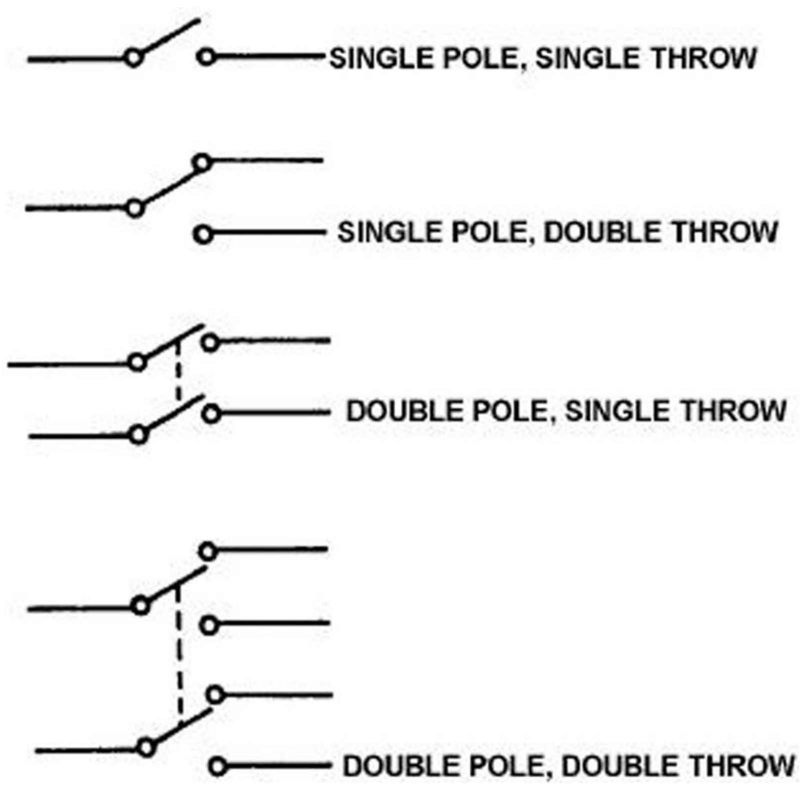


Figure 3–2. Toggle switches.

Cannon plugs

Many types of electrical connectors are used on aircraft systems. One of the most common types is the cannon plug. In essence, a cannon plug provides a means of quickly connecting and disconnecting wires to simplify installation and maintenance. Several illustrations of the parts of a cannon plug are shown in figure 3–3). As you can see, the cannon plug consists of two parts—a plug assembly and a receptacle assembly. Together, they form a cannon plug set. Usually, the receptacle assembly is the fixed part of the cannon plug. As such, it is attached to bulkheads or on a component usually. The plug is the removable part of the connector, which is usually attached to the wires. When the two parts are joined, an electrical circuit is completed.

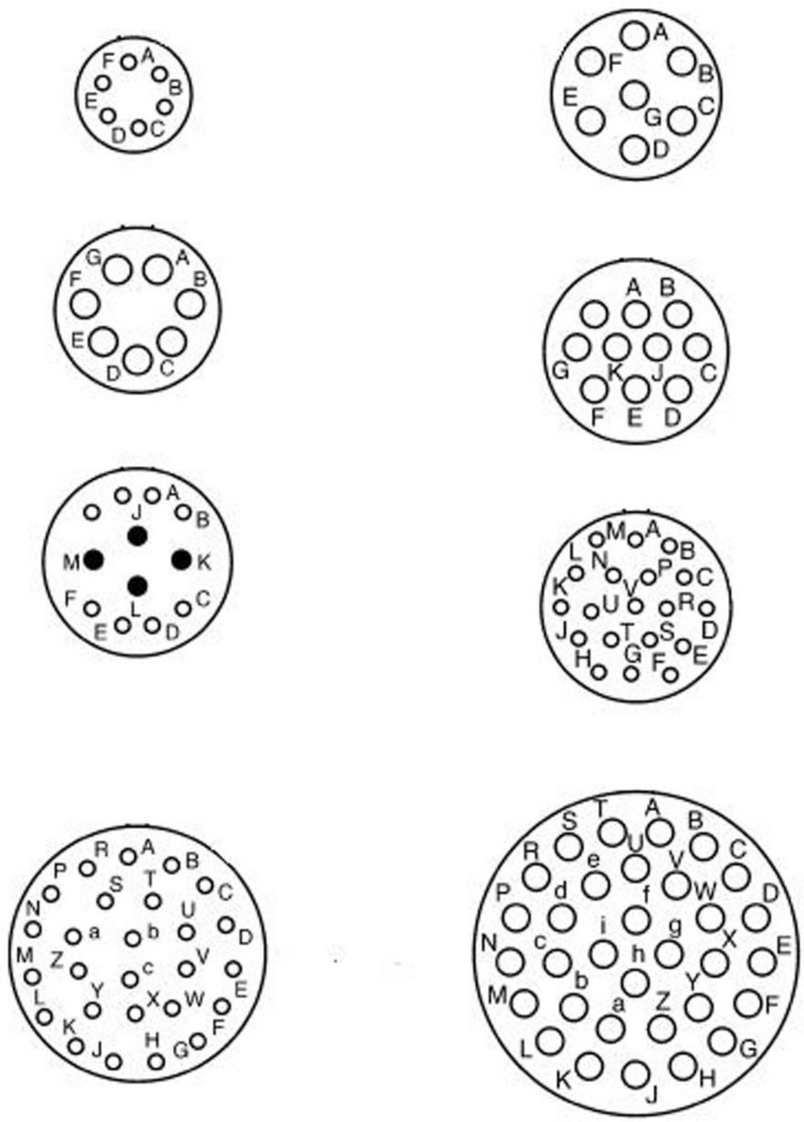


Figure 3–3. Typical cannon plug assembly.

Usually, the pins of a cannon plug are marked with letters, starting alphabetically with capital letters, then alphabetically with small, or lowercase, letters; and if there are more pins after going through the alphabet, they are marked with double capital letters. The exceptions are the letters I, O, and Q. These are not used because they are hard to identify. As shown in figure 3–3, the letter A starts just below the key or slot, and the rest follows in alphabetical order, going clockwise on the outside row, then second row, and so forth.

On an electrical diagram, cannon plugs are identified as shown in figure 3–4 and will list only the letters that you need to know. The small numbers under or above the cannon plug are identification numbers. These numbers are listed in the applicable electrical TO for the aircraft, which tells you the location of the cannon plug.

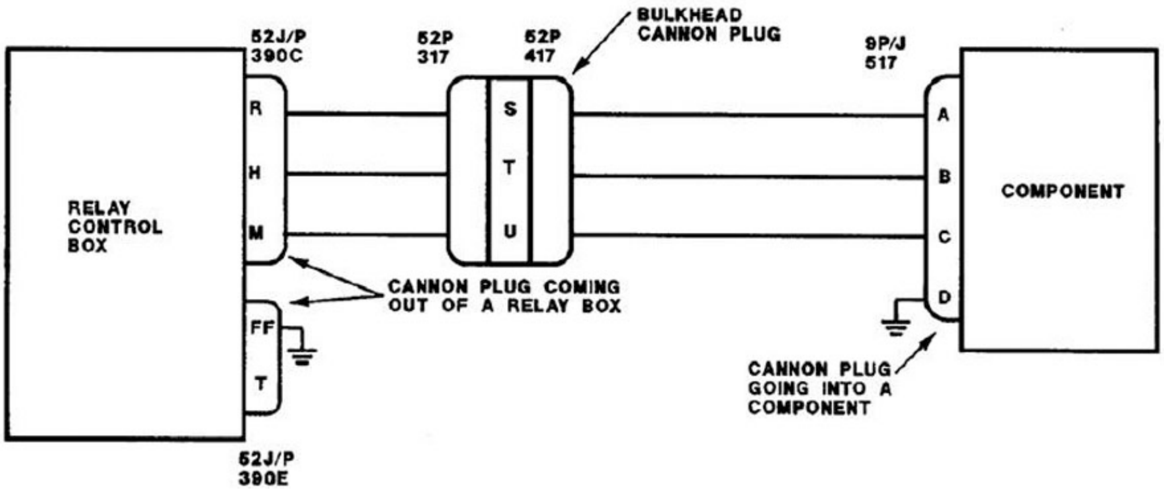


Figure 3–4. Basic cannon plug electrical schematic.

234. Operating a multimeter

The multimeter is a versatile and useful piece of test equipment that can be invaluable in electrical troubleshooting, if used properly. As you would expect, there are several styles of multimeters; however, they all have the same basic functions. For the troubleshooting, you will perform as a fuel systems mechanic, and a basic digital multimeter will more than satisfy your needs.

Multimeter controls and displays

Figure 3–5 shows a typical digital multimeter. As you can see, all controls and connectors are located on the front of the meter beneath the display. The function selector rotary switch in the center of the unit is used to select various measurement functions. The display window consists of these four functional areas:

- Digital display.
- Annunciators.
- Bar graph display.
- Range indicator.

Digital display

There are three full decimal digits, a partial leading digit, a minus sign, and three decimal points in the digital display. The decimal point is positioned automatically for each measurement range. If the circuit being measured is higher than the highest range selected, the display indicates an overload condition by displaying the letters OL.

Annunciators

An annunciator is nothing more than a visual signal that indicates something. The multimeter uses several display annunciators to distinguish between ohms, kilohms (1,000 ohms), and megohms (1 million ohms) in the ohms function, depending on the circuit being measured. The annunciators also provide information about battery condition and operating mode.

TYPICAL DIGITAL MULTIMETER

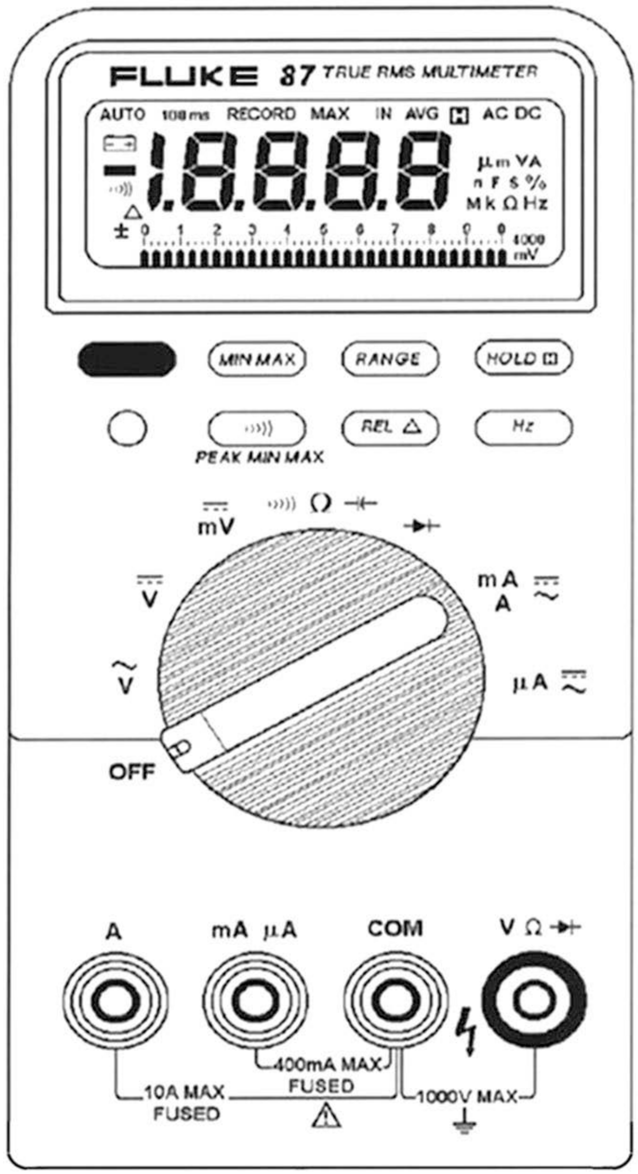


Figure 3–5. Typical digital multimeter.

Bar graph

The analog bar graph is located just below the digital display. The bar graph display consists of a 31-segment bar graph that indicates the absolute value of the measurement by displaying successive segments. The bar graph is updated 10 times as often as the digital display. If an overrange condition occurs, the bar graph will display all segments plus an overrange arrow.

Range indicator

A 4, 40, or 400 range indicator is displayed just below the decimal point to remind you which range you are using. Remember, the number shown on the range indicator is the *maximum* voltage or current you can measure without causing an overload.

RANGE button

The meter is turned on when it is switched to any position other than one of the two OFF positions and is automatically in the auto-range mode. When in the auto-range mode, the meter's internal circuits will automatically select the range based on the circuit being measured. If you need to use the manual-range mode, simply depress the RANGE button. The meter will then switch to manual-range mode. To switch back to the auto-range mode, depress and hold the RANGE button for approximately two seconds.

HOLD button

The HOLD button initiates the touch-hold mode. Sometimes, when taking measurements, the reading will fluctuate. This mode allows you to take measurements in a circuit that is difficult, delicate, or hazardous to reach without taking your eyes off the test leads. When a stable measurement is displayed, a beeper will sound, and the measurement will hold until the HOLD button is depressed and held for approximately two seconds.

Measurement techniques

Most of the time, you will use the multimeter to take two measurements:

- Voltage checks (AC voltage and DC voltage).
- Resistance checks.

In addition to making these two checks, you must also ensure you use the instrument safely.

Voltage checks

Before taking any voltage measurements, ensure the meter is set on the correct voltage (AC or DC) for the circuit being checked. The meter test leads must be placed in parallel with the circuit being measured. Figure 3–6 illustrates the proper meter connection for voltage checks. You must also ensure that the positive (red) test lead is connected to the positive side of the circuit and the negative (black) lead to the negative side or to ground.

Resistance checks

Probably the most important thing to remember about taking resistance (continuity) checks is *NOT* to have power applied to the circuit. The meter must be set to the ohms function, and the test leads must be connected in parallel to the component being checked (fig. 3–6).

Multimeter safety

Today’s digital multimeters are designed for safe, dependable operation when used properly. The following safe practices and procedures should be followed when using a multimeter.

- Use only test leads that have shrouded connectors and finger guards.
- Remove all jewelry before working around electrical equipment.
- Disconnect the positive test lead before disconnecting the common (negative) test lead.
- When possible, use only one hand to take measurements.
- Follow all electrical system technical data safety procedures.
- Ensure the circuit to be tested does not exceed the meter’s limitations.
- Avoid working alone.

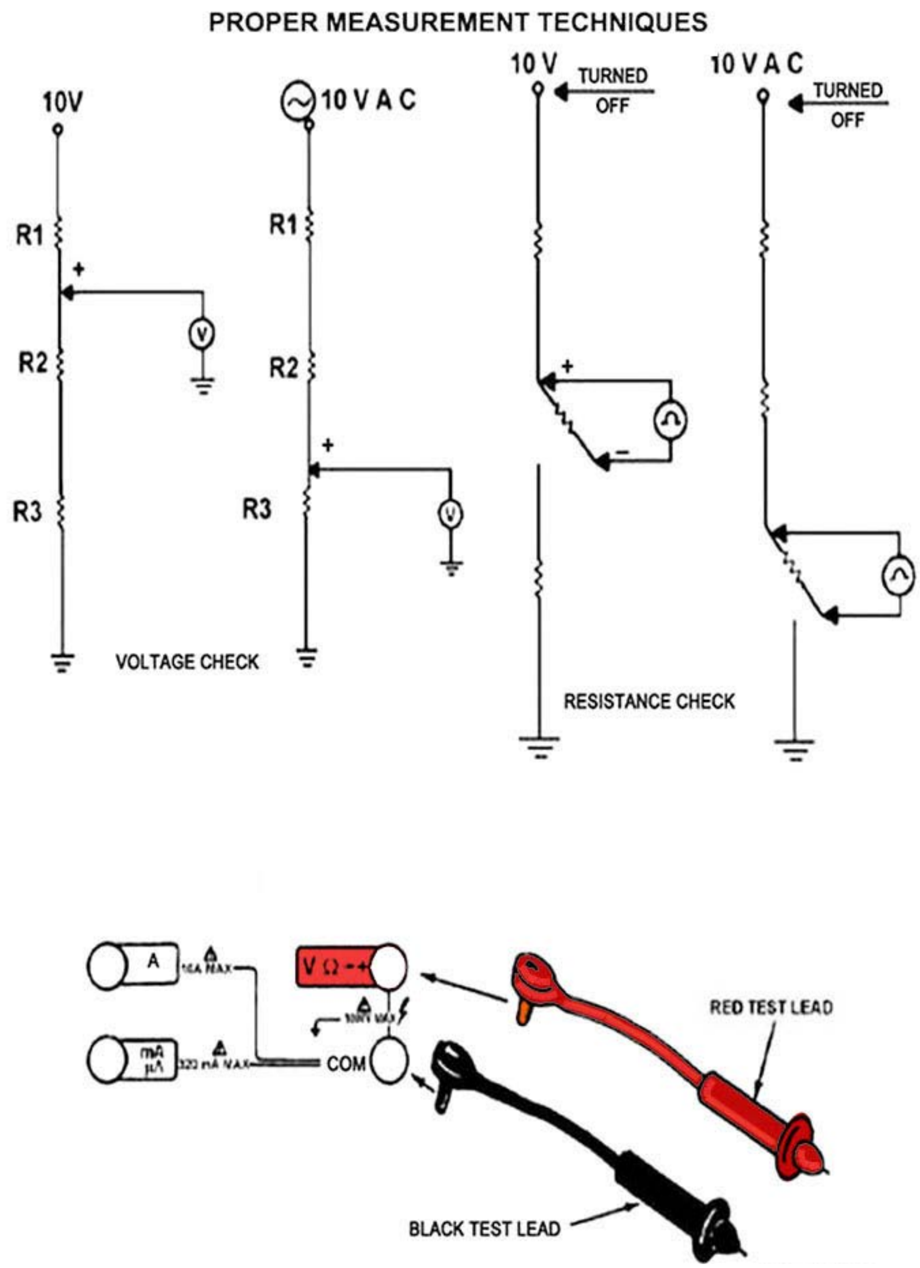


Figure 3–6. Proper measurement techniques.

235. Using a multimeter to check for continuity and power

The process of troubleshooting a fuel systems electrical malfunction differs with each model of aircraft. While some of the older aircraft may only have a section of the maintenance manual devoted to troubleshooting, aircraft that are more modern require a separate fault isolation manual designed specifically for troubleshooting. Regardless of the type of aircraft, you must always use the correct technical data (fault isolation manuals) to assist you in isolating a malfunction. Not using this technical data will likely result in wasted time and effort.

With these thoughts in mind, let’s look at the troubleshooting process for a malfunction on a typical cargo aircraft. The problem is that the number 4 main tank outboard boost pump appears to be inoperative. From your knowledge of fuel systems electrical circuits, you know that the problem could be the pump element itself, a bad cannon plug connector, bad relay, bad switch, open circuit breaker, or faulty wiring. Upon looking up the malfunction in the applicable fault isolation manual, you are directed to locate the appropriate fault isolation diagram. Refer to the fault isolation diagram during this lesson (fig. 3–7).

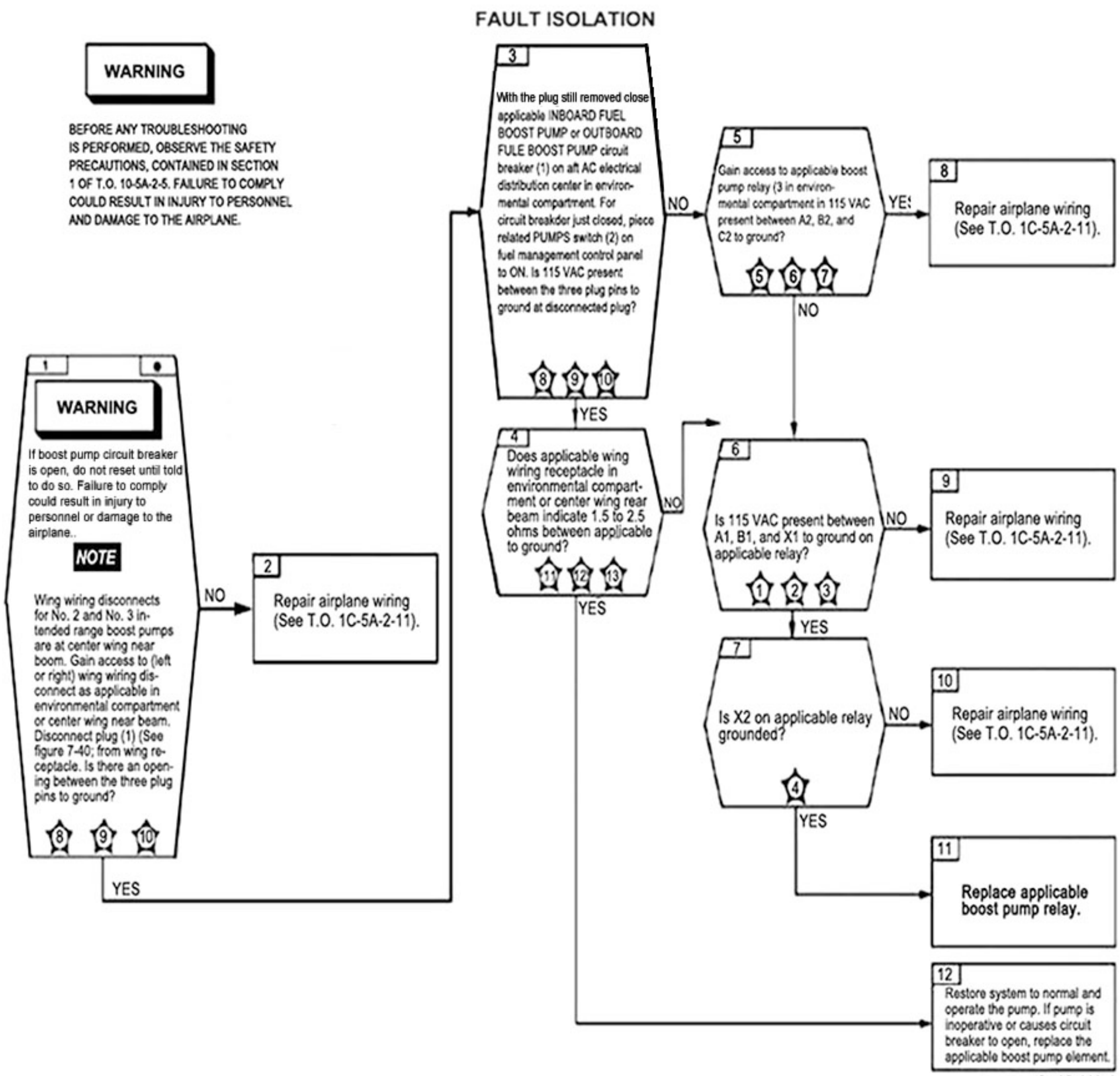


Figure 3–7. Fault isolation.

The first thing you would do upon locating this diagram is READ THE WARNINGS! We will be checking the circuit with NO POWER applied. Starting at block 1 on the far left side of the diagram, the instructions in block 1 tell you to locate the applicable wing wiring disconnect, and disconnect the cannon plug from the wing receptacle.

Next, set the multimeter function to the ohms function for resistance checks and take a measurement between each of the three cannon plug pins and ground. There should be an open indicated at all three pins since power is removed from the circuit and all switches are in the OFF positions. If continuity is found between any or all pins on the cannon plug and ground, the answer to the question in block 1 is NO. You would then proceed to block 2, which directs you to repair the aircraft wiring. At this point, you would need an electrician’s assistance.

If, however, an open is found between all pins and ground, you would proceed to block 3 as directed by the diagram. The fact that an open exists at this point in the circuit indicates that it is safe to apply power.

Following the instructions in block 3, you will now be checking the circuit with power applied. The instructions tell you to leave the cannon plug disconnected and close (reset) the applicable circuit breaker. You are then to place the applicable PUMPS switch to ON.

Now, set the multimeter to the AC voltage function setting ensuring the red test lead is plugged into the red VOLTS/OHMS jack and the black lead is plugged into the COM (common) jack. Locate the ground pin on the cannon plug and place the black test lead on the pin. Holding the black test lead on the ground pin, place the red test lead on each of the other three pins being checked for AC voltage.

If 115 VAC is present, the answer to the question is YES, and you would proceed down to block 4 and follow the instructions there. If the answer were NO, you would proceed to block 5.

Let’s say that you checked the pins and found that not all pins had 115 VAC present. Moving to block 5, you are to gain access to the applicable pump relay and again check for 115 VAC between ground and pins A2, B2, and C2. If the answer were NO, you would go to block 8, which again instructs you to repair wiring. However, we will simulate an answer of YES.

Move down to block 6, which instructs you to check for 115 VAC between ground and contacts A1, B1, and X1 on the relay. Let’s say that 115 VAC was present at all contacts. Since the answer is YES, move down to block 7. If the answer to this question is also YES, go to block 11, which instructs you to replace the relay.

As you can see, much of the guesswork of troubleshooting an electrical malfunction has been eliminated by the procedures in the fault isolation diagram. The same basic procedures and diagrams are used to troubleshoot malfunctions on most aircraft.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

233. Elements, characteristics, and parts of an electrical circuit

1. What is a circuit?

2. Define “current.”

3. What term is defined as the force required to push one ampere of current past a given point in one second?

4. What term is defined as the opposition to current flow?

5. List the five basic parts/functions of a circuit.

6. List three potential power sources for an aircraft electrical circuit.

7. Match the component in column A with its function in a circuit in column B. Items in column B may be used more than once.

Column A	*Column B*
____ (1) Light bulb.	a. Power source.
____ (2) Toggle switch.	b. Load device.
____ (3) Battery.	c. Conductor.
____ (4) Motor.	d. Control device.
____ (5) Fuse.	e. Protective device.
____ (6) Ground.	
____ (7) External power unit.	
____ (8) Circuit breaker.	
____ (9) Generator.	
____ (10) Wire.	
____ (11) Relay.	

8. How many different types of resistors are there? Name them.

9. What component in a circuit allows current to flow through it in only one direction?

10. What component, used in a circuit, protects the circuit from excessive current flow?

11. Explain the basic operating principle of a relay.

12. What is the most common use of solenoids in a fuel systems electrical circuit?

13. What type of toggle switch can complete two individual electrical circuits, but only one circuit at a time?

14. What is the purpose of cannon plugs?

15. How are the pins marked on cannon plugs?

234. Operating a multimeter

1. Name the four functional areas of the typical digital multimeter.

2. What should the meter indicate if the circuit being measured is higher than the range selected?

3. What part of the multimeter provides information about battery condition and operating mode?

4. In which position must the multimeter be placed to turn the meter on?

5. How is the auto-range mode selected?

6. How are the meter test leads connected in the circuit when measuring voltage?

7. What is the most important thing to remember when measuring resistance in a circuit?

235. Using a multimeter to check for continuity and power

1. Regardless of the type of aircraft, what must you always use to troubleshoot an aircraft electrical system malfunction?

2. What function would you set your multimeter to when taking a resistance reading as part of the troubleshooting process?

3. Explain how you would connect the multimeter test leads when checking the pins of a cannon plug for AC power.

Answers to Self-Test Questions

233

1. A complete and continuous path for current flow.
2. The flow of electrons through a conductor.
3. A volt.

4. Resistance.
5. (1) Power source.
   (2) Load device (resistance).
   (3) Conductor.
   (4) Control device.
   (5) Protective device.
6. (1) Battery.
   (2) External power unit.
   (3) Generator.
7. (1) b.
   (2) d.
   (3) a.
   (4) b.
   (5) e.
   (6) c.
   (7) a.
   (8) e.
   (9) a.
   (10) c.
   (11) d.
8. Two—fixed and adjustable.
9. Diode.
10. Circuit breaker.
11. When power is applied to the coil, an electromagnetic field attracts the moveable armature and pulls it toward the coil. When the armature moves, the contacts either open or close.
12. To manually control a fuel level control valve.
13. SPDT switch.
14. They provide a means of quickly connecting and disconnecting wires to simplify installation and maintenance.
15. With letters, starting alphabetically with capital letters, then alphabetically with small, or lowercase, letters; and if there are more pins after going through the alphabet, they are marked with double capital letters. The letter A starts just below the key or slot; the rest will follow in alphabetical order, going clockwise on the outside row first, then the second row, and so forth.

234

1. (1) Digital display.
   (2) Annunciators.
   (3) Bar graph display.
   (4) Range indicator.
2. OL (overload).
3. The annunciators.
4. Any position other than any of the two OFF positions.
5. It automatically defaults to the auto-range mode when the meter is turned on.
6. They must be placed in parallel with the circuit being measured.
7. Ensure power is NOT applied to the circuit.

235

1. Technical data.

2. To the ohms (Ω) function.
3. Set the multimeter to the AC voltage function setting, ensure the red test lead is plugged into the red VOLTS/OHMS jack and the black lead is plugged into the COM (common) jack. Locate the ground pin on the cannon plug and place the black test lead on the pin. Holding the black test lead on the ground pin, place the red test lead on each of the other pins being checked for AC voltage.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

Please read the unit menu for unit 4 and continue ➔

Unit 4. Preparation for Fuel Tank Entry

A VAST MAJORITY OF aircraft fuel systems maintenance requires entry into fuel tanks or cells. Therefore, you should be thoroughly familiar with the proper preparation requirements for a fuel tank entry. The aircraft must be placed in a location where it is safe to repair fuel systems. There must be checklists to ensure all safety precautions are observed. Confined space entry requirements must be met. The days are gone when a person could simply remove an access door, purge the tank for five minutes, and start working. Past ground mishaps have proven safety cannot be over stressed in fuel systems maintenance.

4–1. Aircraft Preparation for Maintenance

Have you ever noticed that fuel systems repair shops are usually located away from all other maintenance facilities? This is because the use of segregated facilities and areas for fuel systems repair is essential for safe and efficient fuel systems maintenance operations. The areas and facilities described in this unit, if used properly, provide adequate protection for both the aircraft and workers from a variety of hazards.

236. Using fuel systems repair facilities and areas

Facilities and areas must be designated and approved for fuel systems maintenance use based on the requirements of TO 1–1–3 before they can be used for maintenance. Facilities not meeting the requirements may be approved on an approved wing/base corrective action plan coordinated through wing/base safety, maintenance group commander (MXG/CC), and civil engineering (fire protection) by restricting some normally permitted operations. The approved base corrective action plan includes the risk assessment code, proposed completion date, and proposed operating procedures.

Provisions may be instituted for emergency repairs or minor repairs in non-approved areas. As a minimum, all facilities shall have fire suppression, alarm/notification systems, electrical systems, and structural features that meet the fire and safety engineering technical letter (ETL) and the requirements of TO 1–1–3, Chapter 3. Fuel systems repair facilities and areas must be as follows:

- Kept clean.
- Maintained in good repair.
- Remained off limits to nonessential personnel.

Inspect the areas and facilities at the start of each shift, and more often as necessary, to ensure safe working conditions are maintained. The MXG/CC must ensure that operation, inspection, and maintenance instructions are available and followed for each item of equipment installed in facilities or otherwise used during fuel systems maintenance. Depending on the type of maintenance performed, four locations may be used for fuel systems maintenance—new facility, existing facility, temporary repair facility, and open (outside) fuel systems repair area.

New facility

As a minimum, if not a separate structure, the fuel systems maintenance facility must be separated from all other areas of the building by not less than a *one-hour masonry fire resistive construction*.

It must have an operational fire suppression system suitable for aircraft hangar operations and wet pipe sprinklers in all adjacent areas. New facilities must also provide a complete automatic overhead water only sprinkler system and a low-level high expansion foam system for all aircraft.

A new facility must have emergency eyewash fountains and emergency personnel showers with a privacy enclosure located in the aircraft servicing area to permit complete disrobing. Provide water for emergency eyewash and showers through a thermostatic mixing valve.

Provide changing areas, locker space, scrub sinks, and personnel showers for both male and female personnel in all fuel systems maintenance facilities. Scrub sinks shall be the hands-free type to permit the washing of hands and arms to the shoulder. To prevent fuel contamination, these areas shall be accessible for aircraft servicing areas without passing through break rooms or offices.

Locate at least two flightline-type, 150-pound HALON 1211-wheeled fire extinguishers within a 50-foot distance, one on each side of the aircraft undergoing maintenance.

Forced air heating supplied by steam or hot water heating will be provided throughout the facility. Radiant tube heating systems may be used in the aircraft maintenance area, if flame is contained in a sealed chamber with combustion air taken from outside the aircraft maintenance area and combustion products exhausted outside the aircraft maintenance area.

Climate control units are required to provide environmentally stable air for air purging, sealant curing, and general repair. The air intake for climate control units should be located in areas free from potential contamination.

Sufficient grounding points must be provided throughout the facility.

A new facility must have electrical systems that meet requirements for Class I Division 1, (Zone 1) below the floor level; Class I Division 1, (Zone 1) throughout foam/cell rooms; Class I Division 2, (Zone 2) throughout the hangar and aircraft maintenance area up to 18 inches; and Class I Division 2, (Zone 2) within 5 feet of the aircraft; and Class I, Division 1 (Zone 1), all wall-mounted outlets and switches shall be.

A new facility must have office space, break room, support equipment/tool room, and restrooms with climate control and positive pressure ventilation to prevent fumes and vapors from migrating from the aircraft repair area. Also, provide rooms for telecommunications, utility/mechanical, and fire protection systems.

Have shop space including fuel/cell rooms to service/repair fuel systems components, as required.

Existing facilities

When major improvements to an existing fuel systems repair facility or conversion of another facility to support fuel systems repair are planned, the facilities shall be upgraded to meet the new facility requirement.

There are several acceptable differences listed below:

1. The following existing fire suppression systems are acceptable in the aircraft servicing area:
    a. A complete automatic overhead water-only sprinkler and a low-level high expansion foam system.
    b. A complete automatic overhead water deluge.
    c. A complete total-flooding, high-expansion foam system.
    d. A complete automatic overhead foam-water deluge (for fighter aircraft only).
    e. A complete automatic overhead closed-head preaction foam-water sprinkler system (for fighter aircraft only).
    f. A complete automatic overhead wet pipe foamwater sprinkler system (for fighter aircraft only).
2. Existing installed Halon 1211 systems with wall-mounted hose reels are acceptable alternatives to the wheeled fire extinguishers.

Temporary facility

Only use temporary facilities as a last resort. Use the existing facility first. Do not use them for ease of maintenance (to prevent towing of aircraft). The entry authority, safety, and fire protection services will initially certify temporary repair facilities. Facilities identified on the master entry plan (MEP) as temporary may be used for 90 days and recertified every 90 days.

