
Aircraft fluid lines are usually made of metal tubing or flexible hose. Metal tubing (also called rigid fluid lines) is used in stationary applications and where long, relatively straight runs are possible. They are widely used in aircraft for fuel, oil, coolant, oxygen, instrument, and hydraulic lines. Flexible hose is generally used with moving parts or where the hose is subject to considerable vibration.

Occasionally, it may be necessary to repair or replace damaged aircraft fluid lines. Very often the repair can be made simply by replacing the tubing. However, if replacements are not available, the needed parts may have to be fabricated. Replacement tubing should be of the same size and material as the original tubing. All tubing is pressure tested prior to initial installation, and is designed to withstand several times the normal operating pressure to which it will be subjected. If a tube bursts or cracks, it is generally the result of excessive vibration, improper installation, or damage caused by collision with an object. All tubing failures should be carefully studied and the cause of the failure determined.

## Rigid Fluid Lines

### Tubing Materials

*Copper*

In the early days of aviation, copper tubing was used extensively in aviation fluid applications. In modern aircraft, aluminum alloy, corrosion resistant steel or titanium tubing have generally replaced copper tubing.

*Aluminum Alloy Tubing*

Tubing made from 1100 H14 (1/2-hard) or 3003 H14 (1/2-hard) is used for general purpose lines of low or negligible fluid pressures, such as instrument lines and ventilating conduits. Tubing made from 2024-T3, 5052-O, and 6061-T6 aluminum alloy materials is used in general purpose systems of low and medium pressures, such as hydraulic and pneumatic 1,000 to 1,500 psi systems, and fuel and oil lines.

*Steel*

Corrosion resistant steel tubing, either annealed CRES 304, CRES 321 or CRES 304-1/8-hard, is used extensively in high pressure hydraulic systems (3,000 psi or more) for the operation of landing gear, flaps, brakes, and in fire zones. Its higher tensile strength permits the use of tubing with thinner walls; consequently, the final installation weight is not much greater than that of the thicker wall aluminum alloy tubing. Steel lines are used where there is a risk of foreign object damage (FOD); i.e., the landing gear and wheel well areas. Although identification markings for steel tubing differ, each usually includes the manufacturer's name or trademark, the *Society of Automotive Engineers* (SAE) number, and the physical condition of the metal.

*Titanium 3AL-2.5V*

This type of tubing and fitting is used extensively in transport category and high performance aircraft hydraulic systems for pressures above 1,500 psi. Titanium is 30 percent stronger than steel and 50 percent lighter than steel. Cryofit fittings or swaged fittings are used with titanium tubing. Do not use titanium tubing and fittings in any oxygen system assembly. Titanium and titanium alloys are oxygen reactive. If a freshly formed titanium surface is exposed in gaseous oxygen, spontaneous combustion could occur at low pressures.

### Material Identification

Before making repairs to any aircraft tubing, it is important to make accurate identification of tubing materials. Aluminum alloy, steel, or titanium tubing can be identified readily by sight where it is used as the basic tubing material. However, it is difficult to determine whether a material is carbon steel or stainless steel, or whether it is 1100, 3003, 5052-O, 6061-T6 or 2024-T3 aluminum alloy. To positively identify the material used in the original installation, compare code markings of the replacement tubing with the original markings on the tubing being replaced.

| Aluminium Alloy Number | Color of Band |
|---|---|
| 1100 | White |
| 3003 | Green |
| 2014 | Gray |
| 2024 | Red |
| 5052 | Purple |
| 6053 | Black |
| 6061 | Blue and Yellow |
| 7075 | Brown and Yellow |

**Figure 7-1. Painted color codes used to identify aluminum alloy tubing.**

On large aluminum alloy tubing, the alloy designation is stamped on the surface. On small aluminum tubing, the designation may be stamped on the surface; but more often it is shown by a color code, not more than 4" in width, painted at the two ends and approximately midway between the ends of some tubing. When the band consists of two colors, one-half the width is used for each color. [Figure 7-1]

If the code markings are hard or impossible to read, it may be necessary to test samples of the material for hardness by hardness testing.