When working in a temporary facility the following requirements must be met:

1. Defuel all aircraft fuel tanks (to be worked) prior to entry into a temporary facility. Draining, to include the removal of fuel or other liquids from cells/tanks via the aircraft fuel systems drains, is authorized.
2. Use only equipment approved for fuel systems maintenance in this facility.
3. Access to emergency eyewash fountains and showers for personnel.
4. Access to changing areas, locker space, and scrub sinks for personnel.
5. Position purge exhaust ducts outside the facility doors, and position to prevent fuel fumes from traveling back into the facility. These ducts are marked off an additional 50-foot radius from the end of the duct.
6. Meet all safety precautions outlined in Chapter 3 of TO 1–1–3 prior to using this facility.
7. Locate at least two flightline-type, 150-pound HALON 1211-wheeled fire extinguishers within a 50-foot distance, one on each side of the aircraft undergoing maintenance.
8. Isolate or evacuate any adjoining offices during fuel systems maintenance to prevent unauthorized entry and endangerment of personnel not associated with the ongoing fuel systems maintenance. Controlled entry into the area is paramount.

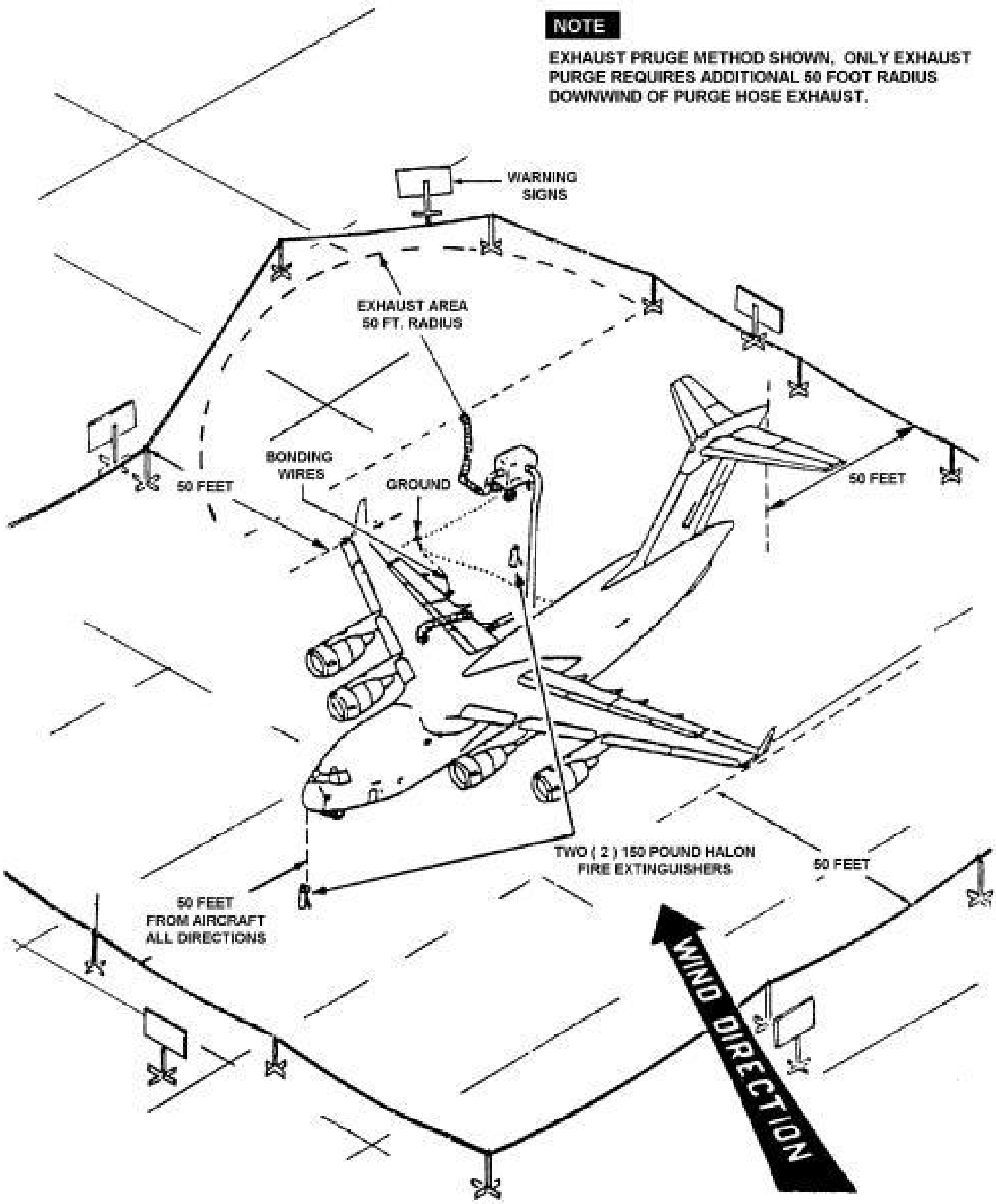


Figure 4–1. Open fuel systems repair area.

Open (outside) fuel systems repair areas

An open fuel systems repair area is any outside area approved by the MXG/CC with coordination from the fuel systems section chief, wing safety, bioenvironmental, fire protection, and the airfield manager. The area must be identified in accordance with TO 1–1–3, Chapter 2. An additional 50 feet may be required if combination air or exhaust purge is used. The fuel systems work accomplished in this area is highly dependent upon weather conditions and available authorized portable equipment. All portable electrical equipment and connections used in hazardous areas must meet the requirements of the National Electrical Code for Class I, Division 1, hazardous locations.

Non-approved equipment may remain in the area, but do not operate while fuel systems maintenance or associated activities are being performed. The area must be equipped with at least two approved portable fire extinguishers. Adjacent aircraft are not allowed to operate under their own power within 100 feet of the area and are limited from operations where a jet blast could affect safety as outlined in TO 1–1–3, Chapter 2, and the applicable aircraft systems TOs. Figure 4–1 shows an open area that is set up for exhaust purging.

Fuel element shop chiefs and shift supervisors should use good judgment when selecting a location for an aircraft requiring fuel systems maintenance.

When using this type of repair area, the following conditions must be met:

1. Available emergency eyewash fountains.
2. Access to changing areas, locker spaces, scrub sinks, and personnel showers for both male and female.
3. Locate at least two flightline-type, 150-pound HALON 1211-wheeled fire extinguishers within a 50-foot distance, one on each side of the aircraft undergoing maintenance. Additional extinguishers are provided as required by the base fire marshal.
4. Do not allow adjacent aircraft to operate under their own power within 100 feet of the repair area. Also, limit operations where jet blasts or noise factors could affect safety.
5. Disconnect all batteries and tag terminals prior to opening the fuel tank.
6. Do not park equipment within five feet of the shadow of the aircraft or within a 10-foot radius of fuel vents or tank openings.

237. Performing maintenance preparation checklists

Each fuel systems repair area must have a checklist, work sheet, or job guide available for use. The checklist below is provided to cover general procedures required to position an aircraft in a fuel systems repair area, and prepare the aircraft for maintenance or tank entry. Checklists will be provided for use at the beginning of each shift (or more often as deemed necessary) over which a permitted entry task or other non-tank entry repair is permitted. All fuel tank entries must be included on the AF Form 1024, Confined Spaces Entry Permit, or local permit. The following are examples of required items. You may add items to your checklist for your facility and the type of aircraft worked.

1. Ensure shift supervisors or designated representatives are conducting a safety inspection of repair areas at the beginning of each shift.
2. Review aircraft 781 forms and brief personnel.
3. Ensure all munitions are removed and downloaded prior to entry into repair area.
4. Tag the aircraft external power receptacles, single point receptacle, and fuel control panel with AF Form 1492, Warning Tag (fig. 4–2).
5. Ensure aircraft batteries (when applicable) are disconnected in accordance with the applicable TOs and the cables are tagged with AF Form 1492.
6. Ensure non-approved equipment is removed from the area.
7. Ensure repair area is roped off and signs are posted.
8. Ensure a single point of entry is established and only authorized personnel enter the open fuel systems repair area.
9. Ensure support equipment is serviceable, properly positioned, and bonded/grounded to the aircraft if required.
10. Ensure atmospheric monitoring equipment is ready for use.
11. Ensure test equipment/support equipment that attaches to the aircraft has “remove before flight” and /or “remove before flight fueling/defueling” streamers.
12. Ensure personal protective equipment is available and serviceable.
13. Ensure fire protection services are notified prior to opening fuel tanks/cells.

14. Ensure personnel remove jewelry and spark/flame-producing objects prior to entering the open fuel systems repair area.
15. Ensure only authorized tools/equipment are used.
16. Ensure hand tools carried into the fuel/tank cell are in a nonmetallic container.
17. Ensure qualified personnel are in position.
18. Ensure voice, visual, or auditory communication is established between workers.
19. Ensure personnel are aware of the emergency response and rescue plan procedures.
20. Ensure an entry permit is generated and issued.

This checklist is general in nature and is not intended to cover peculiarities of individual aircraft or facilities. Therefore, a specific aircraft or fuel systems checklist should be used if available.

238. Performing fuel systems entry requirements

There are many requirements to set up the area. We have discussed several in previous lessons. The following are a few that deserve some discussion. It is never a good idea to memorize the TO, always refer to TO 1–1–3 for the most current and correct information.

Personnel required for fuel tank entry

In accordance with TO 1–1–3, have as a minimum three personnel for all confined space entries; have an entrant, attendant, and an equipment monitor/runner. Their detailed responsibilities will be discussed later. Never attempt tank entry without the required personnel.

Aircraft operation

Do not allow aircraft to operate under their own power within 100 feet of an open fuel systems repair area. Engine operation from nearby aircraft can cause noise, jet blast, or other hazards. These operations should be curtailed when they affect the fuel systems repair area.

Area ventilation

Area ventilation systems consist of large centrifugal exhaust fans attached to the exterior walls. They draw air across the hangar floor and extract the fuel vapors to the outside of the hangar. When these systems are used, they must be operational for fuel systems maintenance operations to be conducted.

The BEF is responsible for evaluating industrial ventilation systems by taking air samples in the work area.

Hot work

The fire protection services approves all *hot work* (e.g., cutting, grinding, welding, soldering, and brazing) done on fuel systems repair facilities and aircraft. Hot work is considered any operation that can provide a possible source of ignition—generates temperatures high enough to ignite fuel. Take special care to eliminate the combustion hazard associated with hot work. The allowable entry safe levels for hot work are 90 ppm or 1.5 percent LEL.

Air Force Form 1492

In previous lessons, we mentioned the AF Form 1492; we will now discuss procedures for filling out the tag. Refer to figure 4–2 for reference.

Part A

Part A is the top portion of the tag. The first block, at the top, is the tag number. The number of tags depends on the aircraft. If you need five tags, then you would start here with “1 of 5,” then “2 of 5,” and so on until you have “5 of 5.”

To the right of the TAG NUMBER block is the date. Always put the date in using the format yyyymmdd (year/month/day).

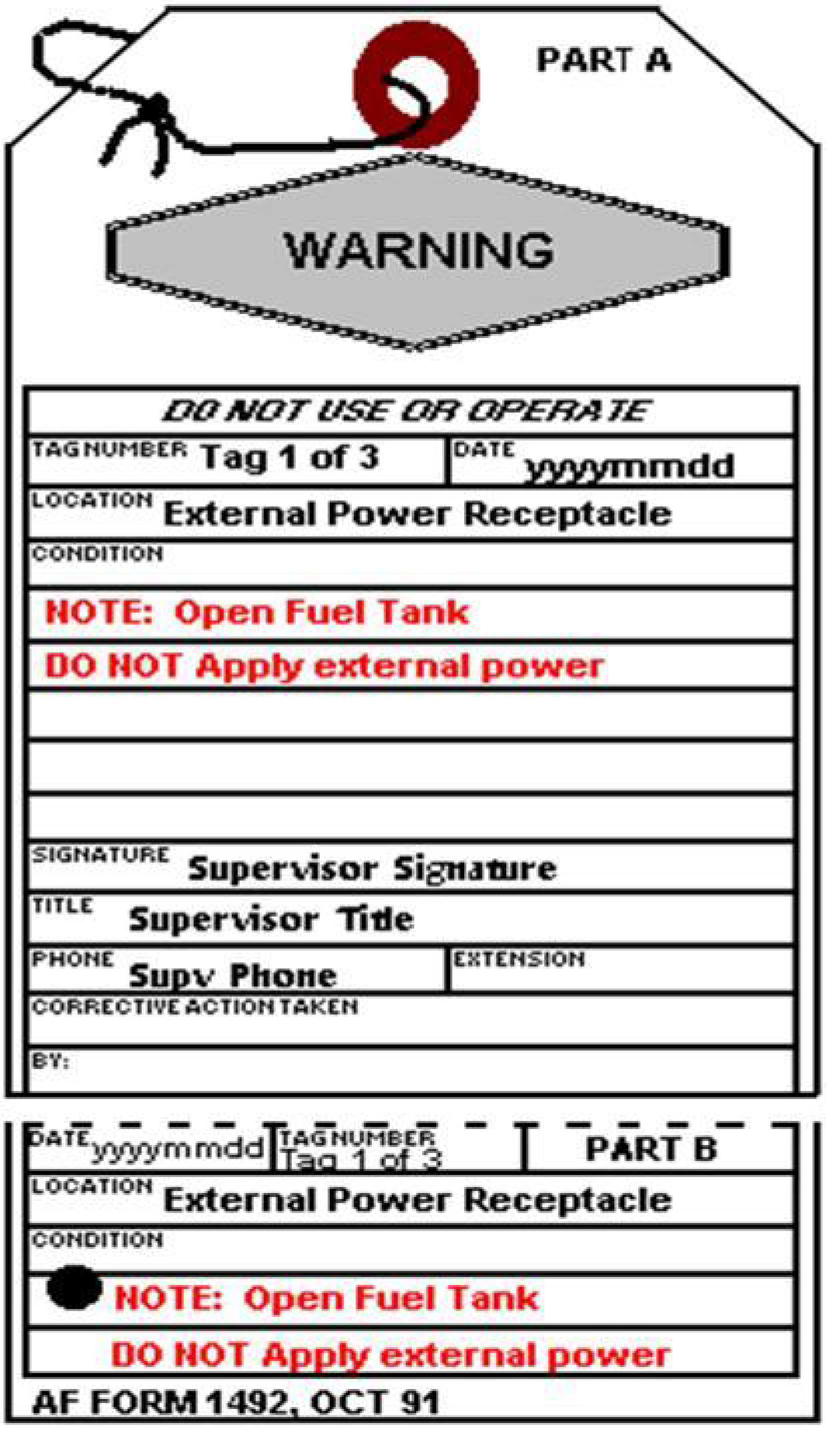


Figure 4–2. AF Form 1492.

Next is the LOCATION block. This block is for where you are putting the tag (i.e., external power receptacle, battery, single point refueling receptacle [SPR], etc.). Try not to abbreviate too much. Although personnel in the fuel shop may know what you mean, others (e.g., electricians and crew chiefs) may not.

Next is the CONDITION block. This entry must be in red or written in pencil and underlined twice with a red pencil. You will always start with “NOTE: Open Fuel Tank.” The second line depends on the location of the tag. It may say DO NOT Apply External Power or Do Not Refuel Aircraft if it is on the SPR. If you are not sure, ask your supervisor.

A red X qualified supervisor must sign the SIGNATURE block: probably a staff sergeant or above that is 7-level qualified. Print their title and phone number.

The EXTENSION, CORRECTIVE ACTION TAKEN, and the BY blocks are left blank unless otherwise directed.

Part B

Part B is the bottom of the tag, below the perforation. This is the portion that will go in the Air Force Technical Order (AFTO) Form 781A, Maintenance Discrepancy and Work Document. The four blocks on this part are the same as PART A; simply copy the information from the applicable boxes from the top to the bottom.

REMEMBER: The top portion must be attached to the applicable location on the aircraft, and the bottom goes in the AFTO Form 781A.

239. Using communication and visual aids

Communication of all types is very important in fuel systems repair. It is easy to see why it is important to communicate with a person inside of a fuel tank at all times, but it is a little more difficult to understand why we must communicate with personnel outside of our repair areas. It is all about safety. In this lesson, we will explain how the different forms of communication translate into a safer work environment for you, your co-workers, and the rest of the maintenance community.

Communication

It is extremely important to maintain communication between members of a work crew and between the work crew and the maintenance operations center (MOC) or job control. Voice or visual signal communications are essential to maintaining a safe working environment. Communication must be maintained between all personnel present. Prior to each entry, brief personnel on visual signals. The use of an approved radio, intercom, or telephone is recommended.

Hand-held radios

Intrinsically, safe mobile radios may be used in fuel systems repair areas and facilities for communication between the MOC and the fuel systems work center or for emergency communication. Never assume your radio is safe; it must be tested and certified. This is an expensive process, and most radios do not meet the requirements. Keep non-intrinsically safe radios and cellular telephones at least 50 feet away from the aircraft. The distance requirements do not apply to adjacent offices that are enclosed.

Aircraft radar

It is known that when high-powered radar is beamed on dry steel wool from 100 feet away, it will ignite. Therefore, separation distances between fuel systems repair areas or facilities and aircraft radar are critical and should be provided in the systems TOs. If the system TO is not available or does not contain separation distances, 300 feet (100 feet when using a dummy load) is the required minimum safe distance. Refer to TO 31Z–10–4, *Electromagnetic Radiation Hazards*, for additional information.

Streamers and forms

Use streamers and tags to denote warnings and danger as appropriate. All support equipment, plugs, caps, and cover plates connected to the aircraft must have a red REMOVE BEFORE FLIGHT streamer. Attach the red streamer to the point where the equipment is connected to the aircraft. Figure 4–3 shows one possible method of streamer attachment. DO NOT use AF Forms 1492 in lieu of red streamers.

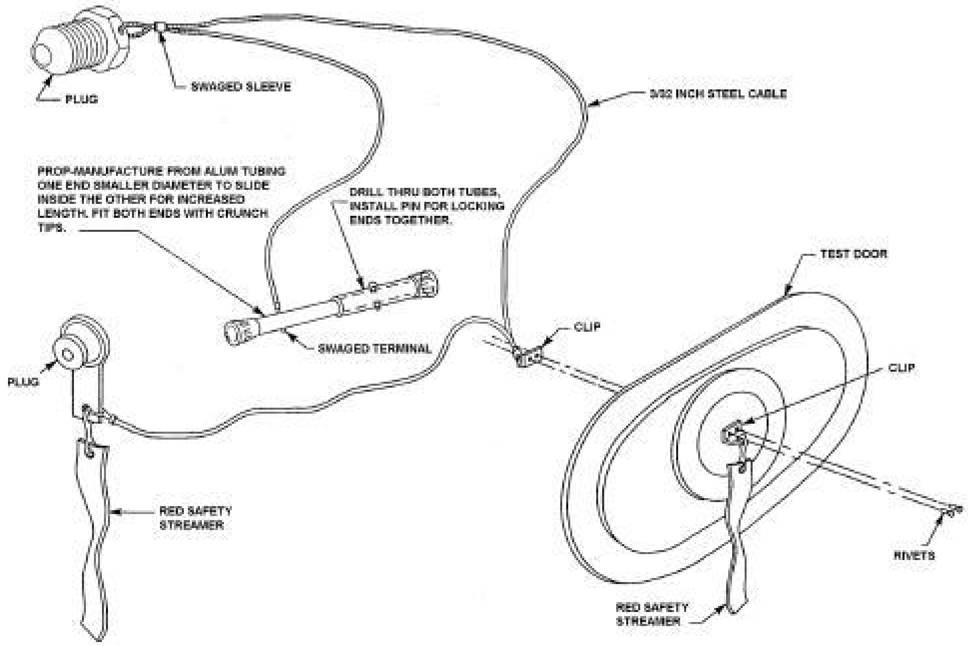


Figure 4–3. Attachment of safety streamers to test equipment.

All vent plugs, vent caps, vent cover plates, and equipment that affect the venting, fueling, defueling, or transferring of fuel on an aircraft must have a yellow REMOVE BEFORE FUELING/DEFUELING streamer. If yellow streamers are not available, use an AF Form 1492 for each vent plug installed on the aircraft. Attach the AF Form 1492 to the single point refueling receptacle and make an AFTO Form 781A, entry noting the location of the plug. Yellow streamers can be manufactured locally and should be 2 to 3 feet long.

Signs

All fuel systems repair areas or facilities must be clearly marked with warning signs—DANGER, OPEN FUEL TANKS, UNAUTHORIZED PERSONNEL KEEP OUT. The signs must be constructed as shown in figure 4–4. All category I facilities must also have NO FUELED AIRCRAFT IN THIS FACILITY signs posted in the aircraft maintenance area.

Rope, chain, or cable

All fuel systems repair areas or facilities must be marked off 50 feet from all points of the aircraft with rope, chain, or cable. The roping of facilities applies to those areas of the structure that are normally open and is intended to control foot traffic into the facility. During combination of air or exhaust purge, an additional 50-feet radius downwind from the end of exhaust duct must also be marked off.

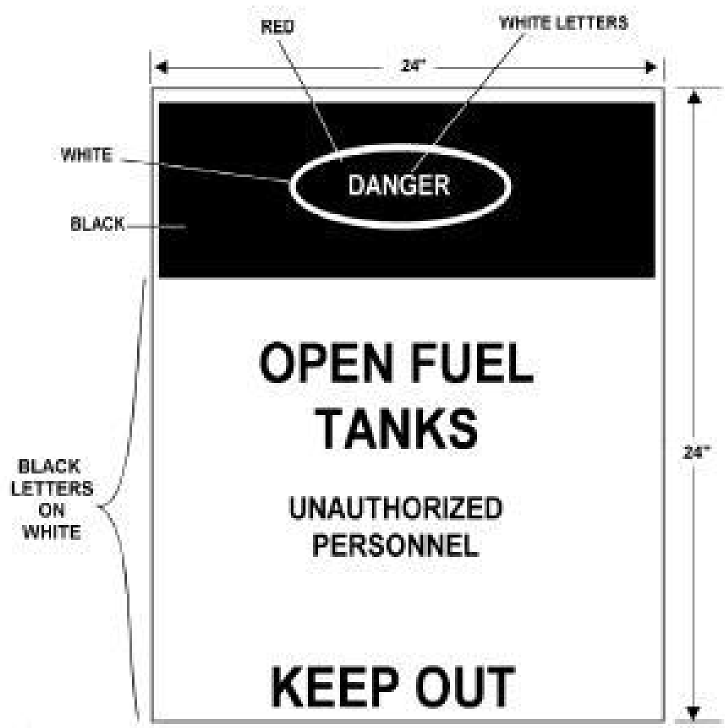


Figure 4–4. Repair area-warning signs.

240. Applying safety when using tools and test equipment

An open fuel systems repair area is a hazardous environment. To perform maintenance in such an area requires special attention to the type of equipment that is brought into it. The following lessons will explain the types of equipment that are authorized for use inside a fuel systems repair area. Follow these lessons, and you will be a safer mechanic.

General requirements

All rolling support equipment used in fuel systems repair areas or facilities must be equipped with antistatic, nonmetal (i.e., rubber or composition) wheels. Inspect equipment prior to bringing it into the fuel systems repair area or facility. Fire extinguishers, sealant guns, mixers, communications equipment, aircraft jacks, and other similar equipment are not considered support equipment. Support equipment must be inventoried or controlled to ensure no equipment is left on or in the aircraft during fueling, defueling, or flight.

Powered support equipment

When setting up an open repair area, position powered-support equipment outside the 50-foot marked area. If possible, position the equipment upwind to guard against possible ignition sources. All support equipment must have cables and hydraulic lines in excess of 50 feet. Exceptions are the HDU–13/M heater, explosion proof fans and blowers, air purifier cart, or any other explosion proof and intrinsically safe equipment; these are allowed within the marked area. Equipment within the marked area must be bonded and grounded to the aircraft. Equipment outside the marked area does not require grounding or bonding. Position ambient air breathing equipment away from vehicle and equipment exhaust, ventilating and purging exhaust ducts or other similar operations, to ensure that air intakes are located in an uncontaminated area.

Work stands

Personnel are subject to falling when working above floor level. Work stands must be provided, used, and maintained in accordance with applicable directives. Work stands must have non-slip step surfaces. Worn step surfaces must be repaired or replaced. Ensure that work stands have static discharge plates and bonding wires as required by TO 1–1–3.

Tools and tool boxes

Rubber wheeled, maxi-type toolboxes are authorized inside fuel systems repair facilities and areas without being grounded or bonded. All hand-carried toolboxes brought into the fuel systems repair facility or area must be placed on a nonmetal, antistatic composition, or rubber mat. Never place the box on another surface or carry it onto the aircraft or work stands. Hand carry required tools to the aircraft in nonmetallic containers (e.g., fiberboard boxes or canvas bags). Toolboxes locked and secured in storage racks need not be removed from the fuel systems repair facility provided they remain locked in the storage rack.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

236. Using fuel systems repair facilities and areas

1. What are three requirements that all fuel system repair facilities and areas must meet?

2. Who ensures that operating instructions are available for each equipment item installed in a fuel systems repair facility?

3. What is one difference between the emergency shower and eyewash requirements in a new facility as opposed to those of an existing facility?

4. In a new or existing facility, a requirement exists for a positive pressurization system in the break room, office, support room, and restrooms; what is the purpose of this system?

5. Besides the requirements listed for the new and existing facility, name two additional requirements when working in temporary facility.

6. What are the requirements for the positioning of exhaust purging ducts when you are working in a temporary repair facility?

7. What requirement must portable electrical equipment meet if used in an open fuel systems repair area?

237. Performing maintenance preparation checklists

1. When should supervisors conduct a safety inspection of a fuel systems repair facility or area?

2. Which items on the aircraft should be tagged with an AF Form 1492?

3. What must you do with the aircraft batteries as part of the aircraft preparation checklist?

4. What is your responsibility regarding support equipment used inside the repair area?

238. Performing fuel systems entry requirements

1. Aircraft shall not be allowed to operate within how many feet of an open fuel systems repair area?

2. Who approves hot work in an aircraft fuel tank?

3. What are the allowable entry safe levels for hot work?

4. What are five examples of “hot work”?

5. What portion of the AFTO Form 1492 will be put in the AFTO Form 781A?

239. Using communication and visual aids

1. What type of hand-held radio used for emergency communication is authorized inside the repair area?

2. Unless otherwise specified in an aircraft TO, what is the minimum distance that must be maintained between full-powered aircraft radar and a fuel systems repair area?

3. Senior Airman Rose is about to install a cover plate on an aircraft fuel tank. What safety item must also be installed?

4. When should an AF Form 1492 be used to flag a vent plug installed on an aircraft?

5. What is the primary purpose of roping off a fuel systems repair facility?

240. Applying safety when using tools and test equipment

1. What is required of rolling support equipment before it may be used inside a repair area?

2. Why is it important to inventory support equipment used in a repair area?

3. When setting up an open repair area, where should you position powered-support equipment?

4. What equipment is authorized for use inside the open repair area?

5. Before using a maintenance stand inside a fuel systems repair facility or area, for what should you inspect the stand?

6. How should tools be brought to the aircraft?

4–2. Confined Space Entry

As defined in Air Force Manual (AFMAN) 91–203, *Air Force Occupational Safety, Fire, and Health Standards*, a confined space, by design, is an area that has limited openings for entry and exit. Confined space, also, has unfavorable natural ventilation that could contain or produce an actual or potentially hazardous atmosphere or other recognized safety or health hazard, and contains the potential for engulfment by a gas or liquid. As you can see, aircraft fuel tanks fit quite nicely in this category and, therefore, require that special safety precautions be taken prior to and during entry.

This section covers confined space entries in detail, including the requirements, responsibilities of personnel, authorization for entry into a confined space, and procedures to be taken in response to an emergency.

Certain sequences of events may require entry into a confined space with hazards present beyond the scope covered in TO 1–1–3; these entries will be coordinated with the local safety office, fire protection services, BEF, and MXG/CC, or civilian equivalent. We will begin by covering those involved in a confined space entry.

241. Performing confined space entries

There are many people with responsibilities related to confined space entries. We will start with the person who has overall responsibility for all entries.

MXG/CC or equivalent

The MXG/CC or equivalent is ultimately responsible for the safe execution of all entries into and work performed in aircraft fuel tanks and cells. The MXG/CC also appoints an entry authority, usually the fuel systems section chief, and issues his or her signature on the letter designating the entry authority. The MXG/CC authorizes the issue of the MEP by signature and ensures all safety, health, and environmental guidelines are followed. Other responsibilities of the MXG/CC include designating open fuel systems repair areas as necessary, substituting non-fuel systems personnel for the attendant position when authorized, and coordinating on waivers of certain safety and health requirements when authorized.

Fuel systems section chief

In most situations, the fuel systems section chief serves as the entry authority for all tanks and is responsible directly to the MXG/CC for ensuring all confined space entry safety practices and procedures in TO 1–1–3 are met. For organizations not having a designated fuel systems section chief, the supervisor most qualified and experienced in aircraft fuel systems repair will be designated the entry authority. In the absence of or when otherwise authorized by the entry authority, the alternate entry authority will perform the duties of the entry authority. The entry authority or designated alternates must complete and sign all field permits. The entry authority designates an alternate entry authority. The entry authority must also designate a fuel tank entry chief and ensure that entrants and attendants are qualified and available.

Entrants

An entrant is any person that physically enters an entry permit required space to perform fuel tank repair. Entrants (2A6X4 or civilian equivalent) are responsible for complying with the conditions of the entry permit, TO 1–1–3, and the directions of the attendant at all times, including vacating the tank or cell when directed. All entrants should complete the tasks requiring tank entry as quickly as possible, while keeping safety and quality maintenance a priority.

Attendants

Attendants have the overall responsibility for monitoring the entry area inside and outside of the aircraft fuel cell or tank, including termination of the entry if unsafe conditions develop. The attendant will be stationed at the tank entrance and remain outside the entered tank. Other duties of the attendant include the following:

- Ensures safe execution of fuel tank/cell entries through compliance with the applicable checklists, safety, health and environmental Air Force instructions (AFI), directives, TOs, MEP, and the entry permit.
- Never permits entry into an immediately dangerous to life and health (IDLH) atmosphere.
- Limits fuel tank/cell entry to qualified and authorized personnel only.
- Has overall responsibility for monitoring the fuel tank/cell for hazards.
- Ensures atmospheric readings are taken and documented on the entry permit in accordance with TO 1–1–3, Chapter 5. Also ensures the atmospheric monitoring equipment serial number is recorded on the entry permit.
- Has overall responsibility for monitoring the entrant through use of voice, visual and/or auditory signals.

- Orders the termination of maintenance and evacuation of fuel tank/cell at the first sign of a hazard or personnel distress.
- Alerts the equipment monitor/runner to initiate the emergency response and rescue plan, if required.
- Acts as member of first team rescue in the event of an emergency.
- Monitors, when authorized, multiple fuel tanks/cells (provided they are capable of maintaining effective communication with the entrants).

Training requirements

Entrants and attendants are required to have some special training requirements. They include, but are not limited to, respirator-qualified, cardiopulmonary resuscitation (CPR), self-aid buddy care, trained on the proper use of all personal protective clothing and equipment. They also must be trained on confined space entry procedures and the emergency response plan procedures. Another important requirement is recognizing symptoms of overexposure to chemicals, solvents, and fuels. The last requirement is very important when you are serving in the attendant role.

Equipment monitor/runner

A minimum of three people will be involved when entering a cell or tank. The duties of two of these people, the entrant and the attendant, have already been covered. The third position is the equipment monitor/runner. An equipment monitor/runner is any person that physically monitors the fuel systems repair area for hazards and support equipment to ensure safe and continuous operation and ensures unauthorized personnel do not enter the repair area. The runner is also responsible for notifying emergency response personnel if necessary. Other duties include the following:

- Has overall responsibility for monitoring the facility/repair area for hazards and unauthorized personnel.
- Monitors essential fuel tank/cell entry support equipment within the facility/repair area to ensure safe and continuous operation.
- Notifies immediately the attendant if a hazard develops or support equipment becomes inoperative.
- Summons rescue team in accordance with the emergency response and rescue plan.
- Acts as member of first team rescue in the event of an emergency.
- Monitors, when authorized, multiple repair areas provided they are capable of maintaining effective communication with the attendants.
- Performs duties of the attendant, if qualified, during rescue but shall not enter the fuel tank/cell.

During extended repair jobs, you may have to fill more than one position. You may start out being the attendant and then become the entrant. It is common to change positions during extended maintenance. You must, however, be qualified to assume the position.

Other office requirements

Three other offices you will deal with are BEF, safety, and the fire protection services. The following are their responsibilities when it comes to fuel systems maintenance.

BEF officials are responsible for the following:

- Coordinate on, and sign the MEP annually.
- Provide guidance on the use of personal protective clothing and equipment.
- Conduct annual surveys as required by applicable directives.
- Provide training on subject matter for which they have expertise.

The safety office has the following responsibilities:

- Coordinate on, and sign the MEP annually.
- Assist with development of the emergency response and rescue plan.
- Observe the annual fuel systems emergency response and rescue plan exercise and ensure the results/findings are documented.
- Coordinate on approval of fuel systems repair facilities/areas.
- Be the wing focal point for confined space issues.
- Provide training on subject matter for which they have expertise.
- Coordinate on equipment substitutions.

Fire protection services have the following responsibilities:

- Coordinate on, and sign the MEP annually.
- Coordinate on approval of fuel systems repair facilities/areas.
- Assist with development of the emergency response and rescue plan.
- Participate in the fuel systems emergency response and rescue plan exercise annually.
- Provide training on subject matter for which they have expertise.

242. Performing emergency response procedures

Everyone involved in a tank or cell entry must be fully prepared to handle an emergency. It is not acceptable to simply hope an emergency never happens. Each person has defined responsibilities, and certain actions must be taken when the need arises. Being prepared is the key to eliminating confined space mishaps.

Every fuel systems repair activity must develop a written emergency response plan, in coordination with MXG/CC, fire protection services, safety, and BEF officials. The plan will establish a rescue team consisting of personnel needed to remove individuals who are incapable of getting themselves out (i.e., self-rescue) of a tank from which rescue is possible.

In addition, the plan will establish base or local emergency response agencies to provide immediate care and removal, if removal by the rescue team is not possible. The response plan will account for all foreseeable rescue situations and will list equipment and facility requirements necessary to remove an incapacitated entrant safely.

Emergency response plans will define the roles and activities of all responding emergency agencies, including rescue from a tank from which removal by the attendant has failed or is not possible.