### Sizes

Metal tubing is sized by outside diameter (o.d.), which is measured fractionally in sixteenths of an inch. Thus, number 6 tubing is 6/16" (or 3⁄8") and number 8 tubing is 8/16" (or 1⁄2"), and so forth. The tube diameter is typically printed on all rigid tubing. In addition to other classifications or means of identification, tubing is manufactured in various wall thicknesses. Thus, it is important when installing tubing to know not only the material and outside diameter, but also the thickness of the wall. The wall thickness is typically printed on the tubing in thousands of an inch. To determine the inside diameter (i.d.) of the tube, subtract twice the wall thickness from the outside diameter.

For example, a number 10 piece of tubing with a wall thickness of 0.063" has an inside diameter of 0.625" – 2(0.063") = 0.499".

### Fabrication of Metal Tube Lines

Damaged tubing and fluid lines should be repaired with new parts whenever possible. Unfortunately, sometimes replacement is impractical and repair is necessary. Scratches, abrasions, or minor corrosion on the outside of fluid lines may be considered negligible and can be smoothed out with a burnishing tool or aluminum wool. Limitations on the amount of damage that can be repaired in this manner are discussed in this chapter under "Rigid Tubing Inspection and Repair." If a fluid line assembly is to be replaced, the fittings can often be salvaged; then the repair will involve only tube forming and replacement.

Tube forming consists of four processes: Cutting, bending, flaring, and beading. If the tubing is small and made of soft material, the assembly can be formed by hand bending during installation. If the tube is 1⁄4" diameter or larger, hand bending without the aid of tools is impractical.

#### *Tube Cutting*

When cutting tubing, it is important to produce a square end, free of burrs. Tubing may be cut with a tube cutter or a hacksaw. The cutter can be used with any soft metal tubing, such as copper, aluminum, or aluminum alloy. Correct use of the tube cutter is shown in Figure 7-2. Special chipless cutters are available for cutting aluminum 6061-T6, corrosion resistant steel and titanium tubing.

A new piece of tubing should be cut approximately 10 percent longer than the tube to be replaced to provide

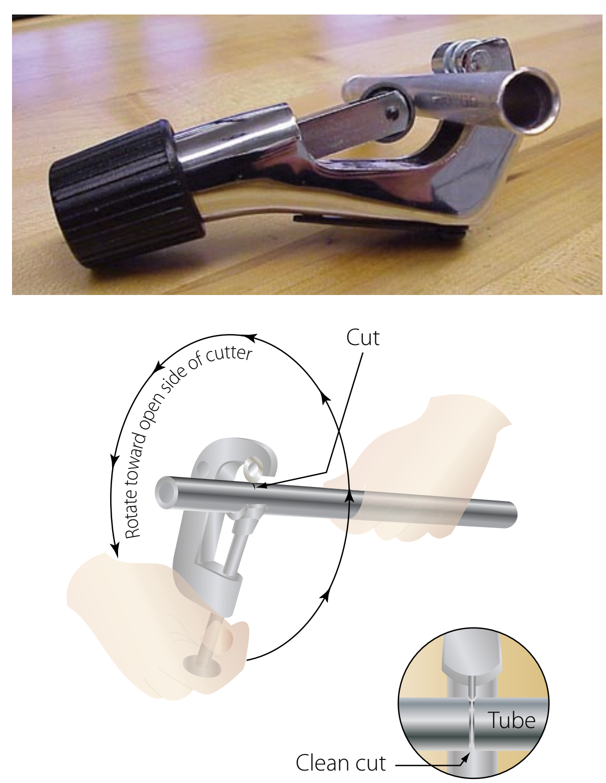



**Figure 7-2. Tube cutting.**

for minor variations in bending. Place the tubing in the cutting tool, with the cutting wheel at the point where the cut is to be made. Rotate the cutter around the tubing, applying a light pressure to the cutting wheel by intermittently twisting the thumbscrew. Too much pressure on the cutting wheel at one time could deform the tubing or cause excessive burring. After cutting the tubing, carefully remove any burrs from inside and outside the tube. Use a knife or the burring edge attached to the tube cutter. The deburring operation can be accomplished by the use of a deburring tool as shown in Figure 7-3. This tool is capable of removing both the inside and outside burrs by just turning the tool end for end.

When performing the deburring operation, use extreme care that the wall thickness of the end of the tubing is not reduced or fractured. Very slight damage of this type can lead to fractured flares or defective flares which will not seal properly. Use a fine-tooth file to file the end square and smooth.

If a tube cutter is not available, or if tubing of hard material is to be cut, use a fine-tooth hacksaw, preferably one having 32 teeth per inch. The use of a saw will decrease the amount of work hardening of the tubing during the cutting operation. After sawing, file the end of the tube square and smooth, removing all burrs.

An easy way to hold small diameter tubing, when cutting it, is to place the tube in a combination flaring tool and clamp the tool in a vise. Make the cut about one-half inch from the flaring tool. This procedure keeps sawing vibrations to a minimum and prevents damage to the tubing if it is accidentally hit with the hacksaw frame or file handle while cutting. Be sure all filings and cuttings are removed from the tube.

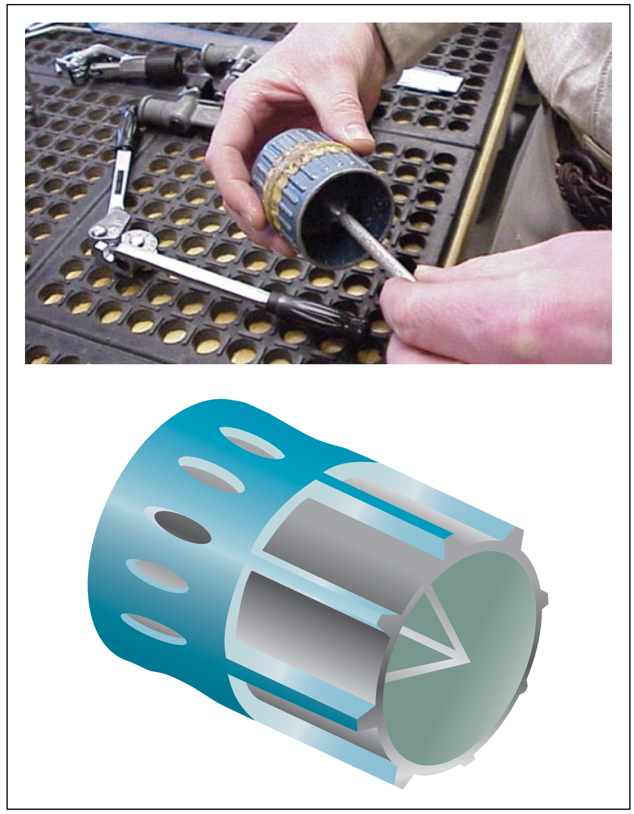


**Figure 7-3. Deburring tool.**

### *Tube Bending*

The objective in tube bending is to obtain a smooth bend without flattening the tube. Tubing under 1/4" in diameter usually can be bent without the use of a bending tool. For larger sizes, either portable hand benders or production benders are usually used. Table 7-1 shows preferred methods and standard bend radii for bending tubing by tube size.

Using a hand bender, insert the tubing into the groove of the bender, so that the measured end is left of the form block. Align the two zeros and align the mark on the tubing with the L on the form handle. If the measured end is on the right side, then align the mark on the tubing with the R on the form handle. With a steady motion, pull the form handle till the zero mark

| **Type Bender** | **AB** | **AB** | **B** | **B** | **B** | **BC** | **B** | **BC** | **B** | **BC** | **C** | **BC** | **C** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tube od | 1/8" | 3/16" | 1/4" | 5/16" | 3/8" | 3/8" | 7/16" | 1/2" | 1/2" | 5/8" | 5/8" | 3/4" | 3/4" |
| Standard Bend | 3/8" | 7/16" | 9/16" | 11/16" | 11/16" | 15/16" | 1 3/8" | 1 1/2" | 1 1/4" | 2" | 1 1/2" | 2 1/2" | 1 3/4" |
| | | | | | | | | | | | | | |
| **Type Bender** | **C** | **B** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** | **C** |
| Tube od | 7/8" | 1" | 1" | 1 1/8" | 1 1/4" | 1 3/8" | 1 3/8" | 1 1/2" | 1 1/2" | 1 3/4" | 2" | 2 1/2" | 3" |
| Standard Bend | 2" | 3 1/2" | 3" | 3 1/2" | 3 3/4" | 5" | 6" | 5" | 6" | 7" | 8" | 10" | 12" |