Rescue capability must exist for all shifts during tank entry. Although the most likely rescue will be from a non-IDLH environment, the plan will account for rescue from an IDLH environment. Exercise the plan with all relevant base agencies at least annually, during which the rescue team will practice making removals from actual or simulated tanks. The wing's confined space program office of primary responsibility documents the exercise and distributes the documentation to affected agencies. Maintain a file copy of the report for two years.

Procedures for initial removal attempts

For tanks or cells where entry for removal is possible, the plan will identify either the authorized attendant or the equipment monitor/runner for initial removal attempts employing the following procedures.

Attendant alerts the runner

Before entering a tank to remove an incapacitated entrant, the attendant alerts the runner and ensures the tank is ventilated properly. Also, the attendant determines, through contact with the entrant, if possible, the nature of the emergency. The attendant samples the tank and ensures a minimum fire-safe level exists before entering the tank. He or she makes any rescue attempts possible from outside the tank.

The runner/equipment monitor sounds the alarm by the quickest means available and initiates contact with emergency response agencies. The plan will describe how this notification is to be accomplished and lists the equipment and facility requirements necessary to remove an incapacitated entrant safely.

Attendant enters the tank

If the plan designates the authorized attendant to remove the incapacitated entrant, the attendant may put on respiratory protection equipment but will not enter the tank until the runner assumes the duties of the attendant. Therefore, the runner must be trained and capable to perform the duties of an attendant as listed in a previous lesson. If the equipment monitor/runner is designated to remove the incapacitated entrant, the attendant will not leave the tank or cell once the runner has entered. Attendants and runners designated for initial removal must have training in CPR and self-aid buddy care, or its equivalent.

Equipment and facility requirements

The emergency response plan must list equipment and facility requirements necessary to remove an incapacitated entrant safely.

Roles of emergency agencies

The plan must define the roles and activities of all responding emergency agencies, including rescue from a tank from which removal by the attendant or runner has failed or is not possible.

Rescue team size and availability

Rescue capability must exist for all shifts during which tank entry is accomplished. The size of the rescue team must be sufficient to ensure that no unattended rescue activity occurs.

Rescue from an IDLH environment

Although most rescues will be from a non-IDLH environment, the plan must account for rescue from an IDLH environment. Tanks containing atmospheres considered IDLH will not be entered using the confined space entry procedures. For the purpose of TO 1–1–3, IDLH is considered to be LEL greater than 20 percent or (1,200 ppm); oxygen content of 19.5 percent or less or greater than 23.5 percent; or a toxicity level of any chemical agents used in the tank at or above IDLH levels specified by BEF. Trained, predesignated teams perform tank entries for the purpose of rescue as specified.

Practice rescue

Exercise the emergency response plan at least once every year. The rescue team may practice making removals from actual or simulated tanks using dummies or available personnel. The wing's confined space program office of primary responsibility documents the exercise and distributes the documentation to affected agencies. Maintain a file copy of the report for two years.

Remember, these elements represent the minimum requirements for an emergency response plan. Fuel element chiefs may supplement these requirements as they see fit.

243. Documenting confined space

A form of documentation applies to confined space entries—MEP.

Master entry plan

The MEP certifies the fuel systems repair supervisor to act as the entry authority for aircraft fuel cell/tank entries. The MEP does not authorize entrance into any permit-required space. The plan certifies, by name and position, the entry authority and designated alternates. It describes the conditions under which the entry authority or designated alternates may issue entry permits. As part of the annual authorization process, the MXG/CC, BEF, ground safety, and fire protection services' official review, validate and approve the MEP based on reviews and assessments.

The MEP contains the following guidelines:

1. Issued for a maximum of one year.
2. Authorize by name and position, the entry authority and designated alternate.
3. Describe the conditions under which the entry authority or designated alternates may issue entry permits.
4. Describe the type aircraft to which the MEP and entry permits apply.
5. Describe the general descriptions of the routine and recurring type work performed during permitted entries and the work centers, which perform the work.
6. Describe the authorized atmospheric conditions of the tank (e.g., tank properly purged, LEL, oxygen, toxicity at prescribed levels).
7. Describe the authorized type of chemicals, sealants, adhesives, and so forth, used in the tank.
8. Describe the procedures, practices, and personnel requirements for periods of deployment to non-Air Force installations or during readiness exercises and operations at remote locations.
9. Name the additional location conditions deemed necessary by the local BEF, safety, or fire protection services.

The MEP specifically states that "any entry not consistent with the conditions of the MEP will not be authorized by the entry authority or any designated alternates." These requirements are not all inclusive; a sample MEP can be found in TO 1–1–3.

Entry permit

Entry permits may be issued for similar tasks performed under similar conditions in different tanks or cells on the same aircraft. The permit must cover the duration of the task or tasks to be performed unless the conditions under which the entry permit was issued change prior to task completion. It must never be issued for more than one year.

The entry authority or designated alternate must amend or reissue the entry permit if conditions of the original permit change prior to task completion and the changed conditions are consistent with the MEP. Entry permit conditions are considered changed if any of the following take place:

1. The original permitted task or tasks change.
2. The aircraft is moved from one repair location to another.
3. Conditions develop that are not in compliance with TO 1–1–3 or the MEP.
4. Chemicals, other than originally permitted, are introduced into the tank.
5. Previously non-permitted personnel require entry into the tank.

Entry permit format

The entry permit is a written document. AF Form 1024 (figs. 4–5 and 4–6), authorizes entry into confined spaces. The form may be modified and reproduced locally.

CONFINED SPACE ENTRY PERMIT

1. Master Entry Plan (MEP)	Is Entry Covered by a CSPT Approved MEP? ☒ Yes ☐ No Date MEP Approved? 2019-10-07

2. General Information

On or Off Installation, Location (GPS coordinates if known) & Description of Space to be Entered

Hangar 5105, B1-B, TK #3 FCGMS

Purpose of Entry

Replace Quantity Harness

Identify any TO or OI that Covers Entry	Authorized Duration of Permit		
1B-1B-2-28JG-50-1	Date 2019-10-23	Time Issued 6:00:00	Time Expires

3. Hazards (Indicate all probable hazards)

☒ Oxygen Deficient (<19.5%) ☐ Airborne Combustible Dust (≥ LEL or Obscures Vision at Distance of 5ft [1.52M] or Less)

☒ Oxygen Enrichment (>23.5%) ☒ Flammable Gases or Vapors (≥ 10% LEL) ☐ Electrical Shock

☒ Material Harmful to Skin ☐ Mechanical Hazards ☒ Engulfment

Other (any other hazards required by applicable TO, OI, etc.)

4. Hazard Controls

Personal Protective Equipment

Coveralls, Gloves

Respiratory Protection

Full-Face Respirator

Communication

Radio, Telephone, Runner

Rescue Equipment

Other (any other hazards controls required by applicable TO, OI, etc.)

5. Preparation for Entry (Any item in this section that is inconsistent with MEP is not a routine entry)

☐ Notification of Service Interruption	Ventilation Methods	Personnel Awareness
☐ Blank/Blind Lines	☒ Mechanical	☒ Pre-Entry Briefing on Specific Hazards, Work to be Performed, Control Methods & Emergency Egress
☐ Purge/Clean	☐ Natural	
☐ Inert	Communication Methods	☒ Signs Posted
☐ Barriers	☒ Visual	☒ Pedestrian & Vehicle Barriers
☐ Double Blank and Blind	☒ Voice	Other (any other required by applicable TO, OI, etc.)
☐ Isolation Methods	☐ Tug Rope	
☐ Electrical Hazardous Energy Control	☐ Radio/LMR	
☐ Mechanical Hazardous Energy Control	Additional Permits	
☐ Atmospheric	☐ AF Form 592, *Hot Work Permit*	

AF FORM 1024, 20160322 — Previous editions currently in use as of date of this form are authorized - All others are obsolete. — Adobe® LiveCycle® Designer ES4 OPR: HQ AFSEC/SEGS

Figure 4–5. AF Form 1024 (front).

6. Atmospheric Testing & Monitoring Record (Continuous monitoring shall be performed during all **construction** confined space operations)

Monitoring Device	Make	PID 2M	Model & S/N	AMU #3254	Date Calibrated	2019-09-09	Date Bump Tested	2019-09-10

Type Hazard	Acceptable Entry Conditions Occupational & Environmental Exposure Limits (OEEL)	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result	Time / Result
Oxygen (O2)	19.5% - 23.5%	21% / 0900											
Carbon Monoxide (CO)	≤ 25 PPM												
Flammables (LEL)	< 10%												
Toxic Gases and Vapors - e.g., Sulfur Dioxide (SO_2), Chlorine (Cl), Hydrogen Sulfide (H_2S), Volatile Organic Compound (VOC), etc.													
Tester Initials													

Continuous monitoring required? ☐ Yes ☒ No Frequency: Additional testing/monitoring or entrant information attached? ☐ Yes ☐ No

7. Authorized Personnel (All listed authorized supervisors must be consistent with MEP to be a routine entry)

Entry Supervisor(s)			Atmospheric Monitor(s)		
Grade	Name (Last, First MI)	Signature	Grade	Name (Last, First MI)	Signature
E-6	Houst, Adam	[signature]	E-3	Wilcox, Jonathan	[signature]

Attendant(s)		Entrant(s)	
Grade	Name (Last, First MI)	Grade	Name (Last, First MI)
E-3	Knoche, Jeremy	E-4	Fones, Christopher

8. Fire Emergency Services or Equivalent

Point of Contact (Last, First MI)	Contact Info (Phone #, Radio Call Sign, etc.)	Date/Time Rescue Service Confirmed
Johnson, Jimmy	696-2197	20191023/0800

9. Coordination (**Not required for entries consistent with an approved MEP**)

Occupational Safety (SEG)	Bioenvironmental (BE)	Fire Emergency Services (FES)

10. Entry Time Log

Name (Last, First MI)	Time In	Time Out	Time In	Time Out	Time In	Time Out	Time In	Time Out	Time In	Time Out	Time In	Time Out
Coffey, Mike	0900											

11. Close-out / Cancellation

Date/Time Work Completed   Date/Time Permit Closed/Cancelled

Additional Comments: Entry Supervisor Print & Sign

This permit must be available on job site during entry.
Maintain the job site copy on file in work center for one year.

AF FORM 1024, 20160322

Figure 4–6. AF Form 1024 (reverse).

Maintaining the entry permit

The permit is maintained at the job site and must be available during tank entry. When the task is completed, the entry permit is returned to the entry authority, and is canceled. Each completed permit, including those that are canceled or revoked, is retained for one year by the organization responsible for the entry and must be available for review. The entry authority/designated alternate will do the following:

- Only issue an entry permit after all controls and testing are established/accomplished. Only issue permits when conditions of the MEP are met.
- Never permit entry into a fuel tank/cell with an IDLH atmosphere.
- Ensure fuel tank/cell entries and the work performed adheres to established safety practices, procedures of TO 1–1–3 and the MEP.
- Establish and maintain a system for controlling entry into fuel tanks/cells and the facility/area during open fuel tank/cell repair in accordance with TO 1–1–3.
- Ensure fuel tank/cell entry team (entrant, attendant and equipment monitor/runner) are qualified in accordance with TO 1–1–3.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

241. Performing confined space entries

1. Who authorizes the issue of a MEP?

2. Normally, who serves as the entry authority for all confined space entries?

3. Who has the overall responsibility for terminating an entry in the event of unsafe conditions?

4. List the duties of the equipment monitor/runner.

5. Which office would you utilize for information on personal protective equipment?

6. Which office is the wing focal point for confined space issues?

7. What should the BEF, safety, and the fire protection services all do?

242. Performing emergency response procedures

1. When developing a written emergency response plan for your fuel shop, with whom must you coordinate?

2. In the event an entrant becomes unable to get himself or herself out of a fuel tank, what is the first step the attendant must take?

3. Under what conditions may an attendant enter the tank to rescue an incapacitated entrant?

4. What training requirement must attendants and equipment monitor/runners satisfy in order to enter a tank to remove an incapacitated entrant?

5. What factor determines the size of the rescue team outlined in the emergency response plan?

6. As a minimum, how often must the emergency response plan be exercised?

243. Documenting confined space

1. For what maximum time may a MEP be issued?

2. On the MEP, what is authorized by name and position?

3. What must you do to the entry permit if new personnel require entry to the tank?

4. The entry authority or designated alternate will not authorize any entry that is not consistent with what?

5. What action must be taken by the entry authority if conditions of the permit change prior to task completion, and the new conditions are consistent with the entry permit plan?

6. Where must the entry permit be maintained during task maintenance?

7. What should be done with the entry permit after task completion?

4–3. Purging and Depuddling

Aircraft fuel tank or cell purging is one of the most hazardous tasks associated with fuel systems maintenance. The purging process requires you take extreme precautions to prevent a fire, explosion, or health hazard. No doubt, you have been involved in purging a fuel tank at some point in your fuel systems career, so you should be familiar with the equipment and general procedures involved in the operation. As a journeyman, you must be thoroughly knowledgeable of every aspect of the purging process. The next few lessons cover these aspects.

244. Performing purging procedures

Purging removes volatile fuel vapors from a fuel tank or cell and reduce the LEL of the atmosphere while retaining an acceptable percentage of oxygen in the tank; in other words, purging is making the tank fire-safe and entry-safe. Before opening a tank to purge it, ensure the tank has been drained. Sometimes the crew chiefs do this, but ultimately your responsibility is to make sure it was done. Ask around; I am sure there are stories in your shop about people who have spilled more than their share of fuel because they did not ensure the tanks were drained before they opened them.

Draining tanks or cells

Fuel must be collected only in approved safety containers, bowsers, or rubber pails. All containers should be marked to denote grade of fuel contained. Bowsers and metallic safety containers must be bonded to the aircraft during fuel transfer (fig. 4–7). Locally manufactured containers must meet the requirements of TO 00–25–172, *Ground Servicing of Aircraft and Static Grounding/Bonding.* Drip pans are not approved fuel collection containers. Fuels without antistatic additives are not allowed to free-fall into any container unless necessary; therefore, keep free falls to the minimum necessary. Place the fuel collection container as close to the drain as possible. After positioning the container, ground and bond as required. Open the drain valve and allow all fuel to drain into the container. After fuel has stopped draining, close the valve and move the container away from the aircraft. Empty all pails and drip pans daily, or more often if necessary.

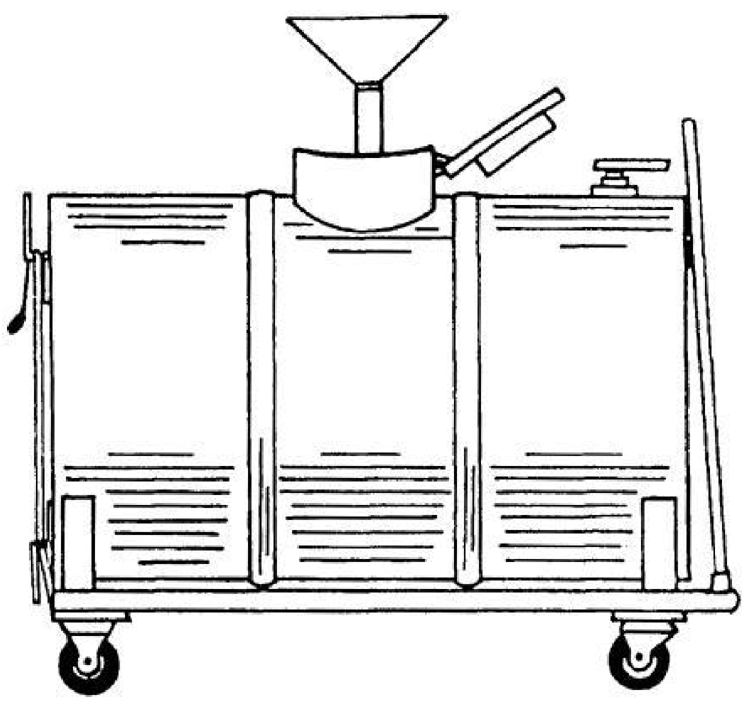


Figure 4–7. Fuel collection container (bowser).

Purging locations

Purging may be accomplished in any authorized facility or open fuel systems area. The most common method of purging you will perform is *air purging*. Air purging is done to make the tank fire and entry-safe. Under certain circumstances, aircraft, which use JP–5 or JP–8, might not require purging because the LEL can be maintained at acceptable levels by ventilating the tank. You need to be aware that ventilation is not the same as purging. *Ventilation* is the process of supplying fresh air to a fuel tank once the tank is considered acceptably purged.

Confined space atmospheric testing

You must purge the tank to an entry-safe condition before performing in-tank maintenance or inspections. An entry-safe condition is 600 ppm or less or (10 percent LEL) for aircraft not requiring explosion suppression foam removal and 1200 ppm or (20 percent LEL) for tanks requiring foam removal. This is because the removal of fuel-soaked foam generates fuel vapors, which are very difficult to maintain at 600 ppm (10 percent LEL). Therefore, 1,200 ppm or (20 percent LEL) has been determined to be an acceptable level. As discussed earlier, the PID is the meter of choice. The meter is used as a constant monitoring device, except during foam removal. The meter must stay turned on and in the vicinity of the entrant at all times. During normal tank entry, take a reading from the meter every four hours and record it on the entry permit. During foam removal, take a reading every 15 minutes as a minimum, or more often as deemed necessary, and always at the furthest point, maintenance will be performed. Always remove the meter from the tank during foam removal. If the meter gets wet or sucks up the fuel, it will damage the meter.

245. Using air purging methods

Air purging is the process of supplying fresh air to a fuel tank to reduce fuel vapors. There are three approved types of air purging—blow, exhaust, and combination. *Blow purge* is the circulating (blowing) of fresh air into a tank. *Exhaust purge* is the process of pulling the existing air out of the tank and exhausting it to a safe area while drawing fresh air into the tank. The preferred method of air purge is a *combination purge of both blow and exhaust purges*. Air purging can be accomplished with installed and/or portable equipment. Air purge shall be continuous during all entries.

Blow purge procedures

After the aircraft has been prepared, the dock or area is set up, and all safety requirements listed in TO 1–1–3 have been complied with, place the blower or HDU–13/M heater convenient to the aircraft. Ensure blowers and heaters are bonded to the aircraft. Position the ducts from the installed blower units to the area where they are needed. Prior to removing the fuel tank-access doors, start the air mover and blower. Next, bond the ducts to the aircraft. Attach the bonding wire to the duct nearest the fuel tank/cell access opening. You are now ready to remove the access door. Once the access door is removed, immediately install the blower duct in the tank opening. Again, to prevent a possible spark from igniting the fuel vapors, it is extremely important that the blower be turned on prior to inserting the air ducts into the tank opening. Purge the tank for 30 minutes, and then remove the duct from the tank. However, do not turn off the blower until the purge procedure is complete. If power fails or the blower starts to malfunction, immediately remove the air duct from the aircraft and move the blower and air duct to an area free from fuel vapors. At this time, it is safe to turn the blower off.

To check the tank atmosphere, take an oxygen reading of the tank atmosphere. If the oxygen level is not between 19.5 and 23.5 percent, continue purging for 15 minutes. Continue the process until a safe oxygen level is reached. When the tank has a safe oxygen level, you may then check for a fire-safe condition. If the LEL is *not* below 1,200 ppm (20 percent LEL), purge for an additional 15 minutes. Continue this process until a fire-safe condition exists. If tank entry is required, repeat the purge procedure until an entry-safe LEL (below 10 percent) condition exists. After the tank has been purged to acceptable levels, depuddle the tank as necessary. If the aircraft is in a hangar and does not contain explosion suppression foam, the LEL must be checked at least every four hours or more often, as deemed necessary to assure a fire-safe condition is maintained. Normally, a LEL check is made at the beginning of each shift. When working in an aircraft containing foam, take a reading every 15 minutes, as a minimum, or more often as deemed necessary. Take the readings at the tank entry point and progressively to the furthest point at which work will be accomplished inside the tank. When all foam has been removed from a tank, it is considered a non-foamed tank and, therefore, monitored as such. Record all readings on the entry permit.

Exhaust purge procedures

Since the procedures for exhaust purging are similar to those of blow purging, we will not cover the entire procedure but note only the differences between the two procedures. The exhaust purge ducts must be attached to the inlet side of the blower rather than the outlet side as in blow purging. This is because the blower will be drawing air out of the tank. Attach the other end of the duct to the aircraft. If necessary, ensure vents and filler caps are open before starting the blower unit.

When exhaust purging, purge for 30 minutes as for blow purging. If needed, move the duct to a different position to complete the purge. The remaining procedures for testing the tank atmosphere are identical to those for blow purging.

Combination purge procedures

As previously stated, the combination purge is the recommended method because it combines blowing air into the tank with exhausting air out of the tank, resulting in a less toxic atmosphere in a shorter time. Ducts from the inlet side of a blower unit are extended to the aircraft. This unit is used to exhaust the vapors out of the tank. Ducts from the outlet side of another blower will be used to blow air into the tank. Requirements for tank atmosphere monitoring or testing are the same as for blow or exhaust purging alone.

Ventilation procedures

Ventilation provides fresh air to the entrant in a fuel tank after the tank has been purged to a fire-safe level. If the tank requires an air supply to maintain or lower the LEL or chemical concentrations, the process is considered purging, not ventilation. Tanks can be ventilated using the same equipment and connections required for an air purge operation. When applying ventilation to a tank, check the ppm every four hours, or more often as determined necessary. Ensure that no fuel is brought into the tank. Solvents, sealants, adhesives, or other chemicals are permitted in quantities that will not cause the generation of a hazardous atmosphere. If a hazardous atmosphere is generated by any of these items, initiate air purge methods.

246. Handling explosion-suppression foam

The Air Force uses explosion-suppression foam in some aircraft fuel tanks to suppress explosive reactions, control ignition rate of burning fuel vapors, and act as a baffle to limit fuel sloshing. It is not a *foamy* substance; it is more like a cross between a sponge and a scrubbing pad used to clean dishes. Fuel tanks containing fuel foam should not explode when pierced by ground fire or when subjected to electrical arcs from failed components or lightning. Foam removal, inspection, storage, and replacement are all a part of your job.

Foam removal procedures

Foam may be removed from an aircraft fuel tank or cell after the aircraft has been defueled, drained, and purged. Always wear chemical-resistant gloves and remove foam slowly to minimize static electricity buildup. Fuel wetted foam tears easily, so use care to prevent tearing the foam. In accordance with TO 1–1–3, entrants shall not “tunnel” through the foam. This is for your safety. While you may be able to remove enough foam to do the job, it may not be enough for a rescue team to get you out.

Foam inspection criteria

After removal and before storage, foam must be inspected for the following:

- Legibility of marking.
- Cleanliness or contamination.
- Burning or singeing.
- Deterioration.
- Tears or punctures.

Explanation of these defects and appropriate corrective actions are explained further in TO 1–1–3, Chapter 5.

Foam storage requirements

Foam can be stored either indoors or outdoors, but the requirements differ for the two locations.

Indoor storage

When storing reusable foam indoors, place it in clean, electro-static-free plastic or canvas bags, or place it on a clean, electro-static-free plastic or canvas ground cloth and cover it with clean, electro-static-free plastic or canvas. The bags must be placed either in a segregated storage area or retained near the aircraft. Segregated storage areas must be approved by the fire protection services and safety office.

Do not store foam in direct sunlight or expose it to high temperatures/high humidity.

Outdoor storage

Short-term outdoor storage of foam is authorized for aircraft in fuel systems repair areas not collocated with an approved-fuel systems repair facility or segregated (separate) foam storage area. Protect foam from exposure to particulate contamination, direct sunlight, and water. Place foam in clean, electro-static-free plastic or canvas bags, or place on a clean, electro-static-free plastic or canvas cloth; also, cover with either clean electro-static-free plastic or canvas. Store the foam in shaded areas around or under the aircraft.

Foam disposal

You must store and dispose of foam not to be reused in accordance with applicable environmental regulations.

Replacement of foam

Foam can be ordered from supply in bulk or precut kits. Use a sharp electric knife, Ontario knife, or a band saw with self-cleaning blades to cut foam pieces. The electric or Ontario knife is best for cutting small quantities or individual replacement pieces of foam. Cut replacement foam identical in form. Mark replacement foam with proper alphanumeric identifier.

Reinstallation of foam

Proper reinstallation of foam is extremely important. Voids designed in the foam provide clearances around fuel systems components such as vents, pumps, probes, and interconnects. All maintainers ensure that proper clearances are maintained around components during reinstallation. After installation, all components inside that fuel tank are tested operationally in accordance with the applicable aircraft TO. If 25 percent or more of the aircraft or fuel tank/cell foam has been removed and reinstalled or replaced, you may need to flush and test the system. Refer to the applicable weapons system TO for fuel system flush and fuel sample requirements.

247. Preparing the drained, opened, and purged tank for maintenance

Now that the tank has been drained, opened, and purged, you may have a few more requirements to meet before you can actually begin maintenance. The tank may require depuddling, removal of internal braces, or both.

Depuddling

Depuddling is the removal of residual fuel that remains after the tanks are drained. The purpose of depuddling is to remove fuel located in low places in the tank so that maintenance can be performed. This process is extremely hazardous because it requires entry into the tanks to remove residual fuel. Depuddling is done using absorbent cloths, sponges, mops, and an approved-safety container or air operated vacuum. All fuel puddles in the path of airflow or where work will be done must be removed. Always wear chemical-resistant gloves and a full-faced, supplied-air respirator when depuddling.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

244. Performing purging procedures

1. What is the purpose of purging a fuel tank or cell?

2. How should approved fuel collection containers, such as bowsers, be identified?

3. Why would aircraft using JP–5 or JP–8 not require purging?

4. What is the difference between air purging and ventilation?

5. What is considered an "entry-safe" atmospheric condition in a fuel tank containing foam?

6. The PID is the meter of choice. During tank entry, where must the PID be located?

7. How often must you record a reading during normal tank entry?

8. During foam removal, how often must you take and record the tank atmosphere?

245. Using air purging methods

1. What air purge method is the preferred method?

2. During preparation for blow purging, what step must be taken immediately before removing the access door?

3. What should you do if the blower motor begins to malfunction during a blow purging operation?

4. After blow purging a fuel tank for the initial 30 minutes, you check the LEL. What should be done next if the LEL is above 20 percent?

5. How often must a LEL check be made on aircraft containing foam?

6. Which type of purging results in a less toxic atmosphere in a shorter time?

7. What procedure supplies fresh air to a tank once it is fire safe?

246. Handling explosion-suppression foam

1. Why is explosion-suppression foam used in some aircraft fuel tanks?

2. What safety equipment must you wear when removing foam from a fuel tank or cell?

3. What is foam inspected for after removal?

4. How should foam be stored in a hangar?

5. When storing foam outside, from what elements should it be protected?

6. If necessary, what tools are used to cut foam pieces?

7. What must occur if more than 25 percent of the foam in a fuel tank has been replaced?

247. Preparing the drained, opened, and purged tank for maintenance

1. What is the purpose of depuddling a fuel tank or cell?

2. What equipment is used for depuddling?

3. How much fuel should be removed from a tank by depuddling?

4. What safety equipment must be worn when depuddling?

Answers to Self-Test Questions

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1. They must be kept clean, be maintained in good repair, and remained off limits to nonessential personnel.
2. The MXG/CC.
3. A new facility requires a privacy enclosure.
4. To prevent fumes and vapors from migrating from the aircraft repair area.
5. Drain all aircraft fuel tanks and defuel before the aircraft enters the facility, any adjoining offices should be isolated or evacuated during fuel system maintenance.
6. Position the ducts outside the facility doors, and position them to prevent fuel fumes from traveling back into the facility.
7. They must meet the requirements of the National Electrical Code for Class I, Division 1 hazardous locations.

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1. At the beginning of each shift.
2. Aircraft external power receptacle, fuel control panel, and single point receptacle.
3. Ensure they are disconnected in accordance with the applicable aircraft TO and tagged with AF Form 1492.
4. Ensure it is serviceable, properly positioned and bonded/grounded to the aircraft, if required.

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1. Within 100 feet.
2. Fire protection services.
3. 90 ppm or 1.5 percent LEL.
4. (1) Cutting.
   (2) Grinding.
   (3) Welding.
   (4) Soldering.
   (5) Brazing.
5. Part B, the bottom portion below the perforation.

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1. Intrinsically safe radios only.

2. 300 feet.
3. A red REMOVE BEFORE FLIGHT safety streamer.
4. Only when a yellow REMOVE BEFORE FUELING/DEFUELING streamer is not available.
5. To control foot traffic into the facility.

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1. It must be equipped with antistatic, nonmetal wheels, and inspected prior to bringing into the area.
2. To ensure that no equipment is left on or in the aircraft during fueling, defueling, or flight.
3. Outside the 50-foot marked area and upwind if possible.
4. The HDU–13/M heater, explosion-proof fans and blowers, air purifier cart or any other explosion-proof and intrinsically safe equipment.
5. Inspect the step surface to ensure it is not worn and ensure the stand is equipped with a static discharge plate and bonding wires.
6. Hand carried in nonmetallic containers, such as fiber-board boxes or canvas bags.

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1. Logistics group commander MXG/CC or equivalent.
2. The fuel systems section chief.
3. Attendants.
4. Any of the following:
   - Monitors essential fuel tank/cell entry support equipment within the facility/repair area to ensure safe and continuous operation.
   - Notifies immediately the attendant if a hazard develops or support equipment becomes inoperative.
   - Summons rescue team in accordance with the emergency response and rescue plan.
   - Acts as member of first team rescue in the event of an emergency.
   - Monitors, when authorized, multiple repair areas provided they are capable of maintaining effective communication with the attendants.
   - Performs duties of the attendant, if qualified, during rescue but shall not enter the fuel tank/cell.
5. BEF.
6. Safety.
7. Provide training on subject matter for which they have expertise.

242

1. MXG/CC, fire protection services, safety, and BEF officials.
2. Alerts the runner and ensures the tank is being properly ventilated.
3. If authorized by the emergency response plan but not until the runner assumes the duties of the attendant.
4. Trained in CPR and self-aid buddy care or its equivalent.
5. The size of the rescue team must be sufficient to ensure that no unattended rescue activity occurs.
6. At least once a year.

243

1. 1 year.
2. Entry authority and designated alternate.
3. Amend or reissue the entry permit.
4. MEP.
5. They must amend or reissue the entry permit.
6. At the job site.
7. Each completed permit, including those that are canceled or revoked, shall be retained for 1 year by the organization responsible for the entry and be available for review.

244

1. To remove volatile fuel vapors from a fuel tank or cell and reduce the LEL of the atmosphere while retaining an acceptable percentage of oxygen in the tank.
2. They must be marked to denote the grade of fuel contained within.
3. Because the LEL can be maintained at acceptable levels by simply ventilating the tank.
4. Air purging is accomplished to make the tank fire-safe and entry-safe. Ventilating is the process of supplying fresh air to an entrant once the tank is considered acceptably purged.
5. 20 percent LEL.
6. It must stay turned on and in the vicinity of the entrant at all times.
7. Every 4 hours and record on the entry permit.
8. Every 15 minutes.

245

1. A combination purge.
2. Start the air mover and blower, and bond the air ducts to the aircraft.
3. Immediately remove the air duct from the aircraft and move the blower and duct to an area free of fuel fumes, vapors, then turn the blower off.
4. Purge the tank for an additional 15 minutes and recheck the LEL.
5. Take reading every 15 minutes or more often as deemed necessary.
6. Combination purge.
7. Ventilation.

246

1. To suppress explosive reactions, control the rate of burning fuel vapors, and act as a baffle to limit fuel sloshing.
2. Chemical-resistant gloves.
3. Legibility of marking; cleanliness or contamination; burning or singeing; deterioration; and tears and punctures.
4. It should be placed in a clean, electro-static-free plastic or canvas bag, or placed on a clean, electro-static-free plastic or canvas ground cloth, and cover it with clean electro-static-free plastic or canvas.
5. Particulate contamination, direct sunlight, and water.
6. A sharp electric knife, Ontario knife, or band saw with self-cleaning blade.
7. You may need to flush and test the system, and take fuel samples.

247

1. To remove fuel located in low places in the tank so that maintenance can be performed.
2. Absorbent cloths, sponges, mops, and approved safety containers or vacuum.
3. All fuel in the path of airflow or where work will be done.
4. Chemical-resistant gloves and a full-faced, supplied-air respirator.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

Please read the unit menu for unit 5 and continue ➔

Unit 5. Integral Tank Maintenance

THE FUNDAMENTAL REASON FOR TROUBLESHOOTING is to locate the exact source of trouble and fix or replace the bad unit as quickly as possible. Leak detection and the analysis of leak paths are the troubleshooting methods used to find the exact location of integral tank leaks so the proper repair or replacement of defective seals can be made as quickly and efficiently as possible. Many circumstances can produce a seal failure (e.g., hard landings, excessive strain during violent maneuvers, vibration due to an inherent aircraft characteristic, shrinkage, and or failure of sealant over time, sloppy maintenance, etc.).

When making repairs, do all jobs properly the first time so that you will not have to do them again. One maintenance handbook states that correct repair is of the utmost importance, and a failure in the same area later is evidence of poor quality workmanship. A quality repair of each leak you are repairing may save many hours of work in the future, as well as provide a safer aircraft for the aircrew. If you expect to do a first-class job, no single step in a seal repair can be overlooked. Each step in seal repair and sealant application is discussed in this unit.

5–1. Fuel-Leak Evaluation and Isolation

Troubleshooting and repairing aircraft fuel leaks are a major portion of your job as a fuel systems journeyman, and each step in the process must be accomplished with accuracy. It is simply not enough to know how to apply sealant to a suspected leak area; you need to be familiar with the procedures to locate and classify a fuel leak, perform leak path analysis, and isolate the leak source before any maintenance can be started. Even the most perfect sealant repair job will leak if accomplished in an area that is not the true leak source. The first lesson of this unit should refamiliarize you with the constructional features of an integral fuel tank, an important starting point in the evaluation and isolation of an integral tank leak.

248. Integral tank constructional features

Integral tanks were developed because they offer the capability of greater fuel containment with a decrease in weight over fuel-cell type construction. The tanks are designed with a seal plane. This seal plane—covered in a later lesson—is made fuel-tight by the addition of gaskets, structural adhesives, elastic films, or other sealants. Figure 5–1 shows a cutaway view of a typical integral wing tank and its structural members.

Primary structural members

Integral tanks are built into both the wing and fuselage sections of an aircraft with the primary structural members forming the boundaries of the tank. These primary structural members—spars, ribs, and skin—form the sides, top, and bottom of the tank.

Spars

Spars are the primary lateral support of the wing, which form the front and rear boundaries of the tank (fig. 5–1, A).

Skin

The skin is the exterior covering of the wing and fuselage. It forms the top and bottom tank boundaries (fig. 5–1, B).