A – Hand B – Portable hand benders C – Production bender

**Table 7-1. Standard bend radii to which standard bending tools will form the various sizes of tubes.**

**Figure 7-4. Tube bending.**

on the form handle lines up with the desired angle of bend, as indicated on the radius block. [Figure 7-4]

Bend the tubing carefully to avoid excessive flattening, kinking, or wrinkling. A small amount of flattening in bends is acceptable, but the small diameter of the flattened portion must not be less than 75 percent of the original outside diameter. Tubing with flattened, wrinkled, or irregular bends should not be installed. Wrinkled bends usually result from trying to bend thin wall tubing without using a tube bender. Excessive flattening will cause fatigue failure of the tube. Examples of correct and incorrect tubing bends are shown in Figure 7-5.

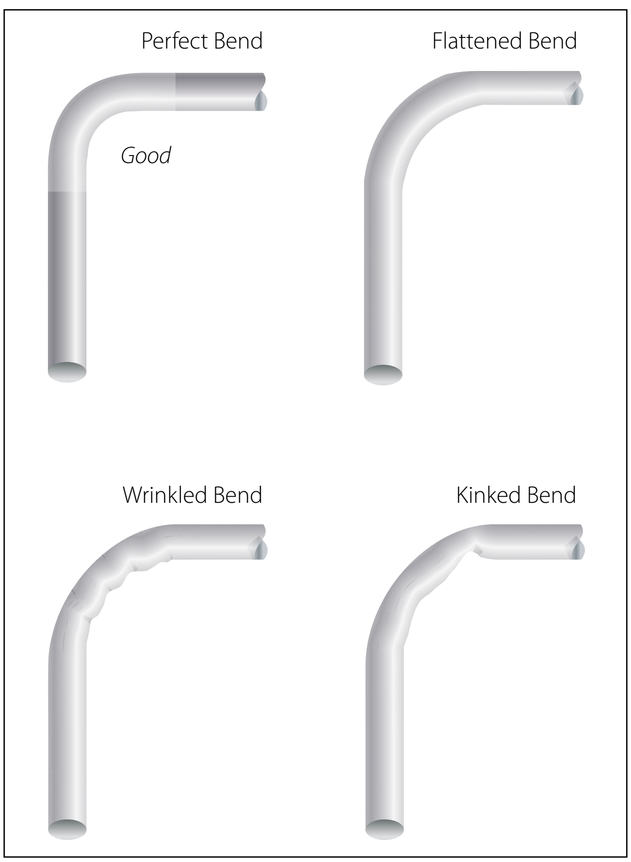



**Figure 7-5. Correct and incorrect tubing bends.**

Tube bending machines for all types of tubing are generally used in repair stations and large maintenance shops. With such equipment, proper bends can be made on large diameter tubing and on tubing made from hard material. The production CNC™ tube bender is an example of this type of machine. [Figure 7-6]

The ordinary production tube bender will accommodate tubing ranging from $\frac{1}{4}$" to $1\frac{1}{2}$" outside diameter. Benders for larger sizes are available, and the principle of their operation is similar to that of the hand tube bender. The radius blocks are so constructed that the radius of bend will vary with the tube diameter. The radius of bend is usually stamped on the block.

**Alternative Bending Methods**

When hand or production tube benders are not available or are not suitable for a particular bending operation, a filler of metallic composition or of dry sand may be used to facilitate bending. When using this method, cut the tube slightly longer than is required. The extra