Ribs

Ribs give shape to the wing while forming the end boundaries of the tank (fig. 5–1, C).

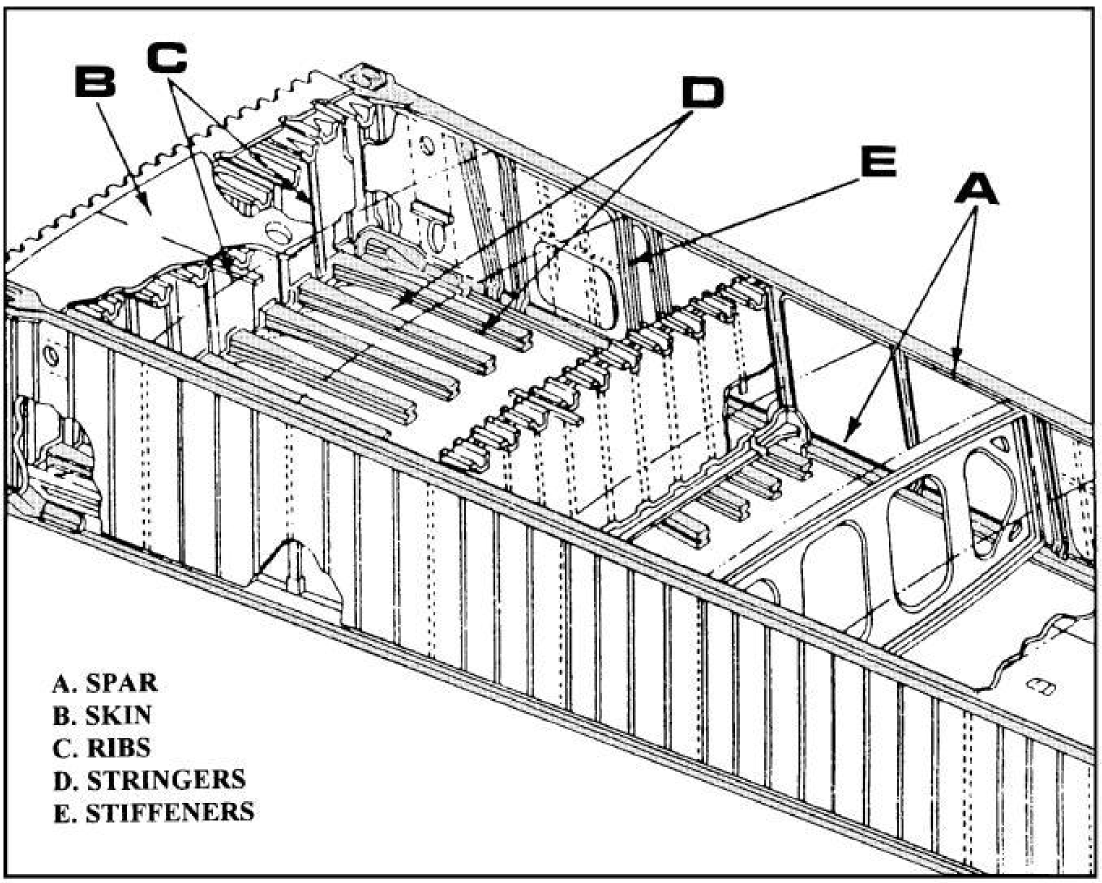

Figure 5–1. Integral tank structural members.

Secondary structural members

Secondary structural members act to stiffen and strengthen the primary structural members. These members include stringers and stiffeners.

Stringers

Stringers provide attachment points for the skin (fig. 5–1, D).

Stiffeners

The stiffeners help to strengthen the spars (fig. 5–1, E). If you have performed integral tank maintenance on a cargo aircraft, you have no doubt removed some of these components.

The primary and secondary structural components are attached by fasteners (e.g., rivets, bolts, hi-loks, etc.), which were covered in detail in a previous lesson. Now that you are familiar with the construction of an integral tank, let's look at how an integral fuel leak is pinpointed.

249. Locating a leak exit point

The four approved methods for locating a fuel-leak exit point on an integral fuel tank are leak-detection powder, torn paper, pressure test, and gas detection. The leak-detection powder method has proven to be the quickest and most cost-effective method for detecting leaks and, therefore, the most common method. The pressure test is often used to locate an exit point. The gas detection method is rarely used and is not covered in this career development course (CDC).

Leak-detection powder method

The leak-detection powder method may be used to localize a leak exit point after the leak has been detected and before the tank is defueled.

Materials used

The materials needed for this test include clean, static-free absorbent wiping cloths, non-waxed or grease pencil, leak-detection powder, and a thick-bristle brush.

Procedures

The first step in performing this method of localization is to strip exterior sealants from seams in the suspected leak areas (if applicable). This is important because the exact leak exit point may be quite a distance from where the fuel is appearing at the exterior seam seal. The fuel may be exiting the structure and traveling along the inside of the seam seal until it finds an opening to penetrate, which, of course, is not the exact leak exit point. To determine which tank is leaking, it is also important to strip the exterior seam seals near tank boundaries.

After exterior seals have been removed, blow out all seams and corners with compressed air—at a maximum of 30 psi—and wipe the area dry. Always remember to wear eye protection when using compressed air. Change cloths as often as necessary to ensure the area is completely dry. Immediately dust the area with leak-detection powder and observe the area to locate the exit point. Carefully observe the powder to identify the exact leak exit point. Mark the area with a grease pencil.

At this point, it is important to continue observing the leak area for signs of additional leak exit points. Do not immediately discontinue the process when you find a leak exit point because there may be more than one. Finally, mark all leak exit points found and wipe off all remaining powder being careful not to remove leak exit point marks.

Torn paper method

The torn paper method is very easy and can be useful in spots where you might not be able to use or see the leak-detection powder. The first couple of steps are the same—strip exterior sealants and blow out leak area with maximum 30-psi compressed air.

The materials required are clean static-free absorbent cloth, non-waxed or grease pencil, and a piece of paper. You can use a piece of computer paper or some brown Kraft paper. An old O-ring package works well.

You want to tear the paper, so you have a fuzzy edge. The fuzzy edge will help you see the fuel being soaked up by the paper. Slowly move the fuzzy edge of the paper along the suspected leak area. The paper absorbs the fuel and provides a visual indication of the presence of a leak. Mark the leak exit point with a non-waxed or grease pencil.

Pressure-test method method

If the leak-detection powder and torn paper method of trying to locate the leak exit point were unsuccessful, a pressure-test method may be used to locate leak exit points. The pressure-test method is effective for the following situations:

1. Locating leaks that appear only under stress.
2. Locating in-flight leaks.
3. Confirming a repair prior to refueling.
4. Locating multiple leaks.

Requirements

To prevent damaging the aircraft, the pressure-test method requires extensive preparation and extreme care during its preparation and execution. Pay particular attention to the aircraft vent systems and specified pressure limits of the applicable tank, and use a water or digital manometer as a pressure-limiting device for this test. In addition to the entries required in the AFTO Forms 781A, you must see that a checklist is developed to ensure all plugs, cover plates, and caps are removed when the test is completed. The test requires two people; one is stationed at the tank-access adapter to monitor the manometer, and the other will locate and mark leak exit points.

Procedures

The pressure-test method involves pressurizing the tank with air. After the tank has been pressurized, apply leak-detection compound to the tank exterior leak area. Spread the leak-detection compound with a brush, observe the area for the formation of bubbles, and mark all leak exit points found. Be sure the leak-detection compound is removed from the aircraft within 24 hours.

Locating a leak near a common tank boundary

Fuel leaks that appear near a common tank boundary of two adjacent integral tanks may originate in either tank. After locating the exit point, determine which tank is actually leaking. One method of isolating the leaking tank is to use the following procedures:

1. Transfer/defuel fuel out of the outboard tank.
2. After allowing time for residual fuel to seep out, check the leak area. If the leak has slowed or stopped, the outboard tank is leaking.
3. If the leak continues, transfer fuel to the outboard tank. Allow time for fuel to drain and recheck the leak area.
4. If the leak has stopped, the inboard tank was leaking.
5. If the leak continues, either both tanks are leaking or residual fuel is giving the indication of a leak. If this is suspected, complete steps 6, 7, and 8.
6. Empty both tanks by defuel/transfer and drain residual fuel.
7. Fuel one tank. If no indication appears, the other tank is the leaker. If the leak is indicated, remove fuel from the full tank and wait for the leak to stop.
8. Fuel the other tank. If a leak is indicated, both tanks are leaking.

Keep in mind that these are general procedures and may not apply to every situation. If specific procedures listed in the applicable aircraft technical data are available, use them. Your own experience and the experience of other craftsmen on a particular aircraft may also be useful in locating a leak on a common boundary.

250. Classifying a fuel leak

Classification of leaks is necessary to differentiate between those leaks that constitute a flight safety hazard and require repair before flight, and those that do not require immediate repair. The size of the wetted area around the leak exit point over a specific time has been determined to be an accurate way to classify the leak. Classification can be done immediately after locating the exit point (localization). Wipe the area dry with a clean, static-free absorbent cloth or use compressed air at a maximum of 30 psi to assist the drying process. Allow the leak to develop for six minutes. The size of the wetted area around the leak exit point is an accurate method to classify fuel leakage. Leak-detection powder may be applied to assist in classifying leaks.

Leak categories

Leaks are categorized as class A through D, as shown in figure 5–2. Surface irregularities may cause fuel to localize and result in dripping even though the leak is a seep or heavy seep. In these cases, use judgment and note the speed at which fuel reappears and spreads after wiping to determine the category of the leak. When in doubt, classify the leak to the next higher leak category for repair determination. In other words, if it is difficult to determine whether a leak should be class B or C, classify it as class C.

Leak limits

Leak limits are shown in the middle columns of the table in figure 5–2. They correspond to the leak category and the fuel type. Leak limits are provided for the most common Air Force aviation fuels. Classify mixtures of aviation gasoline, JP–4 JP–5, JP–8 and/or Jet A and Jet A–1 using the leak classification table.

Leak locations

The location of the fuel leak is also an important factor in determining the severity of the leak. Obviously, a leak near the engine exhaust area would be more critical than the same size leak on the bottom skin near the wing tip. The leak location used with the leak classification determines which condition and action is required. Five locations are identified for fuel-leak evaluation purposes—external, internal vented, internal non-vented, electrical conduit, and external mounted components.

External

These are areas exposed to air or airflow when airborne—upper and lower wing surfaces and exposed fuselage surfaces. Areas that are *not* considered external are those surfaces exposed to airflow only when extended—flaps and slats.

Internal vented

Internal vented areas are ventilated while the aircraft is in flight or on the ground—front and rear spars or dry bays are drained and ventilated to the atmosphere.

Internal non-vented

Areas that are normally adjacent to fuel tanks or fuel lines and have no means of air circulation even though they are drained are considered internal non-vented areas. Enclosed, sealed dry bays are examples of internal non-vented locations.

Electrical conduit

Electrical conduit tubing routes electrical wiring through any fuel tanks to any components.

External mounted components

These are components—shutoff valves or pressure switches—mounted on the outside of a fuel tank.

Leak Classification	6 Minute Leak Limits (By Fuel Type)			Location - Condition/Action				
	AVGAS	JP-4	JP-5, JP-8, Jet A and Jet A-1	External	Internal Vented	Internal Non-Vented	Electrical Conduit & Externally Mounted Component	Near Sources of Heat
Class "A" Slow Seep	0 to 1/4 inch	0 to 1/4 inch	0 to 1/4 inch	1	1	1 (2 places)	4	4
Class "B" Seep	greater than 1/4 to 3/4 of an inch	greater than 1/4 to 3/4 of an inch	greater than 1/4 to 3/4 of an inch	1	2 (2 places max)	3	4	4
Class "C" Heavy Seep	greater than 3/4 to 2 inches without dripping	greater than 3/4 to 6 inches without dripping	greater than 3/4 to 8 inches and/or less than 4 drops per minute without dripping	2	3	3	4	4
Class "D" Running Leak	greater than 2 inches or drips/runs from the surface	greater than 6 inches or drips/runs from the surface	greater than 8 inches or 4 drops per minute	3	3	3	4	4

Figure 5–2. Integral tank leak classification table.

Condition/action

Conditions/actions indicate what action must be taken in regard to the leak. Conditions/actions are determined because of crossing the leak category with the location of the leak in figure 5–2. These conditions/actions are minimum requirements. Leaks can always be repaired back to a no-leak condition.

Condition 1

Document the leak and periodically inspect it for growth to condition 2 or 3. No repair is necessary. A permanent repair should be accomplished when the fuel tank is opened for other repairs.

Condition 2

Document and periodically inspect the leak for growth to condition 3. No repair is required. A permanent repair should be accomplished when the fuel tank is opened for other repairs.

Condition 3

Document and repair to no leakage or back to condition 1 or 2. If the leak cannot be repaired back to a condition 1 or 2, the aircraft is grounded until the leak is returned to condition 1 or 2 or is permanently repaired.

Condition 4

Do not repair by applying sealants externally or by using temporary repair procedures. Correct the discrepancy by repairing or replacing the affected component. The aircraft must be grounded until the repair is complete.

Documentation

Any integral fuel tank leak must be annotated on the AFTO Forms 781A or AFTO Form 781K, Aerospace Vehicle Inspection, Engine Data, Calendar Inspection and Delayed Discrepancy Document. Leaks must also be annotated in the AFTO Form 427, Aircraft Integral Fuel Tank Repair Historical Record (fig. 5–3) or AFTO Form 428, B–1B Aircraft Integral Fuel Tank Repair Historical Record. After a permanent repair is accomplished, clear the entry on the AFTO Form 781A/K and maintain the AFTO Form 427 or 428 as a historical record.

AIRCRAFT INTEGRAL FUEL TANK REPAIR HISTORICAL RECORD PAGE 1 OF PAGES

1. MISSION DESIGN SERIES/TYPE, MODEL AND SERIES	2. MANUFACTURER	3. ACCEPTANCE DATE	4. AIRCRAFT T.O.
KC-135 61-0624	Boeing	20181207	1C-135(K)R 2-5GA-2

ENTRY	DATE	FUEL LEAK LOCATON					LEAK CLASS				TYPE REPAIR		CAUSE OF LEAK	REMARKS	ORGANIZATION
		WING R	WING L	TANK	WING STATION	STRING NUMBER	A	B	C	D	TMP	PRM			
1	20181210	☒	☐	4	427	7	☒	☐	☐	☐	☐	☐	Fastener	No Repair Required	552 CMS
2	20190205	☒	☐	4	415	5	☐	☒	☐	☐	☒	☐	Fastener	Applied Pig Putty	552 CMS
3	20190216	☐	☒	2	253	2	☐	☐	☒	☐	☐	☒	Defective Sealant	Removed Faulty Sealant; Perm Repair A-1/2, B-1/2	552 CMS
4	20190216	☐	☒	1	368	16	☐	☐	☐	☒	☐	☒	Rivet Failure	R2 Fastener, Re-applied Sealant A-1/2, B-1/2	552 CMS
		☐	☐				☐	☐	☐	☐	☐	☐			
		☐	☐				☐	☐	☐	☐	☐	☐			
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AFTO FORM 427, 20120928 PREVIOUS EDITION IS OBSOLETE

Figure 5–3. Sample, AFTO Form 427.

Always consult aircraft historical documents when fuel systems maintenance is to be performed. These documents must accompany the aircraft to depot or contract repair or to the gaining organization when the aircraft is transferred. Leaks and repairs must be entered in maintenance data collection systems, such as the Integrated Maintenance Data System (IMDS), as required.

So far, we have covered the procedures for locating the exact leak exit point and for classifying the leak. Using the results from these two procedures, you can determine how severe the leak is and whether or not it will ground the aircraft. If the leak requires repair, the source of the leak must be isolated. There are three elements of all fuel leaks—exit point, source, and leak path. You have located the exit point so look at what is involved in finding the source and the path.

251. Performing leak path analysis

Leak path analysis is one of the most important steps of integral fuel tank repair. To attempt to repair the leak without locating the entrance and exit point is useless because the repair will only be temporary. Leak path analysis is simply the study of how fuel in an integral tank leaks to the outside. As previously stated, the three basic elements of leak path analysis are as follows:

1. *Leak source*—The originating point inside the tank where the leak initially penetrates the seal plane.
2. *Leak exit point*—The area on the outside of the tank where fuel exits the aircraft.
3. *Leak path*—The route fuel takes to get from the source to the exit.

These three elements are illustrated in figure 5–4.

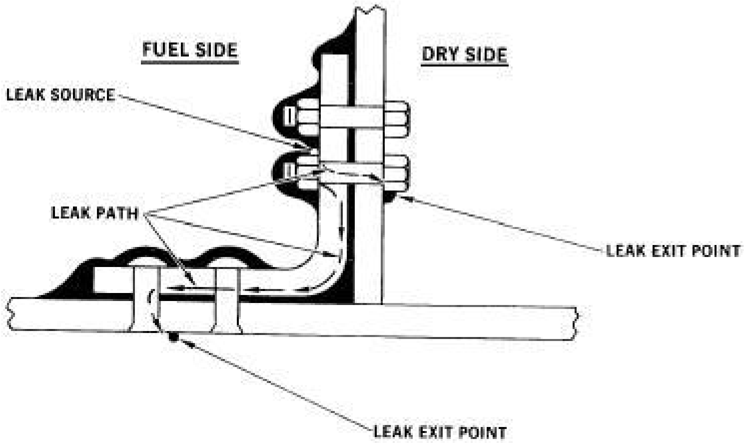


Figure 5–4. Basic elements of leak path analysis.

Analyzing the seal plane

Part of leak path analysis involves analyzing the seal plane of the leak area involved. The seal plane is the barrier containing fuel in the tank. This barrier is composed of several elements, such as sealant, aircraft structure, seals and gaskets, and fasteners. The seal plane is the farthest into the structure that fuel can penetrate, as indicated by the broken line in figure 5–5. If this seal plane is penetrated, fuel will enter a part of the structure that may not be designed to contain fuel (e.g., a channel or void). This may allow fuel to exit the aircraft several feet from the leak source. Any fuel that penetrates the seal plane will leak out at the point of least resistance (e.g., a row of fasteners in the channel may be wet, but the leak appears at only one fastener because that fastener is not as tight fitting as the others are). If that fastener was replaced or sealed over, the fastener with the next least resistance would eventually leak, and the process would continue. Looking at figure 5–5, follow the seal plane—represented by the broken line—to the center of the structure. Notice that fuel is allowed to penetrate the structure at the fastener installed horizontally but is stopped by the prepack seal. Therefore, the seal plane is drawn down to the prepack. If the prepack seal failed, fuel would break the seal plane and would most likely leak out of one or both of the inside fasteners.

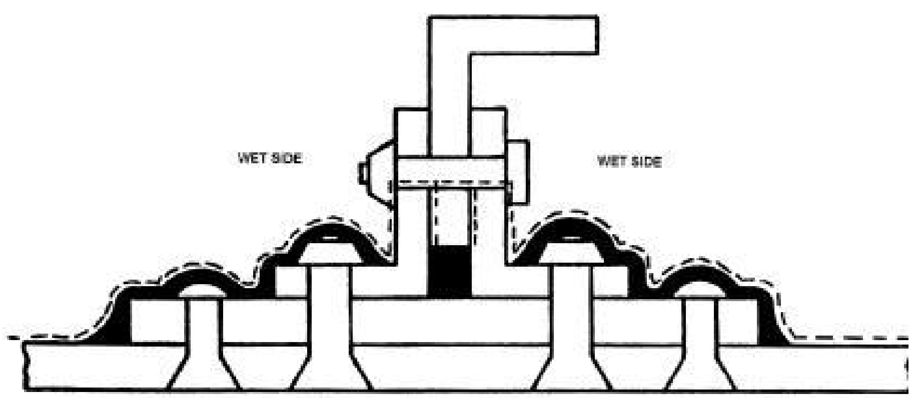
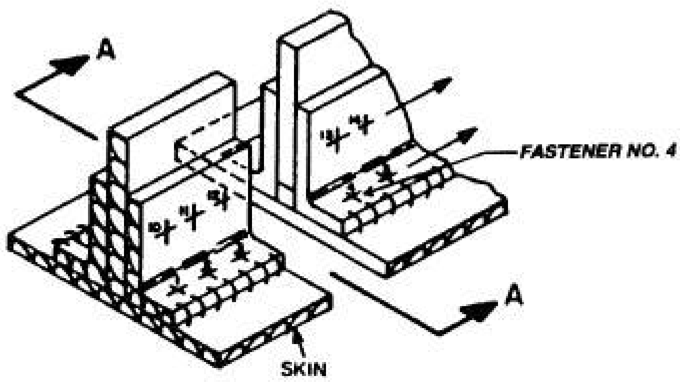


Figure 5–5. Seal plane identification.

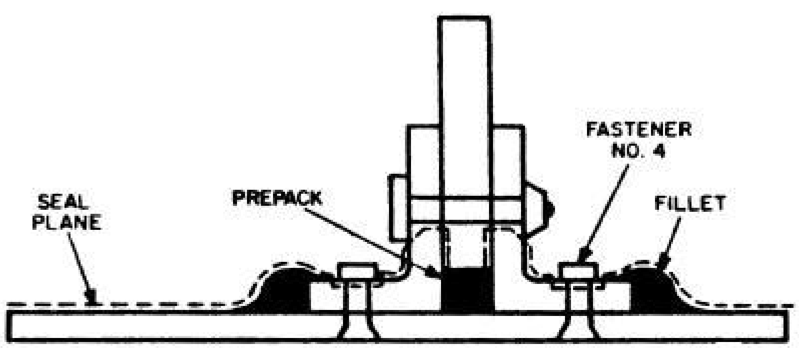
Studying the structure

Another part of leak path analysis is studying the structure in the suspected leak area. This is accomplished by using the applicable drawings in the aircraft structural sealing technical data. It is often helpful to construct a cross-sectional view of the structure to locate the seal plane as shown in figure 5–6. Look at all areas that could be possible leak sources, then trace all potential leak paths from the leak exit point to the tank interior. This process will help define the area of the tank at which the leak source or sources will be found. Always thoroughly analyze all possible leak paths between the exit point and the suspected source. When investigating the location and cause of a fuel leak in the fuel tank boundary structure, keep in mind the fuel leak may be caused by a structural failure. Fuel can leak through an almost invisible crack in the structure. Therefore, when a leak occurs, structural failure should be considered as a possible cause.

This view shows the structural configuration as found in the applicable aircraft technical manual. Let us say the exact external leak exit point was fastener number 4.



Now imagine that a hacksaw is used to cut through the structure as shown below. This exposes the internal structure of the leaking area. A cross-sectional view is drawn below showing the leaking area.



A seal plane is drawn as a dotted line to show the lowest point that fuel will be in contact with the structure. This is a tank that is leak-free or absolute sealed tank. It is easily seen that if fastener number 4 were leaking, the leak sources could be a defective adjacent fillet or the self-sealing fastener itself. The tank will leak any time the seal plane is penetrated

Figure 5–6. Cross-sectional views.

Inspecting the tank interior

Once you have located the exit point and analyzed the leak path, the next step is to inspect the tank interior. A thorough investigation of the area surrounding the leak exit can help isolate the leak source. Study the structure in the leak area and the direction from which the leak seems to be flowing.

Visible defects in the sealant or structure may not necessarily be signs of a leak source. Do not attempt to repair a structural failure by applying sealant to the failed area. You may find that an inspection checklist is helpful when performing a visual inspection of the tank interior. The following possible sealant defects should be included on this checklist:

1. Previously repaired areas.
2. Cracks, scuffs, or nicks.
3. Indications of air bubbles or shrinkage.
4. Lack of adhesion. This is checked by applying a maximum of 100-psi air pressure keeping the nozzle approximately 1 inch from the sealant. The sealant should not separate from the surface.
5. Loss of luster, discoloration, chalking, or missing topcoat.
6. Loss of elasticity. This is checked by firmly pressing sealant with a blunt metal punch *not* smaller than 3/16-inch diameter. The sealant is serviceable if it gives and returns to its original position. The sealant is defective if the punch penetrates it or if it does not return to its original position.

The tank interior should be inspected for loose, cracked, or missing fasteners.

Now that you have found the exact exit point of the fuel leak on the exterior surface of the fuel tank and leak-source analysis has shown the items that should be inspected, how do you pinpoint the leak source inside the fuel tank? How can you attempt a repair without knowing what to repair? There are several methods of isolating a leak source in an integral tank.

252. Using leak-source isolation methods

Leak-source isolation or detection methods are used to assist you in locating the defective area inside the fuel tank. The tests covered here are general in nature, and some of the tests may not be permitted on the type of aircraft that you are repairing. These “leak-source detection methods” will vary in their methods of the pressure used. Some will use a positive pressure, and some will use a negative pressure or vacuum source. Before performing a particular leak test, know which tests are permitted and the sequence in which they are to be performed. The authorized methods, in order of ease and least time required are blow back, pressure box, and leakage-tracing device. Regardless of the method used, always ensure all leak sources are located before starting repairs.

Blow-back method

The blow-back method requires at least two people. This procedure is accomplished by applying non-corrosive leak-detection compound to the suspect leak source and then directing air pressure using an air nozzle into the exact leak exit point. Bubbles will appear in the leak-detection compound when air enters the leak path. Refer to figure 5–7. You want to apply air pressure to the exact leak exit point. The nozzle should be kept a half inch from the surface, and the air pressure can range from 1 to 100 psi. After bubbles are detected, mark the area and, then, you can begin the repair.

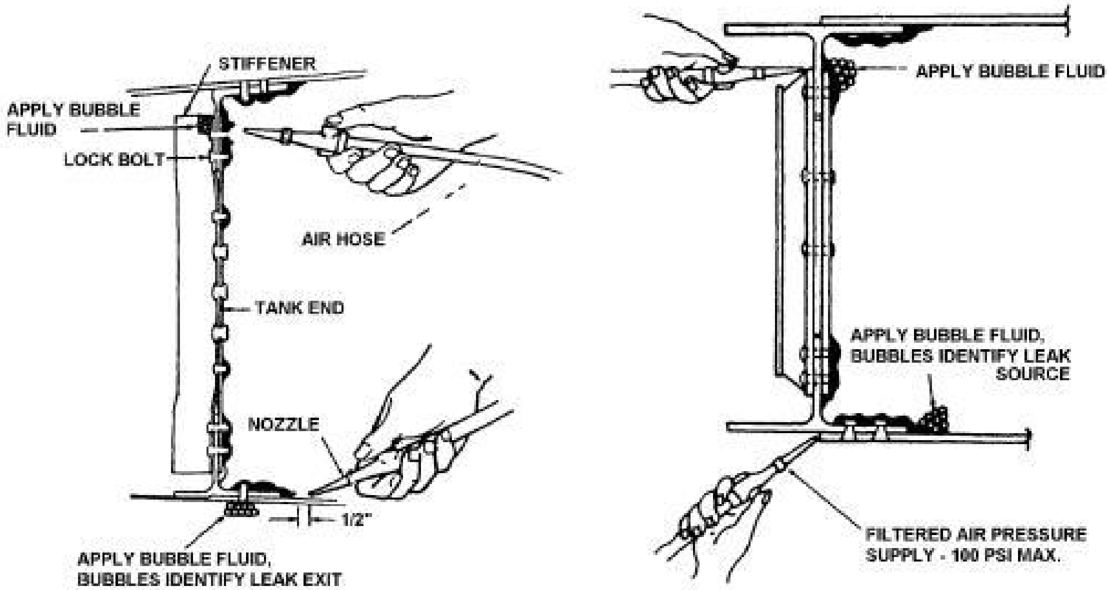


Figure 5–7. Blow-back method.

Leakage-tracing device

If the blow-back method of locating the leak source fails, use the leakage-tracing device. This method requires a small amount of dyed fuel to be injected through the leak exit point. The dye may be red, which leaves a stain, or fluorescent, which is visible with the aid of an ultraviolet light (black light). Several accessories may be used with the dye injection method.

Double-cup assembly

The double-cup assembly is an accessory to the leakage-tracing device. Cups are attached to the inside and outside of the fuel tank. You can then force a dye solution through the leak exit point to the leak source.

Hollow-bolt dye injector

The hollow-bolt dye injector forces dye between the aircraft structure and is an accessory to the leakage-tracing device. Only use the hollow-bolt dye injector when the double-cup assembly method did not identify the leak source.

Vacuum cup

The vacuum cup may be used to confirm sealant repairs or to identify a leak exit point by pulling air, dyed fuel, or leak-detection compound through the tank structure and into a plastic container.

Pressure box

This method involves pressurizing a large exterior surface area, which in turn forces dye back through the leak path into the tank (fig. 5–8). The pressure box attached to the outside of the tank may be flat or contoured. This method is useful in locating seep-type leaks.

Vacuum dye (negative pressurization)

The vacuum dye technique utilizes a control panel, with a water manometer or a digital manometer to create a vacuum pressure throughout the entire tank. This method pulls air, dyed fuel, or leak-detection compound through the tank structure to confirm the leak source. Vacuum dye is used as a last resort when all other methods of isolating a leak source have failed. To prevent damaging the aircraft, the negative pressure-test method requires extreme care during its preparation and execution. Pay special attention to the aircraft vent systems and always use the specific aircraft tech data.

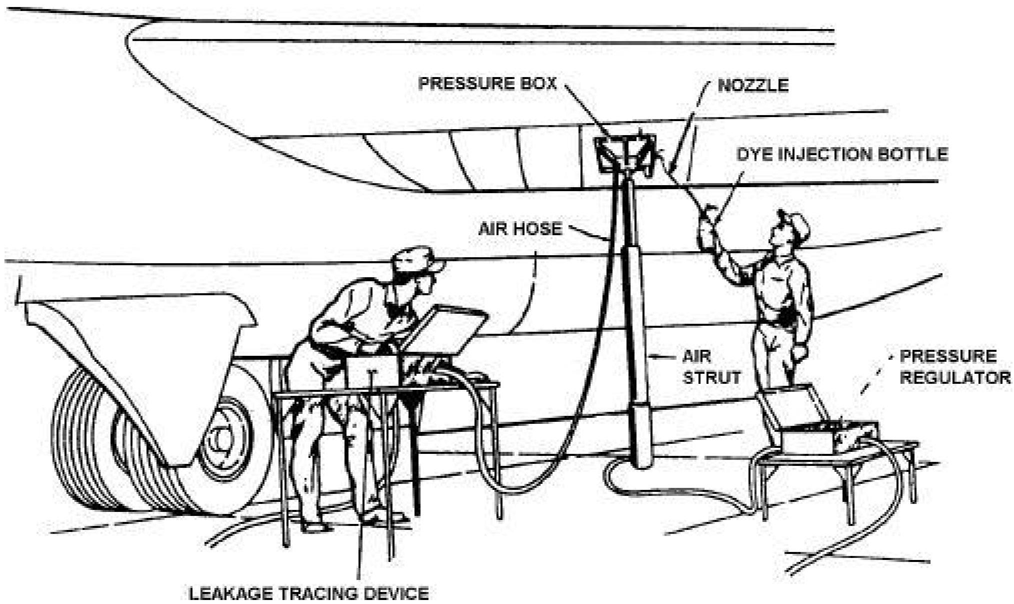


Figure 5–8. Using the pressure box.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

248. Integral tank constructional features

1. What advantage does an integral tank have over a fuel cell?

2. What are the primary structural members of an integral tank?

3. Which structural members form the end boundaries of the fuel tank?

4. What purpose do the stringers serve?

5. Which components aid in strengthening the spars?

249. Locating a leak exit point

1. What are four approved methods to locate a fuel-leak exit point?

2. Why is it important to strip exterior sealants from seams in the suspected leak area as the first step in locating a fuel-leak exit point?

3. What is the maximum air pressure used to blow out seams when using the torn paper method?

4. What provides a visual indication of a fuel leak when using the torn paper method?

5. The pressure-test method of leak localization is considered effective for which situations?

6. What safety requirements must be followed when performing the pressure-test method?

7. How long should leak-detection compound be allowed to remain on the aircraft?

8. When locating a fuel leak near a common tank boundary, which tank should you defuel/transfer first?

250. Classifying a fuel leak

1. At what point is classification of a fuel leak performed?

2. What maximum air pressure may be used to dry the leak area during leak classification?

3. What should you do when in doubt as to the category of a fuel leak?

4. What are two examples of internal vented areas on an aircraft?

5. What action is required for a condition 1 fuel leak?

6. If a fuel leak with a condition 3 cannot immediately be repaired, what action must you take?

7. On what forms must all integral tank fuel leaks be documented?

251. Performing leak path analysis

1. What is the purpose of leak path analysis?

2. What are the three elements of leak path analysis?

3. What is the seal plane?

4. What effect may a seal plane penetration have on leak path analysis?

5. When using structural and sealing technical manuals to study the aircraft structure in the suspected leak area, what procedure may help to trace all potential leak paths?

6. What procedure should be used to check sealant for adhesion?

7. How is sealant checked for loss of elasticity?

252. Using leak-source isolation methods

1. What are the authorized leak-source isolation methods in order of ease of performance?

2. What leak-source isolation method involves directing compressed air at the leak exit point and applying leak-detection compound inside the tank?

3. What types of dye are used with the leakage-tracing device?

4. What accessories are used with the leakage-tracing device?

5. What is the purpose of the double-cup assembly?

6. When would the hollow bolt be useful?

7. Briefly explain the pressure box method of leak-source isolation.

8. In what situation would the pressure box be useful?

9. When would the vacuum dye method be used?

5–2. Integral Tank Sealant Repair

The task of applying sealant to an aircraft structure for containing fuel requires a thorough knowledge of sealants and their application. How many times have you inspected someone's repair and discovered that he or she used incorrect or unserviceable sealant for the application? This section addresses an array of sealants authorized for use during integral tank maintenance. We will discuss uses and characteristics of each major type, as well as the sealing methods used in an integral fuel tank.

253. Characteristics of sealants

Several types of sealants are available for use in sealing integral fuel tanks. These types are divided into three categories—curing sealants, non-curing sealants, and structural adhesive sealants.

Curing sealants

Curing-type sealants are composed of two parts—a base material and an accelerator. The accelerator is added to the base compound before the sealant is mixed. When mixed together, the sealant begins to cure. The cure depends on the type of sealant, temperature, and humidity. It cures to a semi-hardened state and remains flexible. If it did not remain flexible, it would crack as the aircraft structure flexes.

Curing-type sealants have an *application life* or time during which the sealant remains suitable for use. The application time or life for multi-part sealants is the time the mixed sealant remains suitable for application with a brush, injection gun, or filleting gun. This application life is based on standard conditions of 70° F and 50 percent relative humidity. The application life is indicated by the dash number of the sealant and is indicated in hours. You may use B–1/4, B–1/2, or A–2. B–1/4 gives you 15 minutes of application life; the 2 indicates two hours of application life. Do not use sealant when it will no longer wet the surface to which it is being applied or when it is beyond its established application life.

The *tack-free time* of a sealant is the time required for a sealant to cure to the point at which the outer surface will not stick to a plastic film. The tack-free condition can be tested by either touching a piece of plastic or a sealing gun nozzle to the sealant. If no sealant transfers, the sealant is tack-free. Do not fill fuel tanks until sealant is tack-free.

Non-curing sealants

Some aircraft have voids or channels that cannot be sealed with curing type sealant. For these areas there have been non-curing sealants developed. Non-curing sealant is a one-part sealant that remains in a semi-fluid state. Most non-curing sealant contains beads of material that swell when contacted by fuel. The swelling fills the channel and prevents fuel leaks. Temperature changes can affect the sealant; when the weather turns cold, you tend to get more fuel leaks. Simply injecting new sealant into the channel should stop the leak. Non-curing sealants are generally limited to areas where access is difficult or impossible (fig. 5–9).

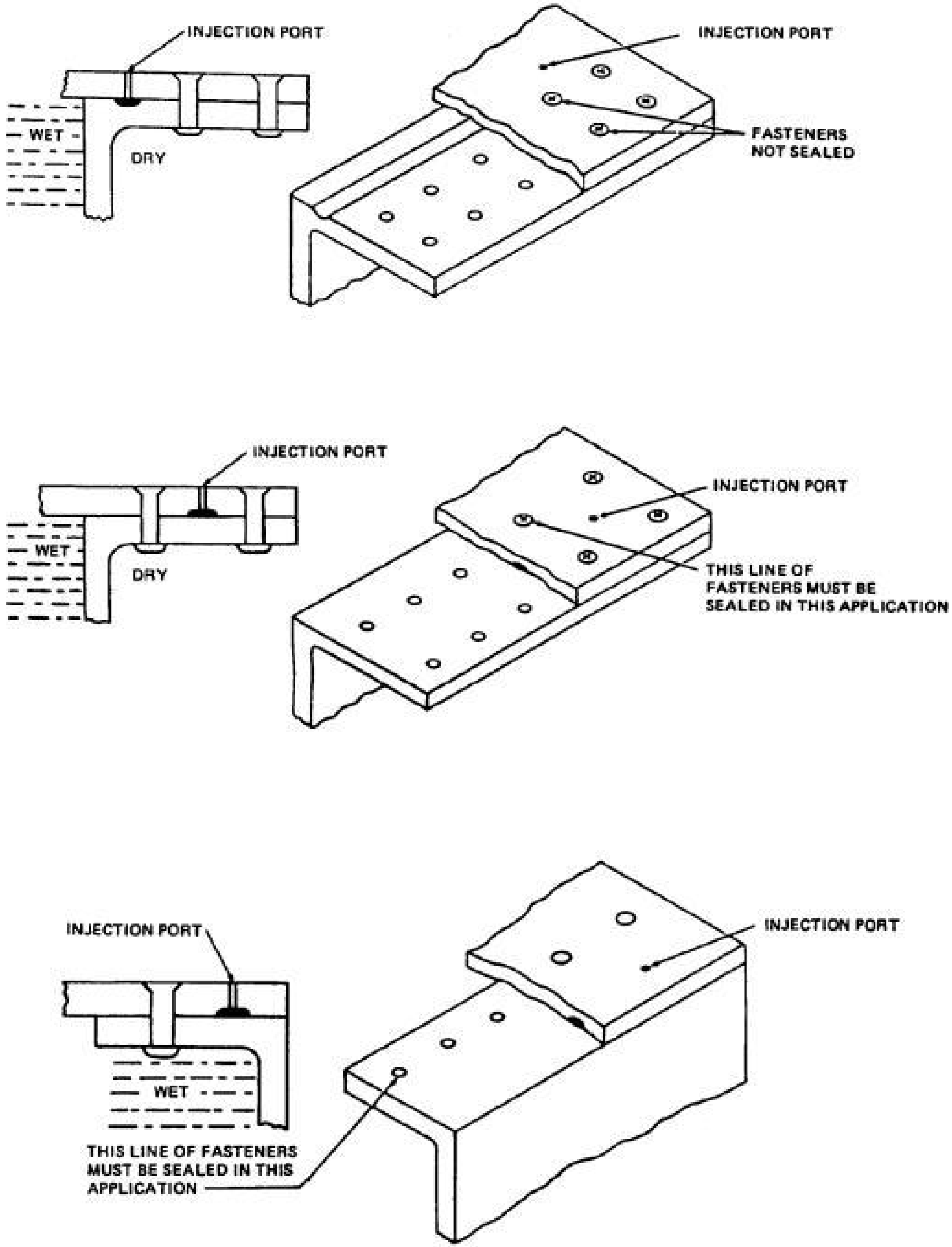


Figure 5–9. Typical locations of injection grooves/channels.

Structural adhesive sealant

Typically, structural adhesive is used during the aircraft manufacturing process (fig. 5–10). It bonds the structure together and seals faying surfaces. It is cured with heat but remains flexible. Generally, fuel leaks are repaired with curing type sealant fillets or topcoats since major structural disassembly is impractical.

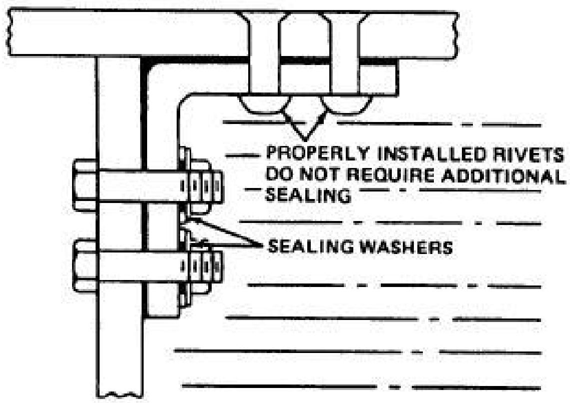


Figure 5–10. Structural adhesive sealing.

254. Access door and fastener sealing methods

Integral fuel tank-access doors are constructed in many shapes and sizes, but there are two basic types—plug and direct-seal (fig. 5–11). A *plug-type access* door opens into the fuel tank. Because of this design, pressure inside the tank acts on the door, providing a tighter seal. *Direct-seal access* doors open to the outside of the tank and fuel pressure tends to push on the door, increasing the load on the door fasteners. The fasteners provide the clamping force used to seal the door.

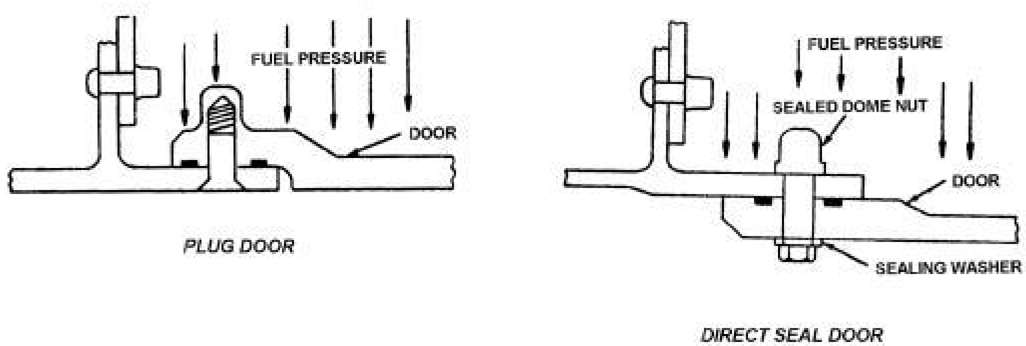


Figure 5–11. Access door sealing methods.

Regardless of the basic type, all access doors are sealed with a static seal of which there are five main configurations—flat gasket, O-ring, molded-in-place, bonded-in-place, and formed-in-place. The first three are illustrated in figure 5–12.

Flat gasket seal

The flat gasket seal is the oldest method of tank-access door sealing. It is simple to manufacture locally and install but may wrinkle easily or require occasional retorque of the fasteners to provide a fuel-tight seal. This type of gasket can be made locally (if need be) from thin rubber or cork. Obviously, flat gasket seals can be used on flat mating surfaces only.

O-ring seal

The O-ring seal method requires that matching is to be machined in the access door and mating surface. When properly installed, they exhibit no leakage and are generally maintenance-free. Disadvantages of this type of seal are that O-rings

- may be installed in the wrong position,
- can be difficult to install around corners or bends, and
- are not reusable.

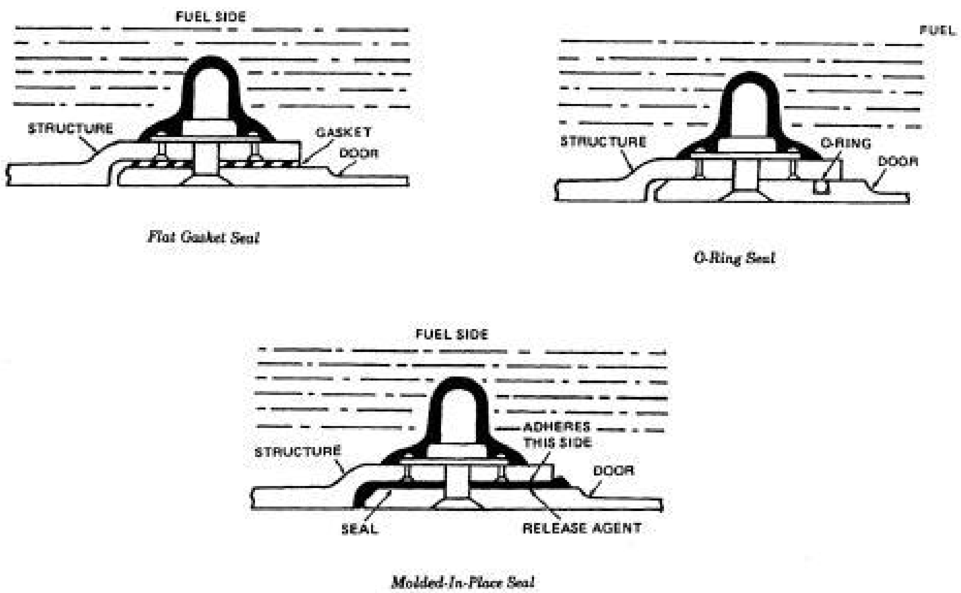


Figure 5–12. Access door seal configurations.

Molded-in-place seal

This method uses a seal molded to the access door during manufacture. They generally provide a good seal and are reusable. This method costs more because when the seal fails, the entire access door must be replaced. However, curing-type sealant can repair minor nicks and cuts in the door seal.

Bonded-in-place seal

This seal is identical to molded-in-place seals except that bonded-in-place seals can be removed, and a new seal bonded in place of the damaged one.

Formed-in-place seal

The formed-in-place seal is established by the application of curing-type sealant and a parting agent between the access door and mating surface. The door is installed prior to the cure of the sealant. Removal of the door frequently destroys the seal. The old sealant must be removed, surfaces cleaned, and new sealant applied.

Fastener sealing methods

The fasteners used in the construction of an integral fuel tank can be divided into two major types—self-sealing and non-self-sealing. Examples of both types are shown in figure 5–13.

Self-sealing fastener

The self-sealing fastener seals the hole by either swelling when installed or by interference fit; this forces the fastener against the sides of the hole by a few thousandths of an inch. The swelling action is caused by the bucking of the fastener (rivet) and is normally enough to prevent fuel from leaking past the fastener. When a leak occurs at a self-sealing fastener, usually it is repaired by applying a fillet seal over the fastener inside the tank.

Non-self-sealing fastener

The non-self-sealing fastener cannot be installed in a hole and expected to be fuel tight. Examples of non-self-sealing fasteners are access door screws, bolts, and hollow rivets, which slip into the holes with little or no interference. One or more of the following methods usually seal them—dome nuts, sealing washers, O-rings, sealant overcoats, machine fittings, and sealant channel.

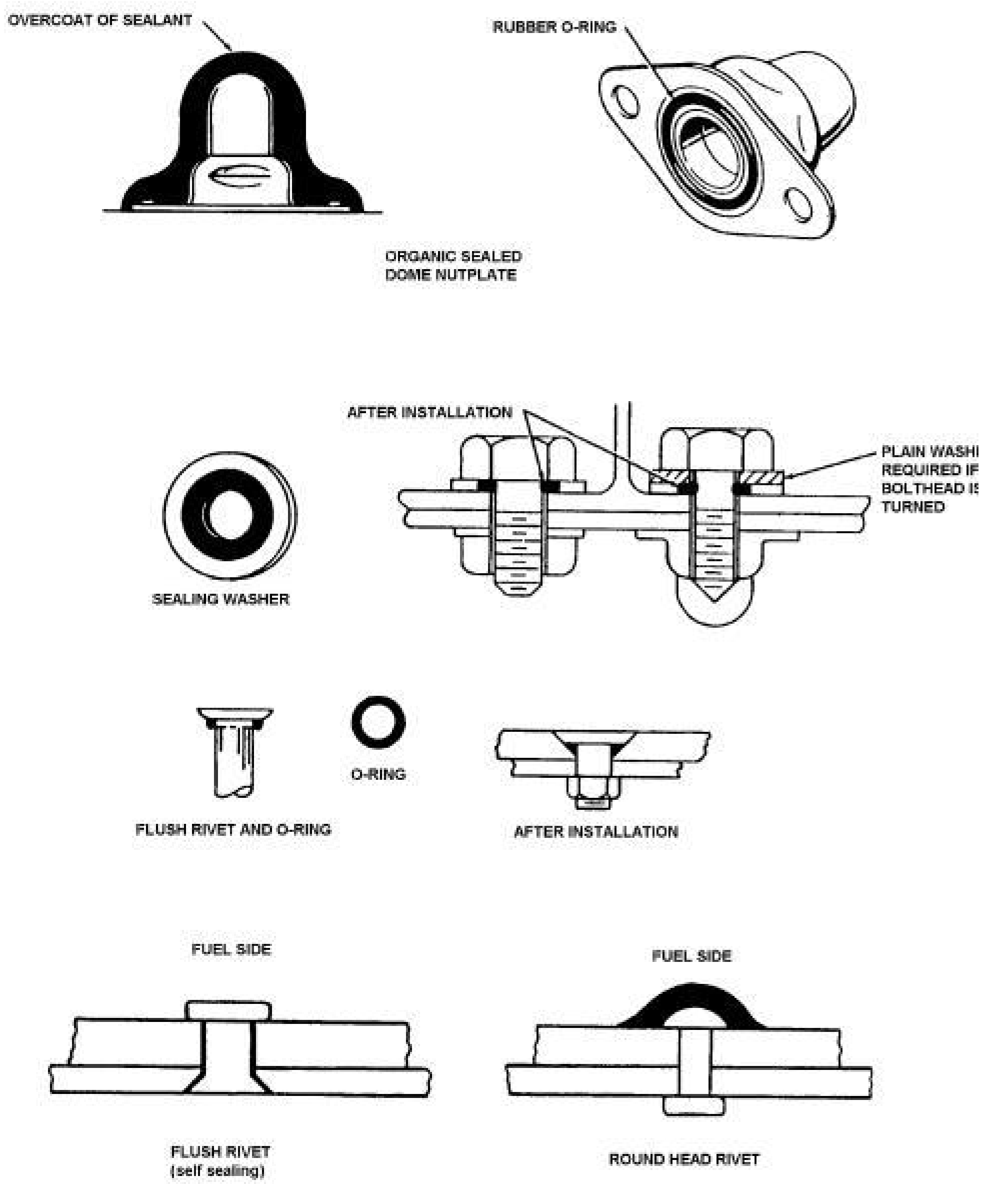


Figure 5–13. Typical fastener seals.

255. Preparing the tank structure for sealing

If possible, try to repair a fuel leak by partial desealing and replacing only the defective sealant. Do not add more sealant to the aircraft than needed to repair the tank. For each pound of sealant added (beyond the minimum required for a complete seal), you have unnecessarily decreased the payload of the aircraft by one pound. In addition, the extra volume of sealant decreases the fuel capacity of the tank. You should try to limit the weight and volume of the new sealant to the weight and volume of the removed sealant.

Removing damaged sealant

After determining which seals must be removed, you are ready to go to work. It is never a good idea to start cutting away old sealant in the area of the seal plane penetration. When repairing a damaged fillet seal, it is not necessary to cut away an entire length of sealant simply to make the repair begin and end at a structural member or at a corner. If the sealant shows no signs of deterioration and has a good bond with the metal surface, a short section can be cut away (fig. 5–14).

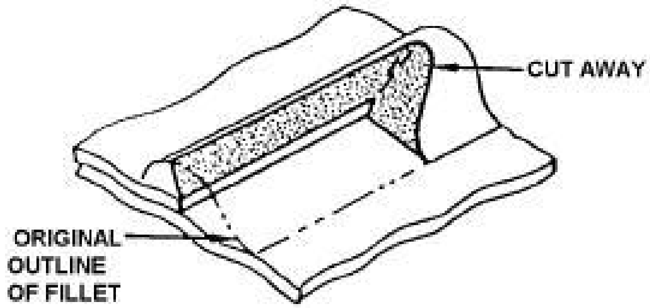


Figure 5–14. Fillet seal cut away for repair.

Both ends of the repair should be cut at approximately a 45-degree angle and abraded at least 1/2-inch to promote adhesion. Prepare the surface for the new seal. If you are working in close, cramped quarters, try resting your hand or arm against a support so if the cutting tool slips, you will not scrape off any of your skin. Also, try to work in a brace—that is, with one hand steadying and bracing the other (fig. 5–15). A pair of cotton gloves also helps to protect your hands against knuckle skinning.

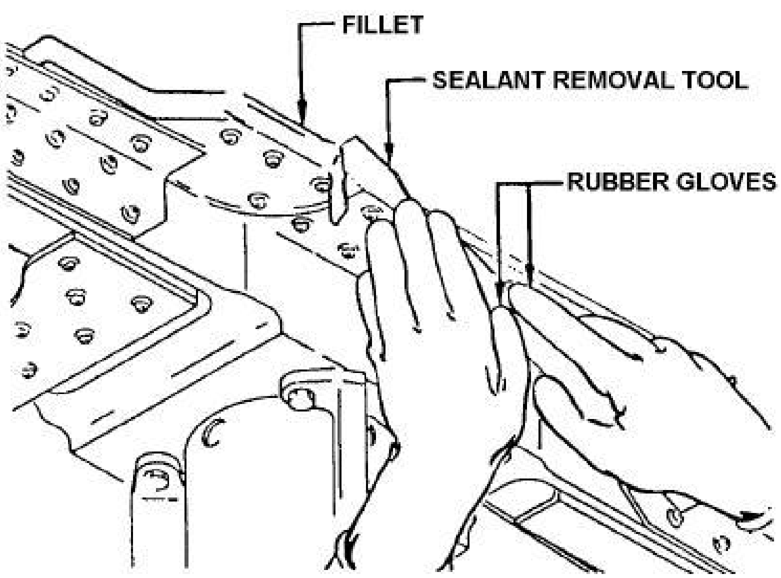


Figure 5–15. Removing faulty sealant.

If necessary, cover the bottom of the tank with barrier material or wiping cloths to protect the tank coating from debris, tools, and other foreign materials. Use only an approved spatula or scraper made from plastic, wood, phenolic, or aluminum to remove the defective sealant. You may remove sealant from short prepacked or injection seals with a hooked wire and a small cutting tool. The entire seal must be clear to permit complete filling with new sealant. Sealant from faying surfaces and some prepacked surfaces or long injection seals cannot be removed without structural disassembly. Always consult the aircraft technical manuals for disassembly instructions, if necessary. Place all removed sealant in a bag or container. For an injection seal, clear the entire channel or groove of all old sealant to prevent trapped air from creating a new leak path.

Final cleaning procedures

After the bulk of sealant is removed, the tank must be cleaned of all debris; small chips and fragments of old sealant can be removed with a vacuum cleaner. After removing all loose particles, final cleaning can be done. Starting from the top, clean all surfaces to be sealed with four-part cleaner or methyl ethyl ketone and cheesecloth or gauze pads. Wear chemical-resistant gloves and a respirator while using solvent. The solvent will cause oil, grease, fuel, dirt, and so forth, to float to the surface, making it easy to remove by wiping. Do not allow the solvent to evaporate on the surface before wiping it clean. Remember, the primary function in final cleaning is to remove undesirable sealant or dirt, not simply to move it. Never dip a soiled wiping cloth into the clean solvent container that contaminates the clean solvent. Change cloths as often as necessary, and after wiping the area dry, repeat the cleaning process at least one more time to ensure the area is clean.

Once the area has been cleaned, do not touch with your bare hands any surface to be resealed. The oils in the skin or perspiration can form a thin film on the metal, which would prevent a good bond between the metal and the new sealant. If the surface is allowed to dry and then is rubbed over with a cleaning cloth, there is a good chance that particles of dust, dirt, and old sealant will be redeposited on the metal surface.

Covering exposed cadmium-plated parts

If you are sealing cadmium-plated parts with MIL-S–8802, MIL-S–83430, or MIL-S–81733 sealant, isolate the parts with either EC1945 or MIL-C–27725. This topcoat must be fully dried prior to application of adhesion promoter and sealing material.

Application of adhesion promoter

Do not touch a clean surface because the oils in your skin or perspiration can prevent a good bond between the metal and the new sealant. After the surface has been cleaned thoroughly, apply a light film of adhesion promoter to all surfaces that require faying surface seals, fillet seals, or prepacked seals. Apply the promoter using clean cheesecloth or a fine-bristled brush. Remove any excessive promoter by blotting with cheesecloth. When applying a precoat sealant, followed by a fillet sealant, the adhesion can be applied to the tack-free surface of the precoat sealant. Let the promoter dry for 30 minutes, but never more than 24 hours, before applying sealant. If more than 24 hours have elapsed or the surface has become contaminated since the application of the adhesion promoter, you must reclean the surface and apply new adhesion promoter. If the adhesion promoter becomes cloudy, discard it.

256. Mixing and applying curing-type sealant

A sealant job takes a total commitment to quality from start to finish. If quality is missing in any aspect of sealant application, the job will fail and you will likely have to start over. This process starts when you mix your sealant and carries forward to the sealant application. This lesson provides you with the knowledge you need to do a quality sealant job.

Mixing curing-type sealants

Mix sealants in accordance with the manufacturer’s instructions or TO 1–1–3. When preparing multi-part, curing-type sealant, the accelerator must be mixed properly to obtain a thorough and complete mixture. Do not attempt to mix a partial kit without using an accurate scale to obtain the proper proportioning of the contents. Discard any sealant or accelerator found to be hard or lumpy. Filleting type sealants must be machine mixed to avoid entrapment of air. Hand-mixing is permitted if done in accordance with manufacturer’s instructions or TO 1–1–3. Figure 5–16 illustrates the procedures for hand-mixing a typical tube of sealant. You may hand mix brushable-type sealants, but machine-mixing (fig. 5–17) is preferred for large quantities. To avoid trapping air, hand-mixing should be accomplished on a flat plate. For small hand-mixed batches of brush-type, class A sealant, mixing may be accomplished in the base material container if care is taken not to entrap air in the sealant. Wear goggles while mixing sealant in the event the sealant should splash into your eyes.

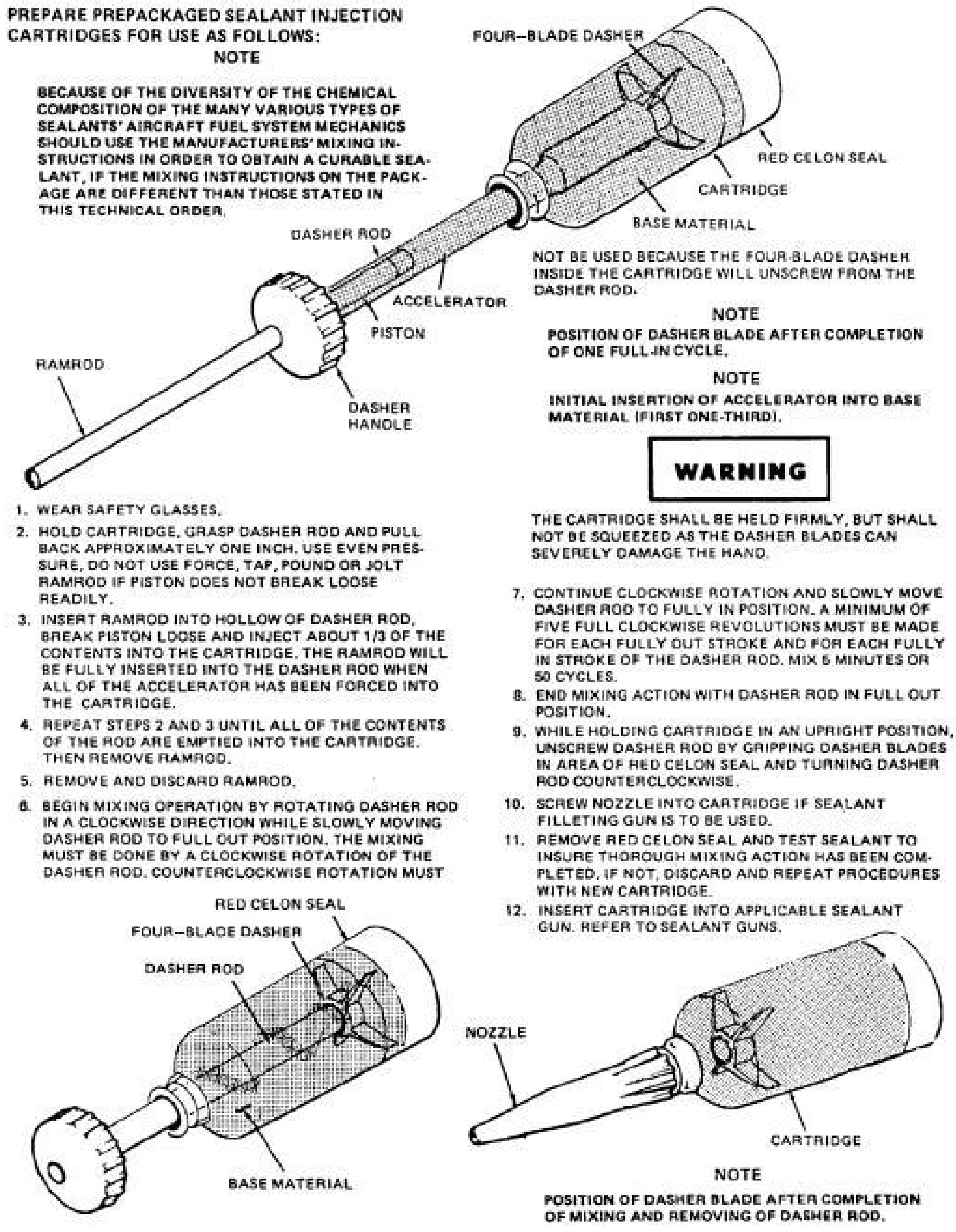


Figure 5–16. Hand-mixing of sealant cartridge.

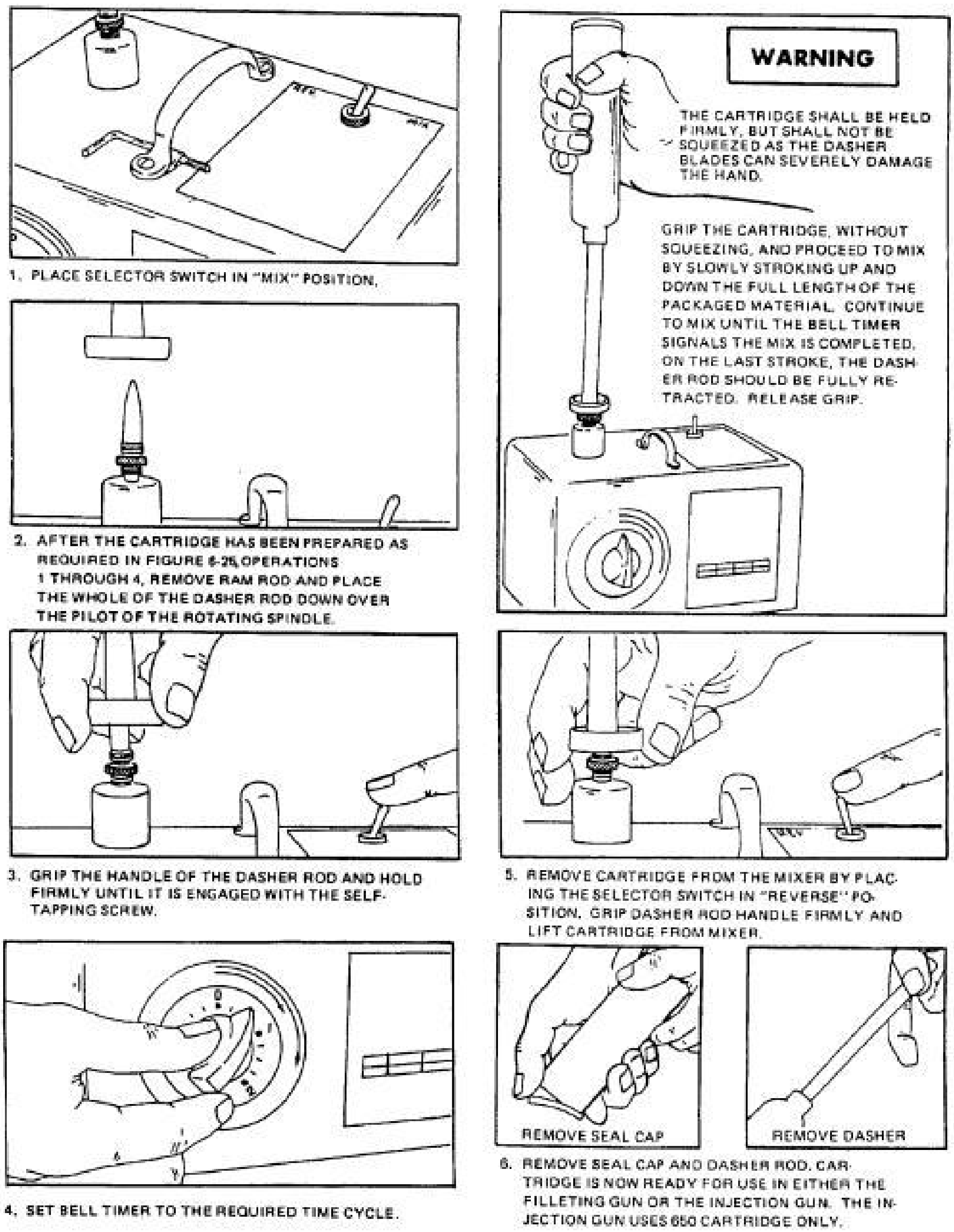


Figure 5–17. Machine mixing of sealant.

Applying the sealant

A combination of seals may be required at a single-leak location. The *brush coat* can be used for fillets and is applied 0.10-inch wider than the fillet on either side of the seam (fig. 5–18). Using an acid brush, apply a seal of brushable curing-type sealant on top of the adhesion promoter. Again, wearing goggles is recommended, and wearing chemical-resistant gloves is mandatory during sealant application. Work the brush coat into and around crevices, holes, seams, fasteners, and on the surfaces to be sealed. Allow the surface to become tack-free before applying the final seal. Do not use brush coats over any primary seal.

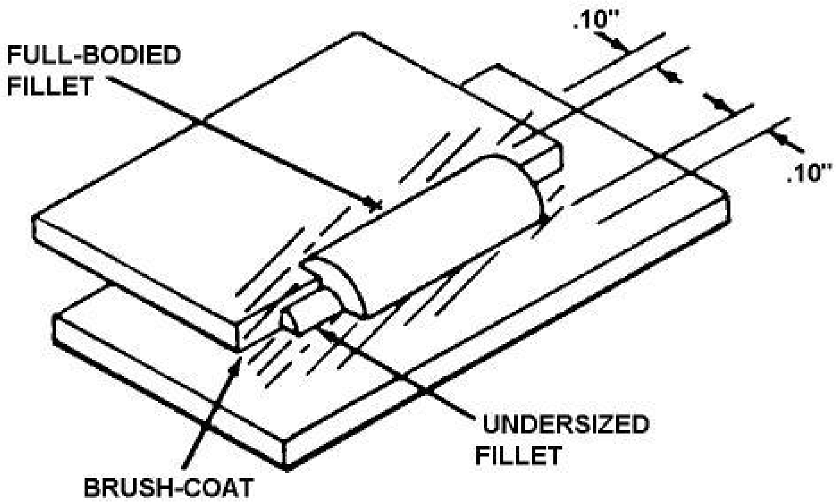


Figure 5–18. Two bead fillet.

Application of fillet seal

First, apply adhesion promoter to the surface if required. Then, insert mixed fillet-type sealant into a filleting gun and select a nozzle for the size of the fillet to be applied; small fillets require a nozzle with a small orifice, and large fillets require a nozzle with a large orifice. If necessary, set up a locally fabricated device to simulate the components to be filleted for help in determining the appropriate orifice size needed.

Next, apply a bead of sealant. For large repairs, apply the sealant in approximately 3-foot lengths. Hold the sealant-filleting gun at a high angle (fig. 5–19) and force the sealant against the work and ahead of the nozzle tip.

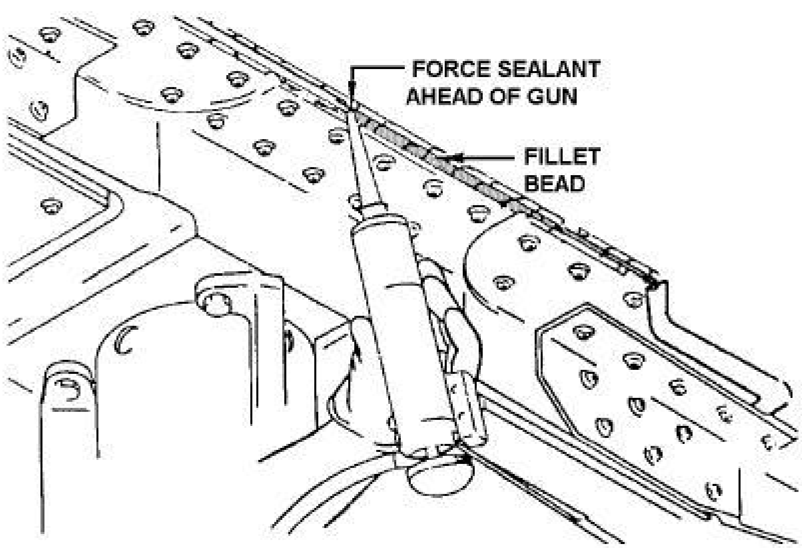


Figure 5–19. Applying the first fillet.

Thoroughly work the bead of sealant with a spatula, filling all voids in the seam while removing trapped air (fig. 5–20). Removing air bubbles is extremely important to obtaining a leak-free service life of the repair.

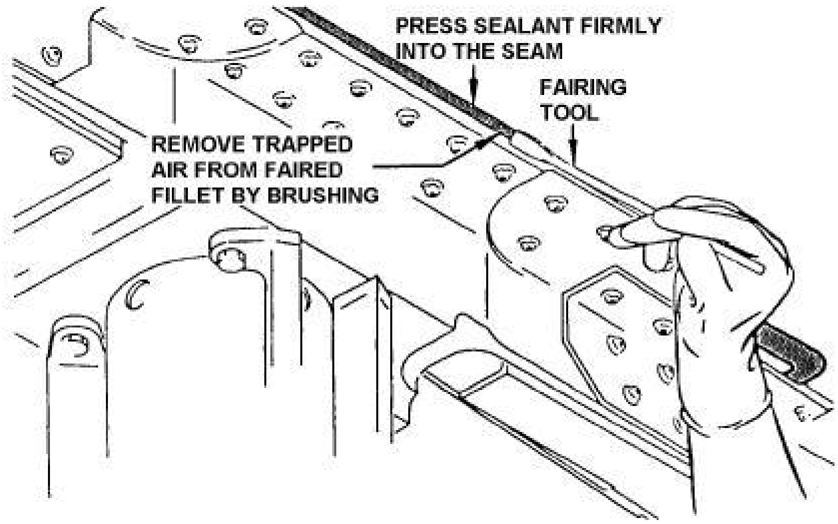


Figure 5–20. Working fillet into the structure.

Applying small fillets

A small fillet is defined as any fillet a half-inch thick or less. For small fillets, a single bead is all that is required. Shape the fillet to conform to the dimensions shown in figure 5–21, or in accordance with the aircraft technical manual. After the sealant is tack-free, examine the fillet for air bubbles. If any air pockets are found, repeat the repair.

Applying large fillet

A large fillet is defined as any fillet greater than a half-inch thick. For large fillets, apply a double bead. Apply a small bead and work into all voids to remove all trapped air. Allow the sealant to cure to tack-free and examine for air bubbles. Open any air bubbles and fill the cavities during application of the final fillet.

Final fillet

After the first fillet has become tack-free, apply the final fillet and shape it to conform to the dimensions shown in figure 5–21, or as required in the aircraft technical manual. After the final fillet is tack-free, examine for air bubbles. Repeat the repair for any air pockets found.

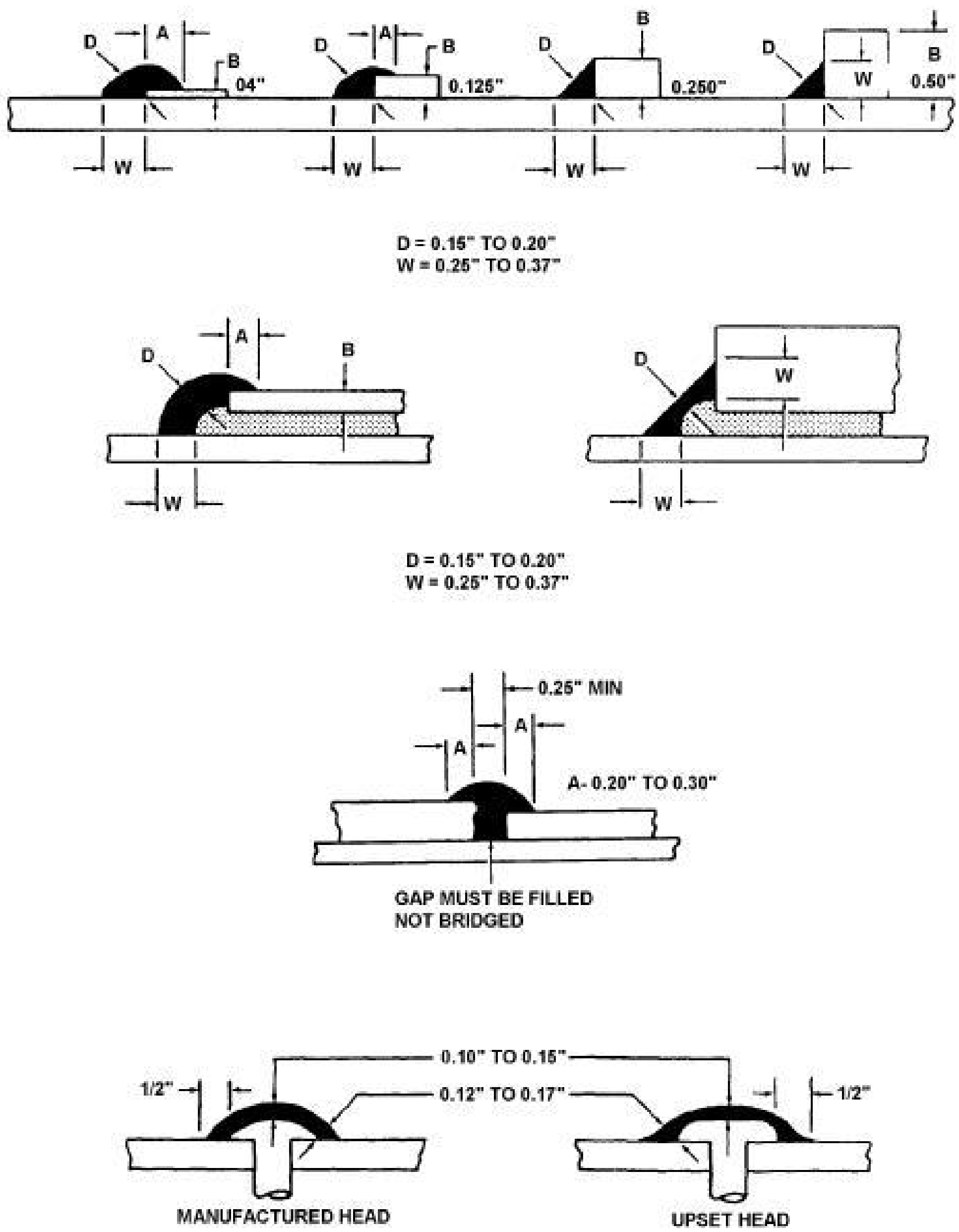


Figure 5–21. Typical fillet dimensions.

Application of injection seals

First, insert the mixed filleting-type curing sealant into the injection gun. For an open void, inject sealant until it extrudes from the opposite end (fig. 5–22), and then slowly remove injection gun. For closed voids, a long injection tip is required to reach the bottom of the void. Inject sealant and slowly remove the injection gun while continuing to inject sealant. Completely fill void with sealant, using care not to trap air in the sealant.

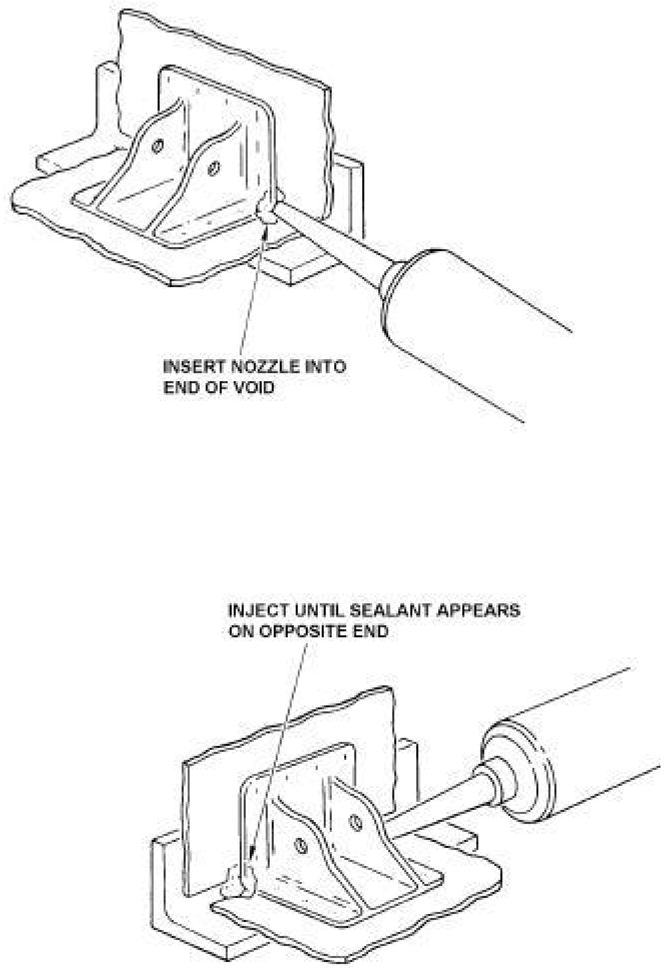


Figure 5–22. Injection sealing.

Application of faying surface seal

Insert mixed filleting-type curing sealant in filleting gun. Apply sealant to faying surfaces. Filleting tip should be large enough to apply a bead of sealant that can be spread over the whole surface and allow some sealant to be squeezed out when the parts are assembled. Spread sealant evenly over entire surface (fig. 5–23). Assemble part and clamp with setup bolts, wing-type Cleco fasteners, or other temporary fasteners. Install permanent fasteners. Apply the final torque before the sealant reaches the end of its application life. Remove excess extruded sealant.

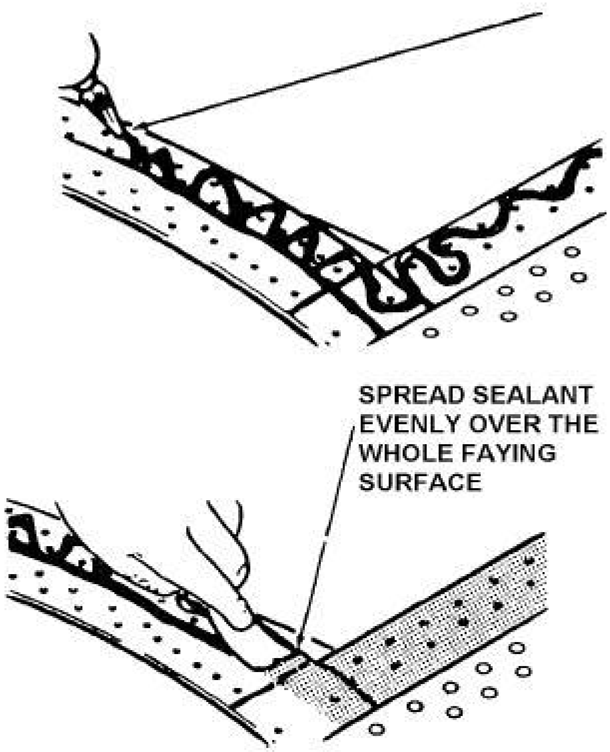


Figure 5–23. Faying surface seal application.

257. Using non-curing sealant by injection

Non-curing sealant designs are made up of a variety of grooves and channels that are filled with a continuous bead of non-curing sealant, which seals the mating structure faying surfaces. In some designs, the fasteners are sealed by this groove.

If this sealant develops a void or gap, a fuel leak will appear (fig. 5–24). Non-curing designs allow little or no access from inside the tank and are repaired from the outside by reinjecting new sealant.

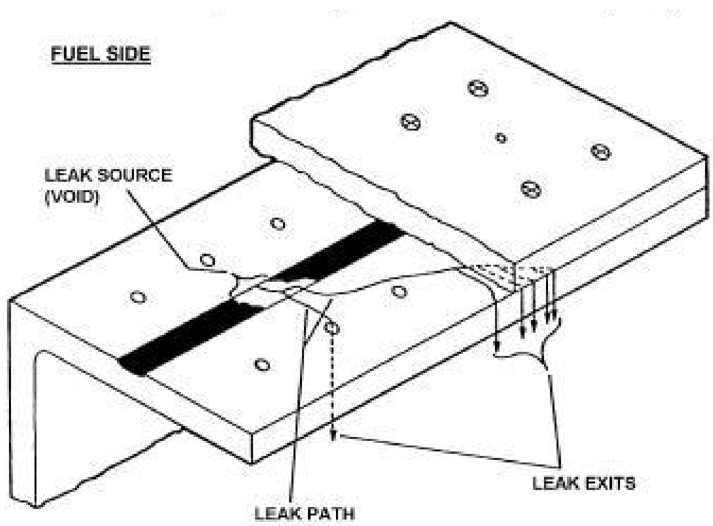


Figure 5–24. Fuel leak, non-curing sealant design.

The new sealant is injected through a series of injection holes provided through one side of the groove, which allows the non-curing sealant to flow into the channel. The injection holes are spaced along the sealant groove at regular intervals (normally from 3 to 6 inches) and, when not in use, are plugged with small flush screws.

After the location of the leak source has been determined, two or more of these screws can be removed—one on each side of the leak path. The new non-curing sealant is injected through one hole and pushes the old sealant out the other hole.

Some non-curing sealants when cold become stiff and resist flow. Local heating of the structure with heating pads in the area of the groove may aid in flushing out the cold sealant. Also, some leaks may require defueling below the leak source before they can be reinjected with new sealant successfully. Non-curing sealants do not harden; therefore, after reinjection of the new sealant, and the leak has stopped, the aircraft can be serviced with fuel.

Injection sealing involves using the high-pressure injection gun covered in a previous lesson. Since the sealant is usually forced into long, narrow channels, take particular care that the channel is clear all the way through or that an air escape is provided at the far end of the channel. If the sealant is forced into a channel without an air bleed, air will form a pocket that may immediately force the sealant back out or rupture the seal as the aircraft goes to a high altitude. Sealant can be removed from short injection-sealed channels with a hooked wire and a small cutting tool. Longer injection channels may require disassembly of the aircraft structure.

In some instances, rather than removing structural components for proper cleaning of an injection channel, the seal plane can be raised to isolate the faulty seal from fuel. The prime Air Logistics Center must approve any major isolation (i.e., raising the seal plane) sealing.

258. Testing and inspecting mixed sealants

On occasion, you may be required to test sealant that has been mixed to ensure it is serviceable. Attempting to apply unserviceable sealant to a repair area is just as bad as applying no sealant at all. The sealant tests we cover in this lesson are visual inspection, performance testing, and shelf-life updating and extension.

Visual inspection

For liquid-type sealants**,** visually examine the sealant containers before use to ensure the lid seals have not been broken. Discard both the base and accelerator if the seal on either is broken. Open both containers—base and accelerator—and check for skinning. If skinning has occurred in either the base or accelerator, discard both. If no skinning is evident, stir both the base and accelerator. Both materials should blend well, without lumps or streaks. Discard both if either material has any evidence of lumps or streaks. For Semkit-type sealants, check the cartridge for evidence of cracks or loss of material. Discard the sealant if either defect is discovered.

Shelf-life updating

MIL-S–8802, MIL-S–83430, MIL-S–81733, and AMS 3276 fuel tank sealants may have their shelf lives updated under certain conditions. Test each batch of material separately. Randomly select one sealant kit per batch for testing.

Performance testing

For this type of test, mix the sealant material in accordance with manufacturer's instructions. The sealant should mix well with no streaks. If it mixes well, apply the mixed material to an aluminum panel coated with MIL-C–27725, fuel-tank coating. Form a bead of material approximately 1/8 to 1/4-inch high and 3 to 6 inches long. The material should flow well and wet the surface easily. Work the sealant to ensure trapped air is removed. Discard the sealant if it does not flow easily or wet the surface easily.

Tack-free time

After the rated tack-free time identified in TO 1–1–3, place a piece of polyethylene plastic film into the sealant. Quickly remove the plastic film from the sealant. No sealant should remain on the film. If any sealant transfers to the film, discard the sealant.

Cure time

The curing-type sealants require applied material to cure for a specified time at standard conditions of 70 ºF and 50 percent relative humidity. The curing sealant may be accelerated by applying heat, not to exceed 120 ºF and/or humidity. After the rated cure time has elapsed, the sealant should be firm but flexible. Push against the sealant with a tongue depressor or other blunt instrument. The sealant should adhere well to the surface. Any indication of non-adherence is cause for rejection.

Shelf-life extension

If all tests are passed, the shelf life for the batch tested can be extended three months from the date of testing. Ensure all containers belonging to the applicable batch are marked with the new shelf-life date. If any failure in visual inspection or testing is observed, discard all material from that batch. Shelf life can be extended a maximum of two times; after that, discard material.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

253. Characteristics of sealants

1. What are the three categories of sealant?

2. What must be mixed together in order for sealant to begin to cure?

3. What is the tack-free time of sealant?

4. What type of sealant has been developed for use in voids or channels that cannot be reached?

5. How is structural adhesive sealant cured?

254. Access door and fastener sealing methods

1. What are the two basic types of integral tank-access doors?

2. What is the difference between the two types of doors?

3. Which type of access door seal is the easiest to locally manufacture and install?

4. What are the disadvantages of an O-ring seal access door?

5. What are the advantages of a molded-in-place access door seal?

6. Which type of access door seal requires the application of a parting agent between mating surfaces and requires installation of the door prior to sealant cure?

7. How does a self-sealing fastener seal the hole?

8. How are non-self-sealing fasteners sealed?

255. Preparing the tank structure for sealing

1. How much sealant should be replaced during tank maintenance?

2. What is done to the ends of a fillet seal repair?

3. When removing sealant in close, cramped quarters, why should you brace yourself against some type of support?

4. What should be used to protect the bottom of the tank from foreign object damage?

5. What is used to remove small chips and fragments of old sealant from a fuel tank?

6. What material must be applied to exposed cadmium plated fasteners before applying adhesion promoter and sealant?

7. Why shouldn’t you touch a cleaned surface?

8. How long should you allow adhesion promoter to dry before applying sealant?

256. Mixing and applying curing-type sealant

1. How large should a typical sealant brush coat be?

2. How would you apply a fillet sealant brush coat?

3. Why should all air bubbles in a fillet be removed?

4. What type of equipment is used to repair an injection seal?

257. Using non-curing sealant by injection

1. What qualities constitute a non-curing sealant design?

2. What happens when a void or gap develops in the sealant channel?

3. How far apart are non-curing injection holes normally spaced?

4. What action should you take when the sealant is too cold to flow?

258. Testing and inspecting mixed sealants

1. Before using liquid-type sealant, you should visually inspect it for what?

2. What material should you use to determine if sealant has become tack-free?

3. What should be the condition of sealant after the cure time has elapsed?

4. If outdated sealant is tested and has been determined to be serviceable, how long may its shelf life be extended?

5–3. Temporary Repairs

Many times, you will be dispatched to look at a fuel leak on an aircraft that is minutes from its scheduled takeoff time. For the aircraft to meet its mission, some temporary or external repairs are approved for your use. Only use temporary repairs to downgrade leak classifications to a flyable condition until such time that permanent repairs can be accomplished. Replace temporary repairs with permanent repairs when the aircraft is grounded, and the tanks are opened for inspection or other maintenance.

259. Performing integral tank temporary repairs

Temporary repairs are applied to the leak exit point and usually do not require tank entry. If a particular method of temporary repair repeatedly fails for a particular leak, make a permanent repair. Permanently repair suspected loose fasteners by replacing them at the earliest possible date. This includes any interference fit fastener that is leaking. To ensure wing structural integrity, treat a leaking interference fit fastener as a loose fastener and replace it at the earliest possible date. Remove temporary repairs accomplished during depot or contractor programmed depot maintenance (PDM) repair and permanent repairs made prior to the release of the aircraft to the using organization. Temporary repairs that were accomplished during the delivery preparation phase of PDM are allowed to remain provided the repairs do not exceed one per fuel tank. *Never* use temporary repairs to mask or repair leaks caused by structural damage, corrosion, or component failure.

There are eight approved methods of temporary repair; however, we will discuss only the five most often used methods. The approved methods of temporary repair, in order of preference, are as follows:

1. Hardman extra-fast setting epoxy with aluminum-foil patch.
2. Aluminum-foil patch bonded with sealant.
3. Epoxy tabs.
4. Click patch.
5. Sealant without aluminum-foil patch.
6. Hardman extra-fast setting epoxy without aluminum-foil patch.
7. Comp Air D–236 injector kit.
8. Oyltite Stik.

Hardman epoxy with aluminum-foil patch

This type of temporary repair is preferred over all others.

Repair limitations/advantages

Temperature limits for this type of repair are 40 to 120° F. The curing times are 40 minutes at 40° F and 15 minutes at 120° F, which makes this type of repair favorable. Note that epoxy adheres better to coatings than to bare aluminum. Therefore, do not remove coatings to apply epoxy. Heat will cause the epoxy to become brittle, so do not use heating devices to accelerate the cure time. The aircraft does not need to be defueled for this procedure.

Materials required

The following materials are required to apply this type of temporary repair:

1. Approved solvent.
2. Clean, static-free absorbent wiping cloths.
3. Hardman extra-fast setting epoxy.
4. Aluminum-foil patch (0.002-inch thick).

Application procedures

To apply this repair, cut a patch from the foil that will extend 1/4-inch beyond the fastener. Clean the surface of the patch to which adhesive will be applied and the area around the fastener with solvent. Mix the epoxy in accordance with manufacturer's instructions and coat the cleaned side of the patch with 0.015 to 0.020-inch epoxy. Press the patch in place over the fastener head.

Removal procedures

Heat is required to remove a repair made with this type of epoxy. Using a heat gun, heat the patch to 200 to 250° F. Note that temperatures below 200° F will not soften the epoxy, and temperatures above 250° F will damage the aircraft paint system. While the patch is hot, use a plastic scraper to pry up part of the patch. Continue to apply heat while using needle-nose pliers to remove the patch. Reheat the area and use the plastic scraper to remove any remaining epoxy.

Aluminum-foil patch bonded with sealant

If Hardman epoxy is not available, the aluminum-foil patch bonded with sealant is the next preferred method of temporary repair.

Repair limitations and advantages

There are no temperature limits for this method when the heating device from the kit is used. The curing time is 40 minutes at 140° F, which is the temperature of the heating device in the repair kit. You will need to refer to the tack-free times listed in TO 1–1–3 for the effect of humidity on cure times. At low temperatures—50° F and below—better results are obtained if the area around the fastener is preheated for a few minutes. For best results, the aircraft should be defueled below the leak exit point.

Materials required

The materials needed for this type of temporary repair include the following:

- Approved cleaning solvent.
- Clean, static-free absorbent wiping cloths.
- Class B sealant.
- Aluminum-foil patch (0.002-inch thick).
- Heat gun.

Application procedures

The first step in this repair method is to cut a patch from the foil that will extend 1/4-inch beyond the fastener. Then, clean the surface of the patch to which adhesive will be applied and the area around the fastener with solvent. Coat the cleaned side of the patch with a thin brush coat of sealant. Now, press the patch in place over the fastener head. Using the heating device, apply heat to the patch for approximately 30 minutes.

Removal procedures

To remove this type of repair, cut the sealant under the edge of the patch with a plastic scraper and pull the patch back. Continue cutting until the sealant and patch are removed.

Epoxy tabs or putty

Epoxy tabs or epoxy putty is probably one of the easiest temporary repair methods available but is not as reliable as those covered previously.

Repair limitations/advantages

Epoxy tabs or putty can be used in any climate, as they have no temperature limitations. The curing time is approximately two minutes. Scuff sanding may help adhesion. The aircraft does not need to be defueled for this procedure.

Materials required

The materials needed for this type of temporary repair are as follows:

- Approved cleaning solvent.
- Clean, static-free absorbent wiping cloths
- Epoxy putty or epoxy tab Type O.

Application procedures

Clean the area around fastener with solvent. Mix the epoxy according to manufacturer's instructions and apply an ample amount of epoxy over the fastener. Feather the edges to approximately 1/4-inch beyond edge of fastener. Remove any excess epoxy.

Removal procedures

To remove hardened epoxy tab, place a plastic scraper at the edge of the repair and tap the scraper with a rubber mallet until the repair pops off.

Comp air D236 injector kit

The comp air D236 injector kit is not as popular as it was several years ago, mostly because of the introduction of new types of epoxies that are easy to apply and have proven to be reliable. This repair method involves using compressed air to force sealant into a leaking flush-type fastener at 900 psi. Unlike other methods, the paint must be removed from the leak area before making the repair. Sealant is injected into the fastener, aluminum foil is placed over the fastener head, and a heating iron is applied to the tape for 5 to 10 minutes at 150 ºF to cure the sealant. An advantage of this temporary repair method is that the aircraft does not have to be defueled.

Oyltite Stik

The Oyltite Stik has been around for many years and has proven to be one of the simplest temporary repair methods available. Advantages of this repair method include the following:

- Aircraft does not require defueling.
- No temperature limitations.
- Immediate cure time.

Application procedures

To use the Oyltite Stik, clean the leak area with solvent. Soften the Oyltite Stik by dipping the open end in the solvent and firmly apply Oyltite Stik to the fastener head. Repeat as necessary, and then remove any excess material.

Removal procedures

Place a plastic scraper at the edge of the repair. Tap scraper with a rubber mallet until the repair pops off.

NOTE: The last few lessons covered some of the more widely used temporary repair methods. For information regarding additional repair methods, consult TO 1–1–3. Always remember that temporary repairs are just that—temporary. They should be replaced with permanent repairs when possible.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

259. Performing integral tank temporary repairs

1. What should you do when a particular temporary repair method repeatedly fails to stop the leak?

2. What must be done to temporary repairs that are made during PDM?

3. How many temporary repairs, if any, may remain on an aircraft if they were accomplished during the delivery preparation phase of depot maintenance?

4. Under what conditions should temporary repairs *never* be used?

5. What are the approved temporary repair methods, in order of preference?

6. What are the temperature limitations of a repair made with Hardman epoxy?

7. What effect will heat have on this type of repair material?

8. When removing a temporary repair done with Hardman epoxy, what are the minimum and maximum temperatures for the heat gun?

9. What tool should you use to pry the patch up?

10. How can you improve the results of the cure time when the temperature is below 50° F when using the aluminum-foil patch bonded with sealant?

11. What sealants may be used for the aluminum-foil patch repair method?

12. What are the temperature limitations for using epoxy tabs?

13. What can be done to improve adhesion of epoxy tab material?

14. What should be done to the edges of an epoxy tab repair?

15. How should you remove an epoxy tab repair?

16. Using the comp air injector kit, how is a temporary repair made?

17. What is the advantage of the comp air injection kit type of repair?

18. What are the three advantages of using an Oyltite Stik for a temporary repair?

Answers to Self-Test Questions

248

1. Greater fuel containment with a decrease in weight.
2. Spars, ribs, and skin.
3. Ribs.
4. Provide attachment points for the skin.
5. Stiffeners.

249

1. (1) Leak-detection powder.
   (2) Torn paper.
   (3) Pressure test.
   (4) Gas detection methods.
2. Because fuel may be exiting the structure and traveling along the inside of the seam until it finds an opening, which is not the exact leak exit point.
3. 30 psi.
4. The fuzzy edge of the paper will absorb the fuel.
5. Locating leaks that appear only under stress, locating in-flight leaks, confirming a repair prior to refueling, and locating multiple leaks in a tank.
6. A water manometer must be used as a pressure-limiting device, entries must be made on the aircraft forms, and a checklist must be used to ensure all plugs, cover plates, and caps are removed when the test is complete.
7. No longer than 24 hours.
8. The outboard tank.

250

1. Immediately after locating the exit point.
2. 30 psi.
3. Classify the leak to the next higher leak category.
4. Front and rear spars and ventilated dry bays.
5. Document the leak and periodically inspect it for growth to condition 2 or 3. No repair is necessary.
6. The aircraft is grounded until the leak is returned to condition 1 or 2 or is permanently repaired.
7. AFTO Form 781A or 781K, and AFTO Form 427 or 428.

251

1. To determine how fuel in an integral tank leaks to the outside.
2. The source, path, and exit point.
3. The barrier, which contains the fuel in a tank, composed of elements such as the structure, sealant, seals, gaskets, and fasteners.
4. If this seal plane is penetrated, fuel will enter a part of the structure that may not be designed to contain fuel (e.g., a channel or void). This may allow fuel to exit the aircraft several feet from the leak source. Any fuel that penetrates the seal plane will leak out at the point of least resistance
5. Construct cross-sectional views of the structure.
6. Apply air pressure at a maximum of 100 psi, keeping the nozzle approximately 1 inch from the sealant.
7. By firmly pressing the sealant with a blunt metal punch—not smaller than 3/16 inch diameter. If the sealant is serviceable, it returns to its original position; if it is defective, the punch penetrates the sealant.

252

1. Blowback, pressure box, leakage-tracing device.
2. The blowback method.
3. Red or fluorescent dye.
4. Double-cup assembly, hollow-bolt dye injector, vacuum dye, vacuum cup, and pressure box.
5. To locate leak sources by forcing dye solution through the leak exit point.
6. When the double-cup assembly was unsuccessful in finding the leak source.
7. A flat or contoured pressure box is attached to the outside of the tank, allowing a large surface to be pressurized with air. The air pressure forces dye back through the leak path and into the tank.
8. When trying to locate seep-type leaks.
9. When all other methods of isolating a leak source have failed—as a last resort.

253

1. Curing, non-curing, and structural adhesive sealants.
2. The base material and an accelerator.
3. The time required for a sealant to cure to the point at which the outer surface will not stick to a plastic film.
4. Non-curing-type sealants.
5. It is cured with heat but remains flexible.

254

1. Plug and direct-seal.
2. The plug door opens into the tank; the direct-seal door opens to the outside and the fasteners provide the clamping force to seal the door.
3. Flat gasket seal.
4. The O-ring may be incorrectly installed, are difficult to install around corners and bends, and are not reusable.
5. They generally provide a good seal and are reusable.
6. Formed-in-place seal.

7. By swelling when installed or interference fit.
8. With dome nuts, sealing washers, O-rings, sealant overcoats, machine fittings, and sealant channel.

255

1. Only the sealant that is defective.
2. They are cut at a 45-degree angle and abraded at least 1/2 inch.
3. To avoid injuring yourself if the cutting tool slips.
4. Barrier material or wiping cloths.
5. A vacuum cleaner.
6. Either EC1945 or MIL-C–27725.
7. Because the oils in your skin or perspiration can prevent a good bond between the metal and the new sealant.
8. At least 30 minutes, but not more than 24 hours.

256

1. 0.10 inch wider than the fillet on either side of the seam.
2. Use a brush to work the sealant into and around crevices, holes, seams, fasteners, and on the surfaces to be sealed.
3. To ensure a leak-free service life of the repair.
4. An injection gun.

257

1. A variety of grooves and channels filled with a continuous bead of non-curing sealant.
2. A fuel leak will appear.
3. Normally 3 to 6 inches apart.
4. Heat the structure with heating pads in the area of the groove.

258

1. To ensure the lid seals have not been broken.
2. Polyethylene plastic film.
3. The sealant should be firm but flexible.
4. It may be extended for three months from the test date.

259

1. Make a permanent repair.
2. They must be removed and replaced with permanent repairs before release of the aircraft to the using organization.
3. A maximum of one per tank.
4. To mask or repair leaks caused by structural damage, corrosion, or component failure.
5. Hardman extra fast setting epoxy with aluminum-foil patch, aluminum-foil patch bonded with sealant, epoxy tabs, click patch, sealant without aluminum-foil patch, Hardman extra fast setting epoxy without aluminum-foil patch, comp air D–236 injector kit, and Oyltite Stik.
6. The temperature must be 40 to 120° F.
7. Heat will cause the epoxy to become brittle.
8. Minimum 200° F, maximum 250° F.
9. Plastic scraper.
10. Preheat the area around the fastener for a few minutes.
11. Class B sealant.
12. There are no temperature limitations.
13. Scuff sanding the repair area.

14. They should be feathered approximately 1/4 inch beyond the edge of fastener.
15. Place a plastic scraper at the edge of the repair and tap the scraper with a rubber mallet until the repair pops off.
16. Use compressed air to force sealant into a leaking flush-type fastener, aluminum foil is placed over the fastener head, and a heating iron is applied to the tape for 5 to 10 minutes to cure the sealant.
17. The aircraft does not need to be defueled.
18. (1) Defuel is not required.
 (2) No temperature limitations.
 (3) An immediate cure time.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

Please read the unit menu for unit 6 and continue ➔

Unit 6. Fuel Cell Maintenance and Inspection

FUEL CELL MAINTENANCE comprises a large portion of our profession as aircraft fuel systems journeymen. Therefore, you should be familiar with the basic features of a fuel cell, as well as handling procedures and precautions. Very seldom can a large fuel cell be removed without being folded into a much smaller package. Frequently, there is only one way that the cell can be folded so that the package is small enough to go through the removal door. If you do not know the correct method, you can be sure the cell is going to be further damaged in removal. You might say, "Well, the cell is damaged anyway, so a little more damage isn't going to hurt anything." This is not always true. Quite frequently, a cell may be only slightly damaged, yet damaged enough that it needs to be removed for repair. If your carelessness or lack of knowledge causes the cell to be extensively damaged during removal, it may not be repairable at the local shop. This means that the aircraft is down for lack of parts for days or even weeks.

New cells "fresh out of the factory" are very seldom defective. Before these new cells are installed in the aircraft, there are certain inspections that detect most of the defective cells before installation. In addition, a large percentage of the cells installed that prove to be defective after installation were probably perfectly good cells before installation.

With that in mind, you can see how difficult it is to say whether removal or installation is more important. If you are the slightest bit careless in the installation of the new cell, you may have the whole job to do over again just as soon as you fill the new cell with fuel, and it starts to leak. This situation can be very discouraging, to say the least.

In this unit, the removal, installation, leak isolation, repair, inspection, and testing of fuel cells are covered. All of these actions are a part of your job as an aircraft fuel systems journeyman. The useful life of a fuel cell depends on your ability and willingness to perform these actions correctly and efficiently.

6–1. Cell Familiarization and Handling

Removing a fuel cell requires more than simply taking off the access door, grabbing the cell, and pulling it out. Many preparation requirements have to be met, and you must observe many precautions when handling the cell. The next few lessons cover the constructional features of different types of cells, requirements for preparing a cell for storage, handling precautions, and some general procedures for the removal and installation of a typical fuel cell.

260. Fuel cell construction

A fuel cell is a flexible bag contoured to the shape of a particular cavity. The cavities are designed specifically to house a particular cell. Fuel cell cavities are designed to be fuel tight. Cells are manufactured in three basic types—self-sealing, bladder, and combination (i.e., part bladder and part self-sealing).

Self-sealing cells

A self-sealing cell is designed to temporarily seal itself when punctured. The sealing action reduces the possibility of a fire and minimizes fuel loss. Four primary layers are in a self-sealing cell—inner liner, nylon barrier, sealant layer, and retainer. Cells may contain more than the four individual layers, but the added layers will fall into one of the following classifications: inner liner, nylon barrier, sealant layer, and retainer. Let's examine the function of each layer of a fuel cell.

Inner liner

The inner liner is constructed of Buna-N synthetic rubber or rubber-coated fabric. The inner liner protects the nylon barrier.

Nylon barrier

The nylon barrier contains the fuel and prevents diffusion through the cell wall.

Sealant layer

The sealant layer is composed of semi-cured natural rubber sealant. The sealant remains dormant until contacted by fuel. When contacted by fuel, the sealant swells and closes the opening.

Retainer

Usually, the retainer is made from woven nylon, rayon, or cotton. Its material strengthens the cell and protects the nylon barrier from external activation. Figure 6–1 shows the lightweight construction of a four-ply self-sealing cell.

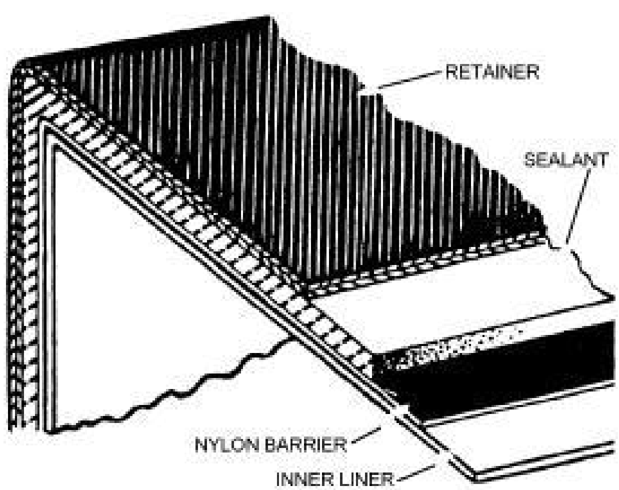


Figure 6–1. Lightweight self-sealing cell construction.

The standard construction is shown in figure 6–2. In this construction, the inner liner is made of nylon. The sealant is placed on the cell in two layers, a layer or layers of cord fabric placed between the two layers of sealant, a layer or layers of cord fabric placed on the exterior of the cell, and an outside lacquer coating which designed to remain fuel resistant for up to 72 hours.

The sealing function is the result of a chemical and mechanical reaction, which takes place when the cell is punctured. The mechanical reaction is the result of the property of the rubber to expand under impact, limiting the damage to a small hole. The chemical reaction results in the rubber material swelling when in contact with fuel as shown in figure 6–3.

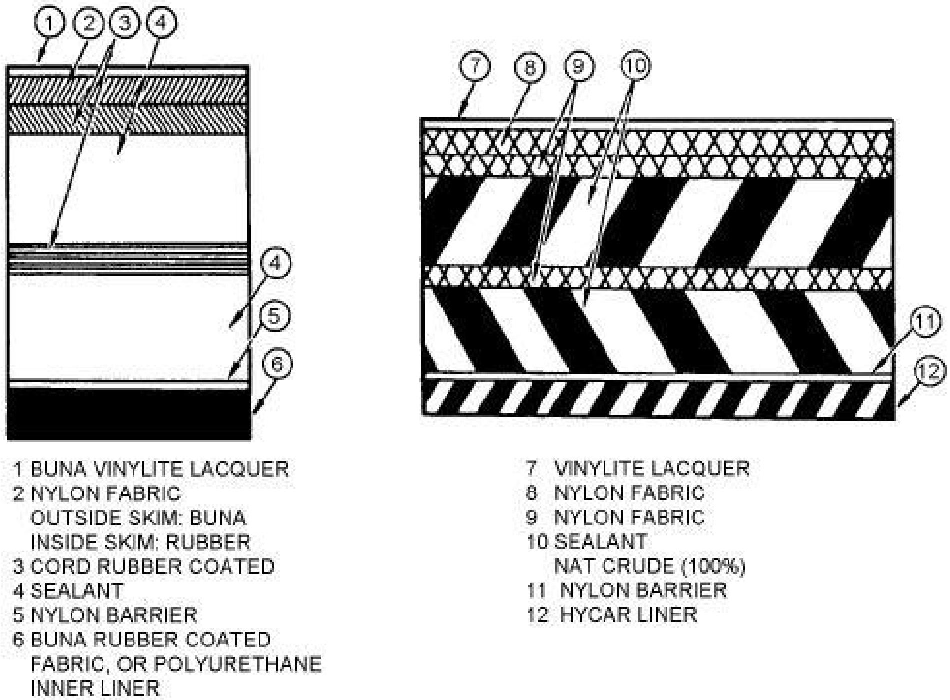


Figure 6–2. Standard self-sealing cell construction.

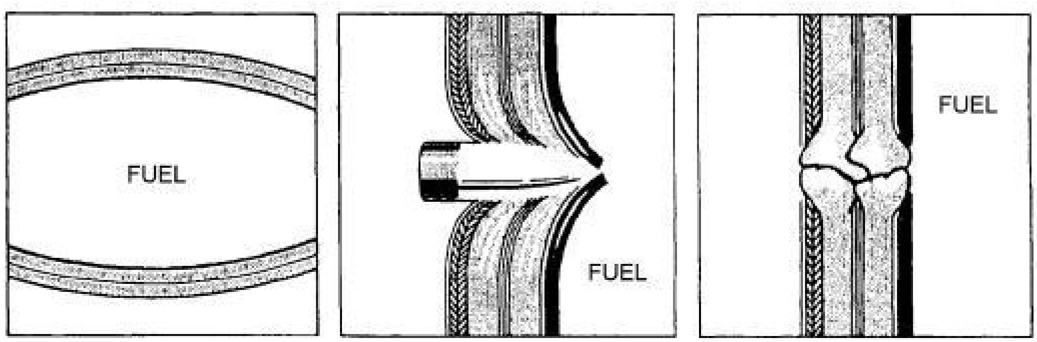


Figure 6–3. Projectile sealing action of self-sealing cell.

Bladder cells

The four basic types of bladder cells are those constructed of the following:

1. Two or more plies of rubber coated fabric.
2. A combination of rubber coated fabric and Buna-N gum.
3. All nylon fabric.
4. Polyurethane-coated nylon fabric over a polyurethane-sprayed inner liner.

Bladder cells are lightweight and are *not* self-sealing. Three primary layers that make up a bladder cell are the inner liner, nylon barrier, and retainer; these layers perform the same function as they do in a self-sealing cell. As you can see, the primary difference between the self-sealing cell and the bladder cell is the absence of the sealant layer in a bladder cell.

Combination cells

These cells consist of both bladder and self-sealing cell construction. Most are usually self-sealing on the bottom and aft sections only. This is because the aircraft is subject to small arms and artillery fire on the bottom and aft sections of the aircraft as it penetrates a target area. Not all aircraft will have combination fuel cells.

Fittings

The three general types of fittings used on fuel cells are rubber face, compression, and metal-to-metal.

Rubber face

This fitting has a ring of metal molded into the opening. It may be fully molded rubber or combined rubber and fabric. A seal is made by compression of the rubber faces between the cell and its mating part.

Compression

This fitting is used on bladder cells and consist of two metal rings. The cell openings are bolted between the rings to create a seal.

Metal-to-metal

This fitting consists of a metal ring molded into the cell opening, which leaves the seal side of the metal exposed. A seal is made by using O-rings between the metal surfaces of the cell fitting and its mating part.

261. Preparing cells for storage or shipment

When fuel cells are received from the factory, they have been treated with a plasticizer that prevents drying and cracking of the cell materials. When the cells are put into use, the fuel has a tendency to extract the plasticizer from the inner lining of the cell. This loss of plasticizer is not detrimental as long as fuel remains in the cell or the cell does not remain empty long enough for the fuel to completely evaporate. While the cell is wet with fuel, the fuel itself acts as a plasticizer. However, when fuel is drained from the cell and the cell is air-purged until the walls are dry, the cell walls are no longer protected and will start to dry out, crack, and check. This cracking and checking may penetrate through the inner liner of the cell and allow fuel to attack the cell structure fabric the next time the cell is used.

Protecting the cell interior

To prevent cracking and checking, you protect the inner cell wall with a thin coating of oil—military specification-lubricating oil (MIL-L)–6081 or VV-L–825—and apply it by wiping or fogging in accordance with TO 00–85A–03–1, *Preservation, Packaging and Packing—External Aircraft Fuel Tanks/Cells*. Do this procedure when it is evident that the fuel cells will remain without fuel for more than 72 hours, or when the cells are prepared for storage or shipment. The oil coating prevents cracking and checking of the inner cell lining, and does not evaporate as fast, nor constitute as great a fire hazard, as fuel would. To prevent the escape of oil or the entrance of contaminants, close all openings to the cell with shipping covers or pieces of cardboard that have been cut to shape and held in place by cell sealing tape.

Inspecting cells in storage

Fuel cells are constructed of age-sensitive elastomers, which are subject to deterioration by oxygen, ozone, sunlight, heat, rain, and similar other factors experienced in normal storage or use. Thoroughly inspect cells taken from storage before installing them in the aircraft. It shall be mandatory that all fuel cells be inspected annually and assigned a shelf-life code. Thoroughly inspect installed cells during depot maintenance.

Folding the cell

Never fold or unfold a fuel cell until the temperature requirements in TO 00–85A–03–1 are met. After the cell has been treated and the openings closed, it is ready to be folded for packing. If a packing crate for a like cell is available, the dimensions can be transferred to the folding operation so that the dimensions of the folded cell match those of a factory-folded cell. If you can find no specific dimensions for folding the cell, keep these general rules in mind:

1. Fold the cell in as few places as possible, keeping all folds gently rounded without sharp creases.
2. Keep all openings away from folds as far as possible.
3. Do not stand or kneel on folds to compress the bundle.
4. Do not draw restraining straps too tight.

If you keep these points in mind, you will not damage the cell by bending the fitting flanges, breaking the cell fabric, or pulling loose the inner liner.

Storing the cell

Air and light are detrimental to fuel cells, so put the folded cell in a plastic bag or wrap it in moisture-proof paper with as little air as possible. The box for storage or shipment of the cell should not be so large that the cell can shift around nor so small that the cell is squeezed. If a wooden box is used, line it with several thicknesses of smooth paper to prevent the cell from chafing against the box walls. Also, lay the paper over the top of the folded cell package before nailing on the container lid. Store the cell according to TO 00–85A–03–1. The storage facility should be maintained at temperatures between 45 to 75 °F.

262. Handling fuel cells

Fuel cells are subject to various kinds of damage during normal handling; therefore, take care when handling them because they are easily damaged during uncrating, preparation, installation, removal from aircraft, and packing. All work surfaces used for fuel cell repair must be clean, smooth, and padded. To avoid damaging the cell, keep cell handling to a minimum. Observing the following general guidelines will prevent you or coworkers from damaging a cell.

1. Never lift, move, or carry a cell by its fittings. Using fittings as lifting or handling points can damage the fittings.
2. Do not unnecessarily collapse or fold a cell; this may damage the nylon liner.
3. Do not drag or tumble a cell because that could damage the cell exterior.
4. Make sure work areas are clear of foreign objects that could damage the cell.
5. Use care when uncrating and crating cells to avoid damaging them.
6. Do not fold cells abusively or by air evacuation.
7. Never fold or unfold a cell if its temperature is below 65 ˚F. Use an approved heater to heat the cell and cell cavity.
8. Prior to collapsing the cell, install cell fitting protector rings as required by the aircraft technical manuals. Install protector rings prior to collapsing the cell.
9. Do not rest cell on sharp objects, table edges, table corners, or cavity edges.
10. Do not place heavy objects on cells.
11. Whenever the cell is out of the cavity, place protective caps on metal fittings that extend from the cell.

Bladder cell handling

Bladder cells are collapsed and folded prior to being placed in shipping and storage containers. Additional protection is provided by the installation of a fiberboard tube that has a minimum diameter of 4 inches. Place the fiberboard tube on the folds to prevent creasing of the cell. Observe the following precautions when folding and unfolding bladder cells:

1. Always fold and unfold cells on clean, smooth, padded surfaces that are covered with canvas and waxed paper or rubberized fabric.
2. New bladder cells that are boxed or crated and stored for more than a year may shrink. Cells can be soaked in warm water prior to air testing and installation.

Self-sealing cell handling

Follow these precautions when folding and unfolding self-sealing cells:

1. Do not permit a self-sealing cell to remain collapsed or folded for more than one hour; collapse or fold just prior to installation or removal.
2. Self-sealing cells are not collapsed for shipping or storage. Ship them in their normal configuration.
3. You may salvage cells that are improperly collapsed, stored, or have for some other reason taken on a permanent crease by placing the cell in an air circulating oven set to 150 °F. Pour warm water over the outside and inside of cell. The heat and moisture will soften the rubber and allow movement without damaging the nylon barrier. After one hour, gradually stretch the cell and install the internal supports. When the cell is restored to its normal shape, allow it to continue to soak for 4 hours at 150°F. Then, remove the cell from the oven and air soak at room temperature for 20 hours before air testing and inspection.

263. Removing and installing a fuel cell

Depending on the aircraft or weapon system in question, the specific procedures for removing and replacing a fuel cell may differ greatly. However, general procedures and precautions for cell replacement are for the most part the same, regardless of the aircraft being maintained. Let’s look at what is involved in a typical fuel cell replacement.

Cell removal procedures

The first step in the removal of a cell is to drain, purge, remove foam, and depuddle the cell as covered in a previous lesson. Ensure the cell and cavity temperature is a minimum of 65 °F for bladder cells and for self-sealing cells. Use a heater, as necessary, to raise temperatures to an acceptable range. Remove the cells in order beginning with cell #1 or individually as required by the specific aircraft technical data. Disconnect all lines and fittings, marking their locations as you remove them. Place all manifolds, hardware, components, and so forth, in a clean, dry area, and cap lines and components as necessary. Mark and inspect components as necessary. Now is a good time to inspect components that are normally not accessible. Untie and remove all lacing cords and disconnect all hangers or retainer rods. Fold the cell in accordance with the aircraft technical manual and TO 1–1–3. When folded correctly, the cell should pass through the access door opening without being strained or scraped. Figure 6–4 shows a typical bladder cell before and after folding. Carefully remove the cell from the cavity

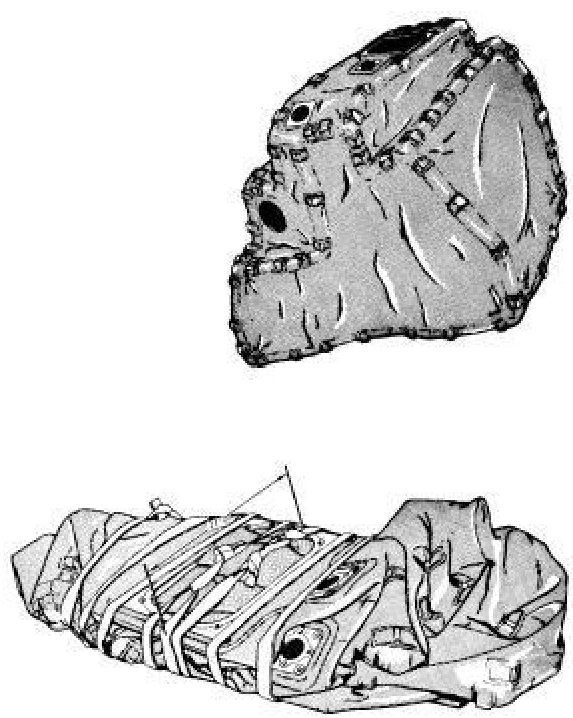


Figure 6–4. Folding a bladder cell.

without forcing it. If the cell hangs up, recheck it to ensure that all fittings, hangers, and so forth, have been removed. After removing the cell and prior to installing the new cell, you must inspect the cavity.

Preparing the cavity

Before installing the cell into the cavity, thoroughly inspect the cavity. Inspect all cell-fitting mating surfaces and connections for cracks, scratches, distortions, dirt, or any other defects, which could cause a leak. Clean mating areas with solvent and replace damaged parts. Other areas to inspect include the following:

1. Backing boards for cracks, chipping, crazing, or other damage, which might damage the cell.
2. Cell-attaching points for damage or missing hardware.
3. All vent or interconnect lines to ensure they are in the proper position and clamps are secure and accessible.
4. Cavities for nicks, burrs, sharp edges, and so forth, which could damage the cell. Smooth the areas in accordance with the applicable aircraft technical manual.
5. The cavity for corrosion, and treat as required.
6. Cavity for dirt, grease, and other foreign matter. Clean as necessary.

Preparing the cell and installing the O-rings

If you are installing a new cell, it must be unfolded. Remember to ensure that the temperature is within the limits previously covered. Obtain the necessary O-rings, ensuring they are serviceable. New O-rings must always be used. Before installing the O-rings, inspect the grooves on the fittings for damage or foreign material. Any foreign material, such as hair or lint, between the O-ring and its mating surface (fig. 6–5) may cause the fitting to leak. Clean the O-ring groove with solvent and inspect them for nicks, cuts, or other damage. If the O-rings are okay, install them in their respective grooves as illustrated in figure 6–6. If an O-ring will not stay in place, apply a small amount of petrolatum to the lower surface of the O-ring groove and to the O-ring itself, then remove any excess petrolatum (fig. 6–7). When removing excess petrolatum, always wear personnel protective equipment such as chemical-resistant gloves. Now, remove all tags, stickers, tapes, and protective devices from the cell. Last, ensure the cell fittings are clean and fold the cell in preparation for installation.

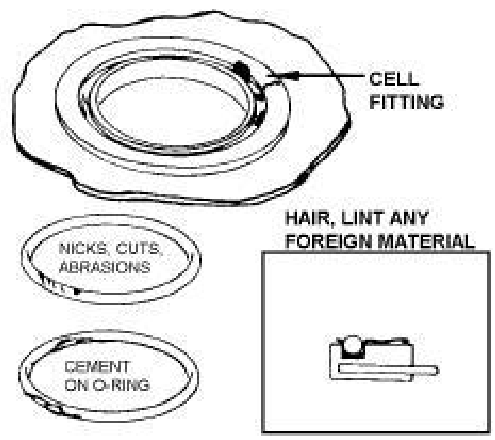


Figure 6–5. Checking for foreign material.

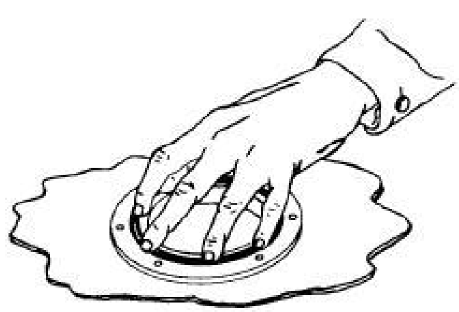


Figure 6–6. Installing an O-ring.

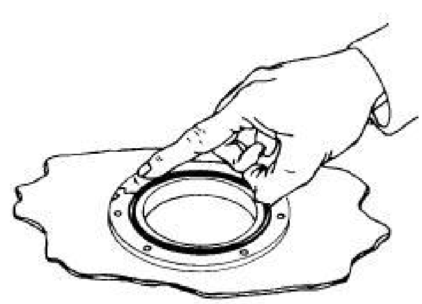


Figure 6–7. Removal of excess petrolatum.

Procedures for installing the cell

Now that the cavity has been prepped and the cell folded, you are ready to begin installation. Ease the cell into the cavity and attach the cell to the aircraft structure in accordance with aircraft system technical manual. Figure 6–8 shows the lacing procedures for a typical fuel cell. Note that Vithane cells stored for an extended period in dry climates shrink in overall size. This condition makes the cell hard to install due to misalignment of cell fittings with mating surfaces. If this occurs, restore the cell by soaking it in warm water (not to exceed 120 °F) for 2 to 4 hours. If this is not possible, apply heat and moisture by capping off all fittings except the access opening. Place a bucket of water or wet rags inside the fuel cell and position a duct inside the access opening for 4 hours, wetting the cloths as often as necessary. When the cell has been restored to normal size, align the cell fittings and interconnects. On fittings that use O-rings, seat the O-rings so they are not pinched by the fitting surfaces. Some fittings may require the use of clamping rings to hold them together and the O-ring in its groove; refer to aircraft systems technical manuals. Install the proper hardware and torque it to the value specified in aircraft systems technical manual.

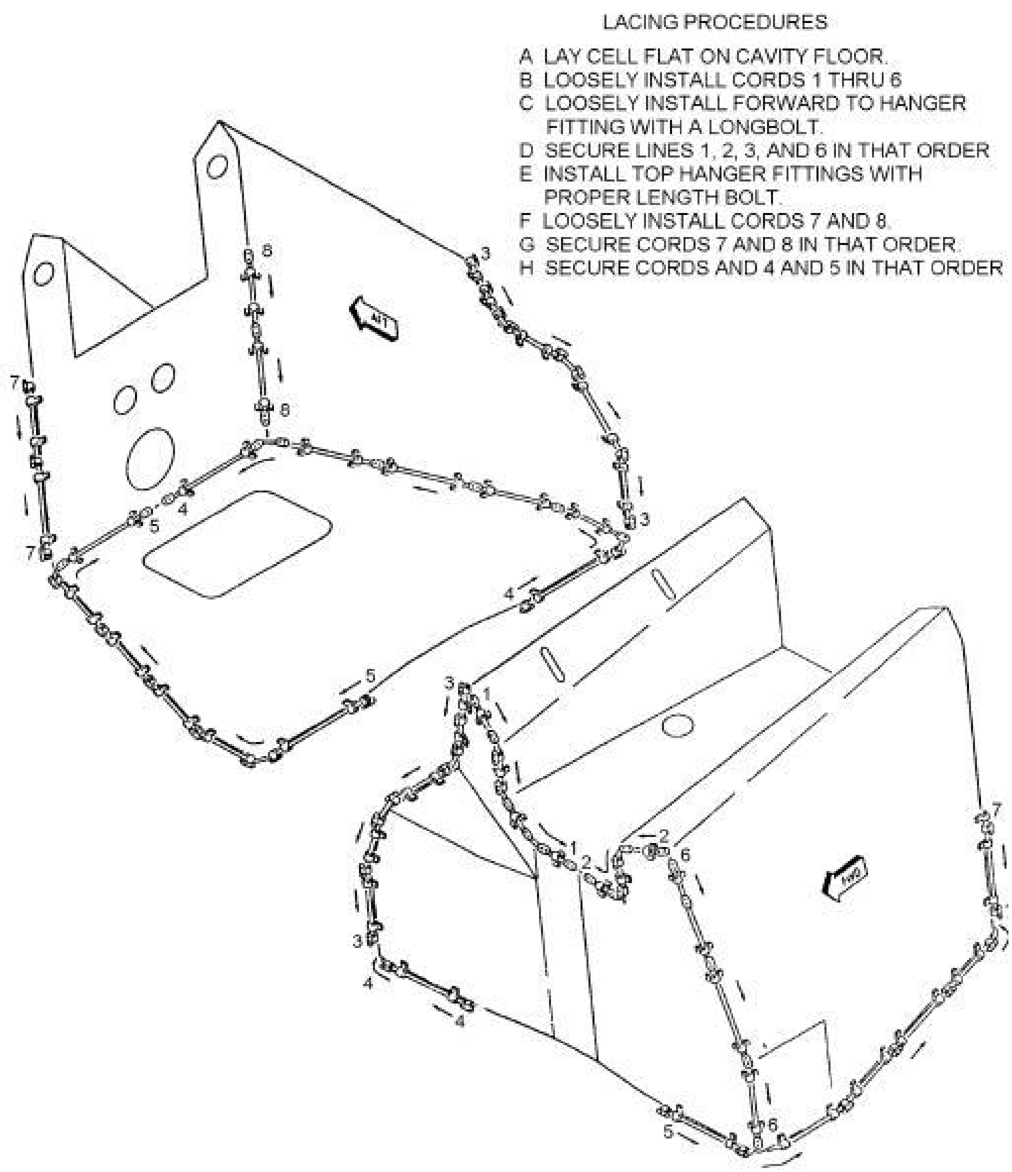


Figure 6–8. Typical cell-lacing procedures.

Lacing cords and knots

Many cells use lacing cords to secure the cell to the cavity. Figure 6–9 illustrates the proper method for preparing the ends of the lacing cord. Figure 6–10 shows the proper method of tying knots in the lacing cords.

Closing the cell

Before installing the cell access door, be sure to clean the entire interior surface using a sponge or cheesecloth moistened in water. Do not use any solvents to clean the inside of the cell. Ensure that you remove all foreign objects and inspect the cell interior for damage. Once you are satisfied that the interior is clean, install the cell opening cover and torque the bolts to the value specified in aircraft systems technical manual. To prevent damage to the cell fittings and adjacent structures, ensure only bolts of the proper length are used. In fact, unless bolts were found to be damaged or corroded, use the same bolts that you or someone else previously removed.

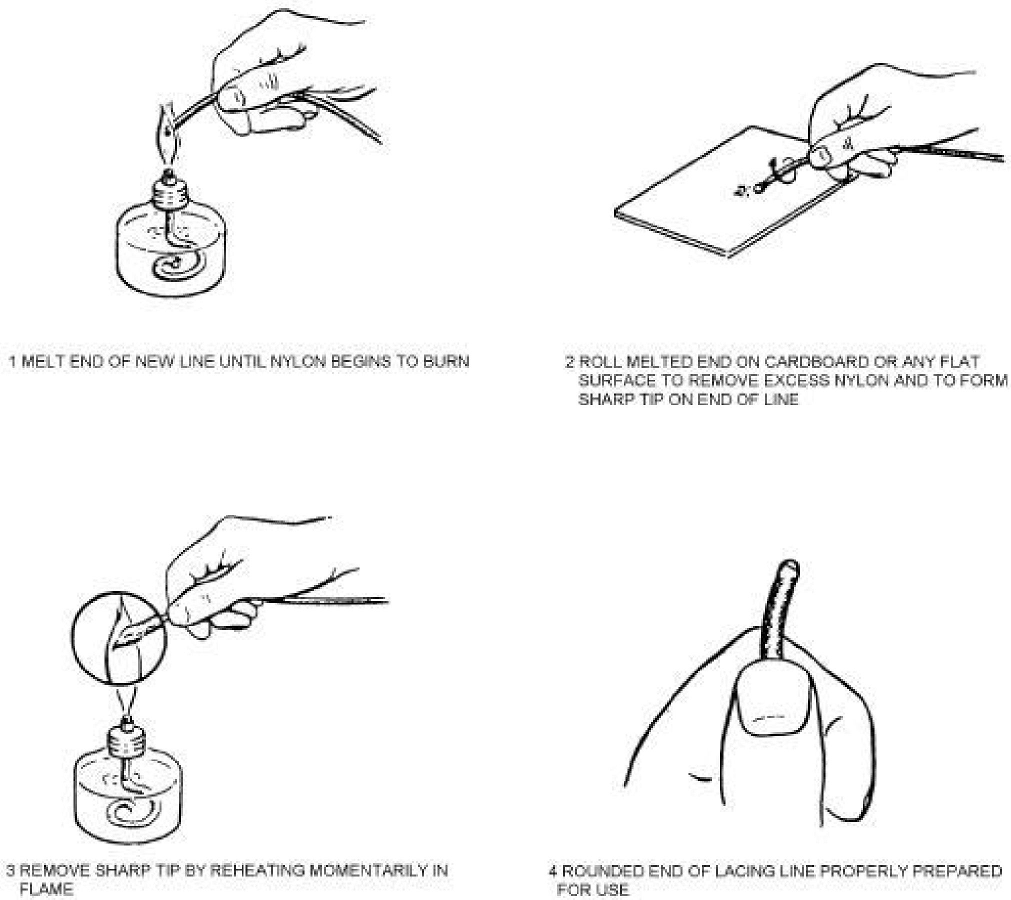


Figure 6–9. Lacing cord end preparation.

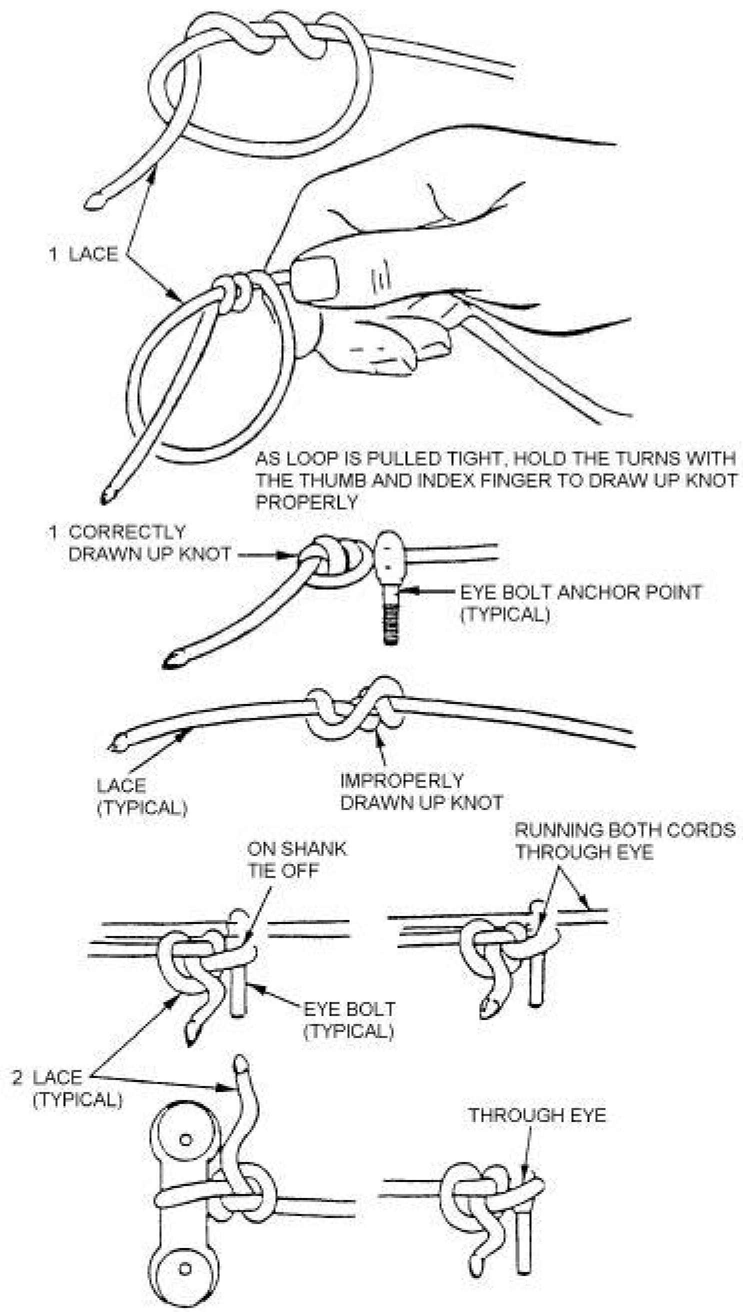


Figure 6–10. Lacing cord knots.

Torque procedures

After the bolts have been installed, apply torque to the value specified in the aircraft systems manual. Typical bolt torque patterns are shown in Figure 6–11. Once a torque pattern is established, the same pattern must be followed. You can use a speed handle or ratchet to do the initial installation on the bolts. Do not make them too tight, wait for the torque wrench.

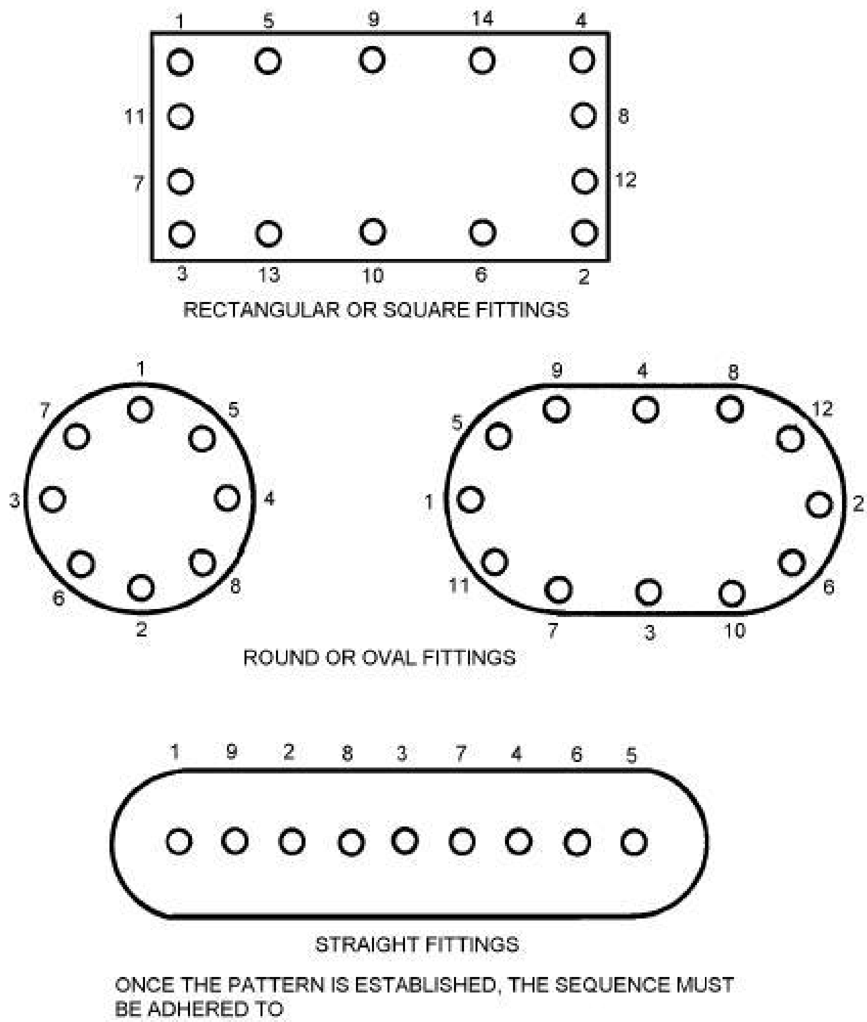


Figure 6–11. Torque patterns for bolts.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

260. Fuel cell construction

1. What are the three types of fuel cells used on aircraft?

2. What are the four primary layers in a self-sealing cell?

3. Which cell layer actually contains the fuel?

4. Which cell layer protects the nylon barrier from external activation?

5. How long must the outside lacquer coating of a self-sealing cell remain fuel resistant?

6. What are the four types of bladder cells?

7. On a combination cell, where are the self-sealing sections located?

8. How is a seal made on the rubber face type of fitting?

261. Preparing cells for storage or shipment

1. What material is applied at a cell factory to prevent drying and cracking of cell material?

2. What danger is presented when the interior walls of a cell begin to crack and check?

3. What can you do to prevent the cracking and checking of a cell interior that has been drained and purged?

4. When should a cell's interior be covered with a thin coat of oil?

5. Where should the openings be located when folding a fuel cell?

6. Before storing a cell, how should you protect it from air, which could dry out the cell?

7. What should be the temperature of a building used to store cells?

262. Handling fuel cells

1. During what times are cells susceptible to damage?

2. What temperature should the cell be when you need to fold it?

3. What should be done with metal fittings that extend from the cell when the cell is out of the cavity?

4. What additional protection is given at the folds of bladder cells?

5. Before installation, what should you do with new bladder cells that have been in storage for more than a year?

6. What is the maximum time that a self-sealing cell may remain collapsed or folded?

263. Removing and installing a fuel cell

1. What is normally the first step in preparing for a fuel cell removal?

2. When removing more than one cell, in what order should they be removed?

3. How do you know when a cell has been folded properly in preparation for removal?

4. What do you look for when inspecting the mating surfaces of cell fittings?

5. What can you do to an O-ring that will not stay in place during the installation of a cell fitting?

6. How can Vithane cells, which have shrunk, be restored to normal size?

6–2. Fuel Cell Leak Troubleshooting

Depending on the aircraft and cavity-drain system used, locating and isolating a leak on a fuel cell can be simple or complicated. One thing is certain, a person engaged in fuel cell leak evaluation and repair must possess a thorough knowledge of the construction and installation of the fuel cells on the applicable aircraft. Since it would be impractical to cover leak isolation procedures for every type of existing fuel cell configuration, we limit our coverage to information applicable to all fuel cell configurations.

264. Locating leaks in installed fuel cells

The most important factor in fuel cell leak isolation is a thorough knowledge of the aircraft fuel cell and cavity-drain system, including manifold routing and cavity-drain locations. The grouping of the fuel cells, attitudes of the draining surfaces, location of the drain passages, size of the leak, and whether it occurs while the aircraft is on the ground or during flight are some of the variables which make any single set of procedures difficult to follow in detecting and isolating a leak.

Aircraft use two basic types of cavity-drain systems—a common manifold type (fig. 6–12) and an individual type (fig. 6–13). By studying the cavity-drain system in relation to the cells and equipment, and making a leak flow chart, you can trace the leaks to the cell or cells that are leaking before you open the tank or cell. This reduces the need for removing and installing the cell access doors. When you see fuel at the overboard drain port of a *common manifold* type drain system, disconnect each individual cell cavity-drain fittings and check them for dripping or seeping fuel. With the individual type cavity-drain system, each cavity has its own drain line. Therefore, when fuel appears at the overboard drain or weep hole, it is evident which cell cavity is the origin. Once you have isolated the cavity, inspect the cell and associated plumbing and fittings for signs of leaks. Some cavities have a continuous strip of black leak-detection tape installed around all fittings. The tape becomes tacky upon contact with fuel, indicating a leak. It may not always be a bad fuel cell. A bad O-ring could be the cause of the leak. When you have an aircraft that has the individual cavity drain, you must also ensure that fuel is not leaking into the cavity to form another source such has another cavity, adjacent dry bays, or manifolds. Cavities are supposed to be fuel tight. Never rule it out that a leak may be present. Good troubleshooting skills are essential for locating leaks.

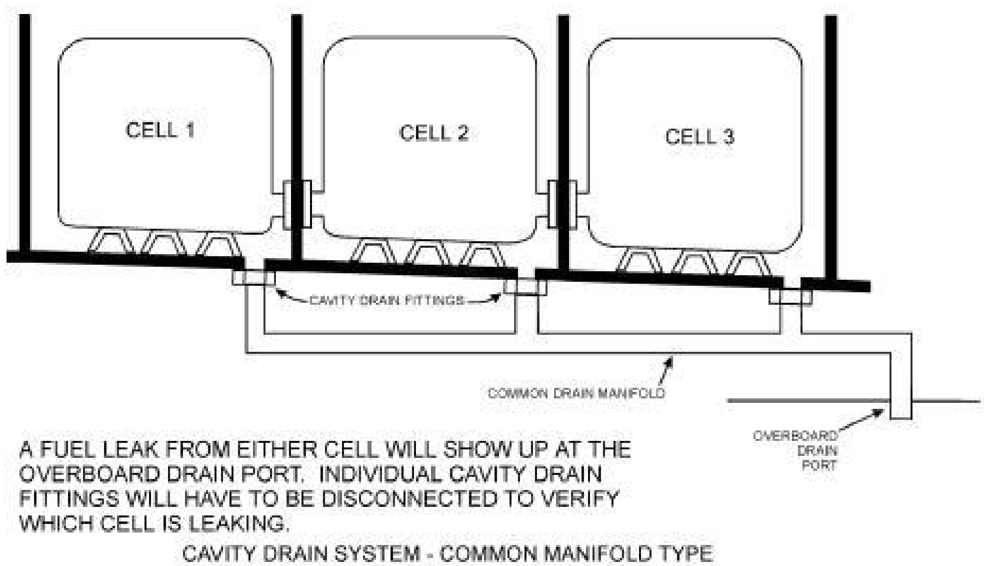


Figure 6–12. Cavity-drain system-common manifold type.

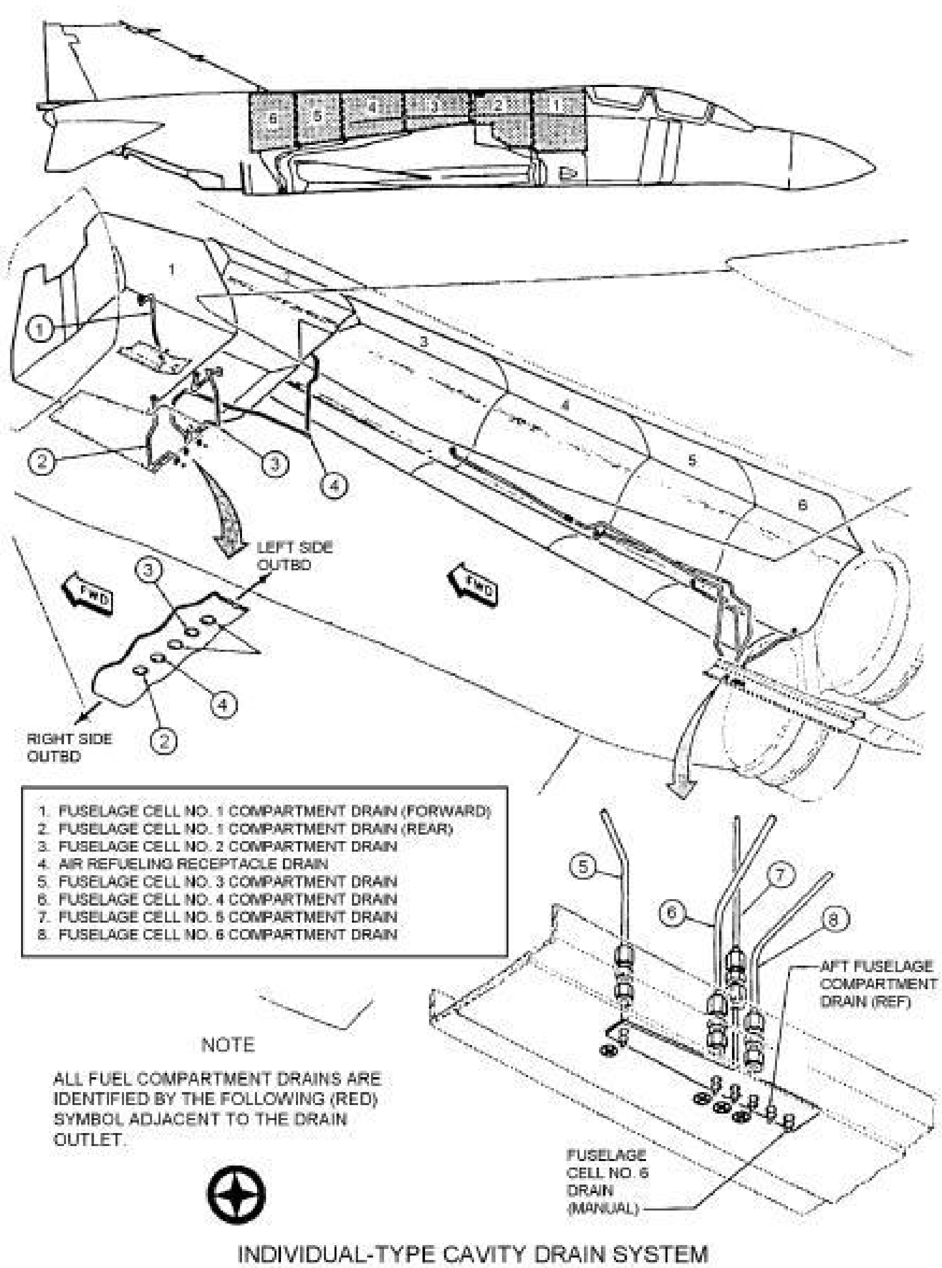


Figure 6–13. Cavity-drain system––individual type.

265. Determining types and causes of cell leaks

Characteristics of a cell leak, such as its severity, location, and flight or ground conditions of the aircraft, usually give a good indication of where the leak may be originating. Cell leaks can be broken down into three classes—fast and severe, seeps, and intermittent leaks.

Fast and severe

A fuel leak caused by a ruptured or cut fuel cell, a loose interconnect fitting, pinched or distorted O-ring in a cell fitting, or missing O-ring is usually evident immediately after fueling. These leaks usually spill large quantities of fuel into the cavities quickly. The fuel will then leak out the cavity drain.

Seep leaks

Fuel leaking through pinholes in the cell structure or seeping under loose cell fitting bolts, interconnects, or wicking under a cell fitting may not reach the overboard drain for hours after the leak begins.

Intermittent

Intermittent leaks caused by loose cell fitting bolts, cell interconnects, and equipment installed at or near the top of the cell will leak only when the tank is full of fuel or when the aircraft is in either a climb or a descent. These leaks often go unnoticed and are potentially more dangerous than obvious leaks. They may also require extensive and time-consuming troubleshooting procedures to locate the source.

Normally, in-flight leaks result in a false leak indication at one or more cavity drains, which will dry by the time the aircraft lands. The following list of procedures may help you in locating high-level or in-flight leaks, depending on the aircraft.

1. Dye the most probable cell or tank.
2. Top off the tanks or cells in the late evening or early morning hours. Fuel expansion during warmer periods of the day may force fuel into the vent area of the cell.
3. Alter the aircraft attitude by repositioning the aircraft to achieve a nose-up or nose-down attitude.
4. Pressurize the system in accordance with the applicable technical manual if the tank or cell is normally pressurized during flight. Check the upper portion of the cell and components with leak-detection compound.
5. Operate all the applicable fuel systems to eliminate the possibility of non-cell leaks.
6. The helium leak detector may also be used to detect high-level or in-flight leaks.

If it is difficult to determine which cell or tank is leaking, one cell or tank can be defueled and the other refueled. Reversing the fuel configuration will further help confirm the leak.

Many fuel leaks are the result of poor-quality maintenance during cell installation. Fuel cell fittings, access doors, interconnect fittings, and equipment installed inside the cell requires careful installation. You must torque fasteners to the proper values and make sure not to over tighten them. A distorted, kinked, cut, twisted, or missing O-ring will cause fuel to leak from the cell. Double-check all O-rings to ensure they are the proper size and are correctly installed in the cell fitting before torquing. Never install used O-rings.

Always locate the true source of all leaks before beginning repairs. Do not repair leaks singularly as they are found because this practice is excessively time consuming and costly. If you find a leak that requires repair, inspect the cell for other leaks and complete all repairs during the same time. The removal of cells for testing may cause material failures, so make every effort to pinpoint the leaking cell and area before removal.

266. Determining cell repair limitations

The following defects are reparable on an installed fuel cell:

- Pinholes.
- Inner liner cuts.
- Loose supports or hangers.
- Blisters.
- Loose seams or patches.
- Weather-ozone checking (except when cords are damaged).

Each repair element is encouraged to repair all fuel cells to the fullest extent possible. However, base cell repair capability is normally based on tools, equipment, facilities, skills, frequency of each repair, and mission requirements. The following repairs are best performed at depot or contractor facilities:

- Self-sealing cell repairs greater than 3 inches in diameter.
- Repair or replacement of hangers or straps.
- Repair or replacement of lacing ferrules.
- Repair or replacement of fittings.
- Corner repairs.
- Extensive weather ozone checking.

Again, this does not mean that these types of repairs cannot be done at a field-level maintenance element having the capability to do so, but that they are normally best performed at depot facilities because of the time or special equipment required. The following repairs usually are accomplished at the field level:

- Pinhole damage.
- Closed hole or slit type damage.
- Blister repair.
- Loose seams or patches.
- Weather ozone checking requiring a patch less than 12 square inches.
- Self-sealing cell hole damage less than 3 inches in diameter.
- Corrosion treatment.

The following conditions warrant condemnation of the cell upon approval from the system manager.

- Self-sealing cell activation that exceeds two hundred square inches or extends into a corner or step off area.
- Damage in an awkward location-making patch roll down impossible.
- Weather ozone checking of the inner liner that exceeds five percent of the total area or which requires a patch larger than 36 square inches.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

264. Locating leaks in installed fuel cells

1. What variables make it difficult to develop a predetermined set of troubleshooting procedures when isolating cell leaks?

2. What are the two types of cavity-drain systems found on aircraft containing fuel cells?

3. What material can be installed around cell fittings to aid in locating fuel leak origins?

265. Determining types and causes of cell leaks

1. What characteristics of a cell leak normally will indicate the location or origin of the leak?

2. What conditions or defects will likely result in a fast and severe type of fuel cell leak?

3. What should you do after locating a cell leak that requires repair?

266. Determining cell repair limitations

1. Which cell defects usually can be repaired on an installed fuel cell?

2. Normally, on what factors is cell repair capability based?

3. What types of cell repairs are best performed at depot or contractor facilities?

4. At what maintenance level are pinholes and blisters in a fuel cell normally repaired?

5. To what extent can weather-ozone checking be repaired at field level?

6. What conditions warrant the condemnation of a fuel cell?

6–3. Fuel Cell Inspection and Testing

Fuel cell inspections are essential in that the inspections may detect defects, which may cause or have caused leaks. There are two types of inspections we will cover—interior and exterior cell inspection. There are many criteria when it comes to inspecting fuel cells. This section will be a brief overview of procedures for new/removed fuel cells. The last section will cover testing of fuel cells. After you remove or prior to installing a new fuel cell, you need to test it to ensure its serviceability.

267. Inspecting the interior

To perform the inspection, have a platform or table that is large enough to allow positioning of the cell. The surface of the work area must be clean, smooth, and padded. Never lay a cell directly on a floor or other surface that has dirt, grit, sharp objects, or cutting edges. Never fold or unfold a cell if its temperature is below 65 °F. Use an approved heater to heat the cell and cavity if necessary.

As you begin the inspection, be sure to have TO 1–1–3 available. The TO establishes procedures and criteria for the uniform inspection of cells and fittings. Use this TO as well as your knowledge of cell construction to aid you in the inspection. When you discover a defect, refer to the applicable section of TO 1–1–3 for the allowable limits. For example, let's say that one of your workers just removed a bladder cell from an aircraft and a small cut was discovered in the inner liner. Should you condemn the cell, repair the area, or simply disregard the cut because it does not render the cell unserviceable? By referring to TO 1–1–3, you would find that cuts, holes, or tears in the inner liner of a bladder cell are not acceptable, but they may be repaired at field level. Other defects include but are not limited to the following:

1. Edge looseness at liner lap. One-quarter inch width if one-inch bond is maintained between laps.
2. Checking due to ozone of Buna rubber not acceptable.
3. Channels around entire outer edge of fitting flange. One-quarter inch maximum width.
4. Buffing through inner liner; not acceptable.

If your visual inspection does not disclose a cell failure, there is still a chance that the fuel cell leak is at a fitting, O-ring, or gasket seal. Because these components may be replaced, the cell can still be used if no other defects exist. The limits for installed cells and removed cells are different. Always refer to TO 1–1–3.

268. Inspecting the exterior of an installed cell

In TO 1–1–3, there are procedures for inspecting cells that are installed and removed. The exterior installed cell inspection is limited to what you can see. You are not required to disassemble the cell so you can inspect the entire outside of the cell. In some cases, this may only be around the access door area. On a new/removed cell, the exterior inspection is just as important as the interior inspection. The outside is subject to damage during handling, shipping, testing, and the removal process.

The exterior inspection does not list as many requirements as for the interior. As we know, the outside does not have to contain fuel. The following are just an example of some things to look for when doing your exterior inspection.

Exterior Inspection	
Acceptable	**Not Acceptable**
Blisters or ply separation between any plies except liner and sealant—one-inch maximum dimension.	Permanent set or crease.
Skim coat paint blisters.	Damage through outer cord or fabric ply.

After you have performed your exterior inspection, you may continue with your task or reinstall the cell. You may not always remove a cell because it is leaking. There are instances when the cells are removed so others can repair structure or perform inspections behind our cells. If you have removed a cell for other maintenance and do find a defect, it will have to be repaired or replaced, even if it was not leaking prior to removal.

269. Cell testing procedures

Essentially, there are four methods used for testing fuel cells. We will cover the two most commonly used—soapsuds and chemical test. In the soapsuds method, a soapy water or "bubble" solution is used. In the chemical test method, ammonium hydroxide and an indicator solution are used. Both tests can be used to find a leak or to confirm a repair.

External soap suds testing

External soapsuds testing is a very practical test because no chemical or fuel is placed inside the cell. For this test and the chemical test, pressurize the cell. Each manufacturer may have specific pressures to be used with certain cells. In general, fuel cells of up to 1,000-gallon capacity can be pressurized to 1/2 psi without danger to the cell, and cells over 1,000-gallon capacity can be pressurized to 1/4 pounds per square inch gauge (psig). Because these pressures are so small, a manometer is the simplest gauge to use, either water or approved digital type. On cells of 1,000-gallon capacity and under, 1/2 psi equates to 14 inches on the water manometer; on cells of over 1000-gallon capacity, 1/4 psi equates to 7 inches on the water manometer (fig. 6–14).

CAPACITY	AIR PRESSURE	WATER MANOMETER
0 - 1000 GALLONS	1/2 PSI	14 INCHES
1000 GALLONS AND UP	1/4 PSI	7 INCHES
ALL VITHANE CELLS	1/4 PSI	7 INCHES

Figure 6–14. Cell test pressure limits.

First, you need to install a test plate with air adapters to the access door, and then install all other test plates to the other fittings. Connect air source and manometer to the plate. Maintain appropriate air pressure in the fuel cell for 1 to 2 hours before testing. After the cell is pressurized to the correct pressure, brush or wipe a soap and water solution—1 cup liquid soap to 1 gallon warm water—over the outer surfaces of the cell. Leaks can be seen as air bubbles appear. Next, verify the repair or mark leaks with a non-waxed pencil. Deflate the cell and remove all plates. Rinse soap residue from the cell using clean water.

Chemical test

The chemical test is a little more involved than the soapsuds test. It is based on the fact that ammonium hydroxide vapor turns a phenolphthalein indicator bright red. Before performing the chemical test, remove all red-colored markings from the outside of the cell; otherwise, these markings will indicate a leak during the test. Air purge the fuel cell until excessive fuel or oily residue has evaporated.

Attach a locally fabricated plate with two inlet fittings (fig. 6–15) to any fitting on the cell. One inlet is for the air pressure source and the other is for the manometer. Install cover plates on all other openings except the access door. Before pressurizing the cell, place a cloth pad moistened with ammonium hydroxide–approximately 100 cubic centimeters for testing cells up to 1,000-gallon capacity and 200 cubic centimeters for testing cells with capacities over 1,000 gallons —in the cell and install the access door. Inflate the cell and maintain the air pressure for one to two hours before testing. Next, prepare the leak-detection solution by mixing 15 grams of phenolphthalein crystals into 2 quarts of water, and then add 2 quarts of alcohol. Additional quantities of the indicator solution can be made by increasing the quantities of each ingredient proportionately. Soak a large white cloth in the indicator solution and wring it out thoroughly. The cloth should not be dripping wet. Spread the cloth over the cell surface and smooth it down. A leak in the cell wall can be noted as a bright red spot appearing on the cloth directly over the leak. Do not assume you have only one leak, check the entire surface of the cell. Mark any leaks with a nontax pencil. Deflate cell and remove all test plates. A note of caution is needed here—ammonium hydroxide vapors are extremely strong and are toxic. Ensure the cell is properly purged before entering. Last step is to clean all metal surfaces with an authorized cleaning solvent to prevent corrosion.

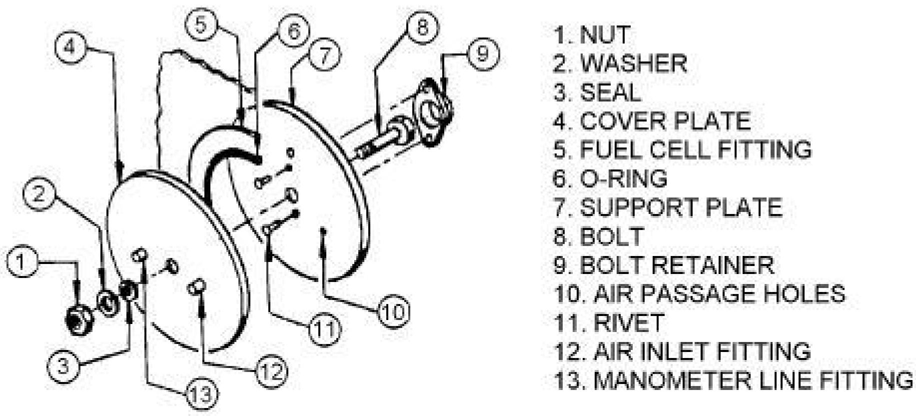


Figure 6–15. Fuel cell test fitting.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

267. Inspecting the interior

1. What type of surface must be used for cell inspections?

2. What are the limits for edge looseness at liner lap for interior cell inspection?

3. If you do not find a defect with the fuel cell, what are other possible leak sources?

4. What resource should you use to aid the inspection of a cell?

268. Inspecting the exterior of an installed cell

1. When doing an exterior inspection on an installed cell, what are you required to inspect?

2. What or how can the exterior of a fuel cell become damaged?

3. List two “not acceptable” conditions concerning exterior cell inspection.

269. Cell testing procedures

1. What are the two common methods for testing fuel cells?

2. What piece of equipment is used as an air pressure gauge during the soapsuds test?

3. What amount of ammonium hydroxide is required to test a cell with a capacity of 1,200 gallons?

4. What amount of phenolphthalein crystals is added to 1 gallon of indicator solution?

5. Why do you need to clean all metal surfaces after performing a chemical test?

Answers to Self-Test Questions

260

1. (1) Self-sealing.
   (2) Bladder.
   (3) Combination.
2. (1) Inner liner.
   (2) Nylon barrier.
   (3) Sealant layer
   (4) Retainer.
3. Nylon barrier.
4. Retainer.
5. 72 hours.
6. (1) Those constructed of two or more plies of rubber coated fabric.
   (2) Those constructed of a combination of rubber coated fabric and Buna-N gum.
   (3) Those constructed of all nylon fabric.
   (4) Those constructed of polyurethane-coated nylon fabric over a polyurethane-sprayed inner liner.
7. On the bottom and aft sections of the cell.
8. A seal is made by compression of the rubber faces between the cell and its mating part.

261

1. Plasticizer.
2. The cracking and checking may penetrate through the inner liner and allow fuel to attack the cell structure fabric the next time the cell is used.
3. Coat the cell interior with a thin coating of oil (MIL-L–6081 or VV-L–825). This may be done by wiping or fogging.
4. When packaging the cell for storage or shipment, or when the cell is to remain without fuel for more than 72 hours.
5. As far away from folds as possible.
6. Put the folded cell in a plastic bag or wrap it in moisture-proof paper with as little air as possible.
7. Between 45 to 75°F.

262

1. During uncrating, preparation, installation, removal from aircraft, and packing.

2. Below 65 °F.
3. Place caps on them.
4. A fiberboard tube.
5. Soak them in warm water.
6. 1 hour.

263

1. Drain, purge, remove foam, and depuddle the cell.
2. Cells should be removed in order beginning with cell #1 or individually as required by the applicable aircraft technical data.
3. The cell should pass through the access door opening without being strained or scraped.
4. Cracks, scratches, distortion, dirt, or other damage that could cause a leak.
5. Apply a small amount of petrolatum to the O-ring groove and the O-ring itself.
6. Soak them in warm water (120 ˚F) for 2 to 4 hours. If this is not possible, apply heat and moisture by capping off all fittings except the access opening. Place a bucket of water or wet rags inside the fuel cell and position a duct inside the access opening for 4 hours, wetting the cloths as often as necessary.

264

1. The grouping of the fuel cells, attitudes of the drain surfaces, location of the drain passages, size of the leak, and whether the leak occurs while the aircraft is on the ground or in flight.
2. Common-manifold type and individual type.
3. Black leak-detection tape.

265

1. The severity, location, and flight or ground conditions of the aircraft.
2. A ruptured or cut cell, a loose interconnect fitting, a pinched or distorted O-ring in a cell fitting, or missing O-ring.
3. Inspect the cell for other leaks.

266

1. (a) Pinholes.
   (b) Inner liner cuts,
   (c) Loose supports or hangers.
   (d) Blisters.
   (e) Loose seams or patches.
   (f) Weather-ozone checking (except cord damage).
2. Tools, equipment, facilities, skills, frequency of each repair, and mission requirements.
3. (a) Self-sealing cell repairs.
   (b) Repair or replacement of hangers and straps.
   (c) Repair or replacement of lacing ferules.
   (d) Repair or replacement of fittings.
   (e) Corner repairs.
   (f) Extensive weather-ozone checking.
4. Field level.
5. Weather-ozone checking requiring a patch measuring less than 12 square inches.
6. Self-sealing cell activation that exceeds two hundred square inches or extends into a corner or step off area; damage in an awkward location making patch roll down impossible; and weather ozone checking of the inner liner that exceeds five percent of the total area or which requires a patch larger than 36 square inches.

267

1. The surface must be clean, smooth, and padded.

2. One-quarter inch width if one-inch bond is maintained between laps.
3. Fittings, O-rings or gaskets.
4. TO 1–1–3.

268

1. To what you can see.
2. During handling, shipping, testing and the removal process.
3. Permanent set or crease and damage through the cord or fabric ply.

269

1. Soap suds and chemical test.
2. Manometer (water or approved digital type).
3. 200 cubic centimeters.
4. 15 grams.
5. To prevent corrosion.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

Glossary

Terms

Abrade–To prepare a surface for cementing or sealing by roughening.

Accelerator–The curing agent used in multipart curing-type sealant.

Activation–A condition occurring in self-sealing cells when fuel contacts the sealant layer, causing the sealant to swell.

Alloy–A homogeneous mixture or solid solution, usually of two or more metals.

Ambient–Surrounding.

Attendant–A trained person, outside of the confined space, who acts as the observer of the entrant.

Base compound–The major component of a multipart curing-type sealant, usually synthetic rubber.

Blister–A raised spot on the surface or a separation between the plies of a fuel cell, which usually fills a void or bubble.

Bonding–The equalization of static electricity charges between two or more objects.

Boundary structure–The fuel tight primary structure of an integral tank forming the tank boundaries. Comprised of skin panels, bulkheads, and spars.

Buffing–Method of abrasion forming a roughened or velvety surface.

Bucking–The process of installing a rivet.

Cavity–The structural members surrounding a fuel cell acting as a secondary container and help support the fuel cell.

Chalking–A sealant condition where white, chalk-like material is found under the surface of sealant.

Channel–A passage formed by structural discontinuity or a groove machined into a faying surface.

Confined space–Any space with limited ingress and egress, which can be bodily entered.

Corrosion preventive compound–A material applied to a surface to provide corrosion resistance.

Crazing–A surface irregularity characterized by many hairline indentations or ridges.

Cure–The metamorphosis of a curing type sealant from a soft state to a firm rubbery condition.

Depuddling–The removal of fuel or other liquid puddles from cells or tanks. Usually, depuddling is accomplished with a sponge and bucket or air operated vacuum system.

Deseal–Removal of sealant from a surface.

Designated alternate entry authority–An individual designated by the entry authority to issue field permits. This person is listed on the master permit.

Dome nuts–Plate nuts with a mechanical seal at the base and a cap over the top to provide a fuel tight seal.

Enclosed area–A space with limited ingress and egress not large enough to be bodily entered. Enclosed areas will be treated the same as confined spaces.

Entrant–An employee trained and authorized to enter a confined space.

Entry–Any act resulting in any part of an employee’s body breaking the plane of the opening of a confined space or enclosed area. This includes any ensuing work in the confined space or enclosed area.

Entry authority–The person authorized by the MXG/CC to issue field permits, usually the fuel element chief.

Entry permit–The permit authorizing entry into a confined space.

Entry safe–Conditions at which it is safe to enter a confined space. General conditions are 10 percent LEL (20 percent LEL for foam removal), oxygen level between 19.5 percent and 23.5 percent and toxicity limits within the limits prescribed on the master permit.

Emergency communications–Any type of communications link available for requesting emergency assistance.

Ethylene glycol–A colorless, syrupy alcohol, normally used as an antifreeze in cooling and heating systems.

Explosion proof apparatus–An apparatus enclosed in a case capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within and which operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

Faying surface–Surfaces that are extremely close together.

Faying surface seal–A seal between mating surfaces to prevent corrosion or to prevent fuel from traveling along or through mating surfaces.

Fillet seal–A primary seal applied along the edges of faying surfaces and over, along and between installed parts.

Fire-safe–An atmospheric concentration of combustible vapors equal to or less than 20 percent LEL.

First fillet (undersize fillet)–The first small bead or undersize fillet of curing-type sealant applied to a surface.

Fitting–Attaching points of a fuel cell for functional equipment such as pumps, vents or outlets.

Fuel cell–A flexible bag contoured to the shape of a fuselage or wing cavity and designed to contain a liquid. Three basic types of cells are bladder, self-sealing and a combination.

Grounding–The removal of a static electrical charge from the surface of an object by connecting the object to an approved ground.

IDLH (immediately dangerous to life and health)–Any condition that poses immediate threat to life or may result in acute severe health effects.

Incapacitated–Deprived of strength and ability.

Inerting–The replacement of oxygen in the atmosphere with a gas to the point the atmosphere will not support combustion or explosion.

Injection seal–A seal accomplished by injecting a curing type or noncuring-type sealant into holes, channels and other voids in fuel tank boundaries.

Inner lining–First ply of fuel cell material, functions as a support and protects nylon barrier. May be constructed of fabric or rubber.

Intrinsically safe–Equipment and wiring not capable of producing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a flammable or combustible atmospheric mixture in its most easily ignitable concentration.

Leak path–The path or trail leaking fuel follows from the leak source to the leak exit point.

Leak exit–The point outside of a tank where a leak first appears.

Leak source–The place inside the tank where the leak originates.

Lower explosive limit (LEL)–The lowest concentration of flammable or combustible vapors that can be ignited by a spark or flame.

Nominal–Small; trifling.

Parting agent–A material used to prevent sealant from sticking to a surface.

Permanent repair–A repair that returns a tank to a no leak condition.

Plasticizer–An additive in rubber or plastic to increase the pliability or low temperature flexibility of the finished product.

Ply–A layer of basic fuel cell construction, either fabric or non-fabric.

Purge–A process that removes flammable or combustible fluids and vapors.

Rescue team–A group of two or more specially trained employees (preferable fuel system repair specialist (Air Force Specialty Code [AFSC] 2A6X4 or equal) who are designated to rescue entrants from confined spaces.

Sealing groove–Grooves machined in the faying surface of a fuel tank boundary for injection sealant.

Self-sealing fastener–A fasteners that provide a fuel tight seal without the application of sealant.

Separations–Areas of nonadhesion between cell plies but exhibit no evidence of trapped liquid.

Shank–The long narrow part of a bolt.

Static electricity–The accumulation of an electrical charge on a person or object due to friction, wind or induction.

Tack-free–The condition of a sealant during the curing stage when the sealant will not stick to polyethylene plastic when pressed lightly to the surface.

Task–Any designated work (e.g., inspection, repair, etc.).

Temporary repair–A repair designed to down grade leak classifications to a flyable condition until such time as a permanent repair is applied.

Tolerance–The permissible deviation from a specified value of a structural dimension.

Turnbuckle–A metal coupling, used for tightening a rod or cable, having an oblong piece internally threaded at both ends into which a threaded rod is screwed.

Ventilation–The process of supplying fresh air to a tank or cell after it has been fluid purged.

Void–Any opening, small crack or crevice occurring at the juncture of structural members.

Weathering-ozone checking –Short small cracks on the surface of a fuel cell, generally caused by environmental conditions.

Weep hole–A small hole drilled at the bottom of an enclosed area to allow fluid to drain out.

Wetted surface–Any surface that is in direct contact with fuel.

Abbreviations and Acronyms

°F	degree Fahrenheit
Ω	ohm
AC	alternating current
AFI	Air Force instruction
AFMAN	Air Force manual
AFTO	Air Force technical order
AGE	aerospace ground equipment
AN	Air Force-Navy
BEF	bioenvironmental engineering flight
CDC	career development course
cfm	cubic feet per minute
CPR	cardiopulmonary resuscitation
DC	direct current
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
ETL	engineering technical letter
FOD	foreign object damage
HDU	generation heater
IDLH	immediately dangerous to life and health
IMDS	Integrated Maintenance Data System
LEL	lower explosive limit
LO	low observable
MEP	master entry plan
MIL-C	military specification-coating
MIL-H	military specification-hose
MIL-L	military specification-lubricating oil
MIL-S	military specification-sealant
MOC	maintenance operations center
MXG/CC	maintenance group commander

NFPA	National Fire Protection Agency
PDM	programmed depot maintenance
PID	photo ionization detector
ppm	parts per million
psi	pounds per square inch
psig	pounds per square inch gauge
QD	quick disconnect
RAM	radar absorbent material
RCD	rapid curing device
rpm	revolutions per minute
SPDT	single-pole, double-throw
SPR	single point refueling receptacle
SPST	single-pole, single-throw
TO	technical order
VAC	volts alternating current
VDC	volts direct current

Student Notes

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