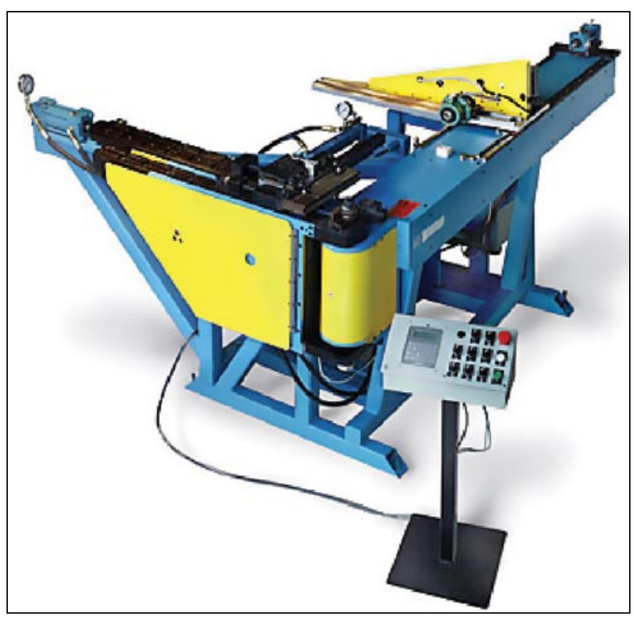


**Figure 7-6. CNC tube bending machine.**

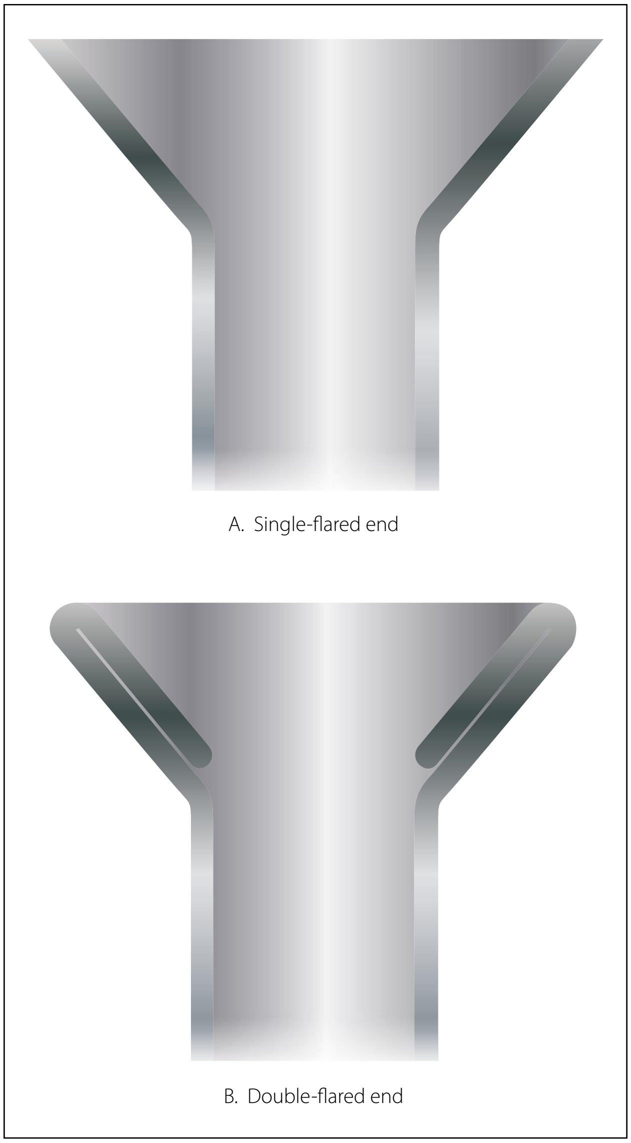



**Figure 7-7. Cutaway view of single and double-flared tube ends.**

length is for inserting a plug (which may be wooden) in each end. The tube can also be closed by flattening the ends or by soldering metal disks in them.

After plugging one end, fill and pack the tube with fine, dry sand and plug tightly. Both plugs must be tight so they will not be forced out when the bend is made. After the ends are closed, bend the tubing over a forming block shaped to the specified radius. In a modified version of the filler method, a fusible alloy is used instead of sand. In this method, the tube is filled under hot water with a fusible alloy that melts at 160 °F. The alloy-filled tubing is then removed from the water, allowed to cool, and bent slowly by hand around a forming block or with a tube bender. After the bend is made, the alloy is again melted under hot water and removed from the tubing. When using either filler methods, make certain that all particles of the filler are removed. Visually inspect with a borescope to make certain that no particles will be carried into the system in which the tubing is installed. Store the fusible alloy filler where it will be free from dust or dirt. It can be remelted and reused as often as desired. Never heat this filler in any other way than the prescribed method, as the alloy will stick to the inside of the tubing, making them both unusable.

### *Tube Flaring*

Two kinds of flares are generally used in aircraft tubing: the single flare and the double flare. [Figure 7-7 (A and B)] Flares are frequently subjected to extremely high pressures; therefore, the flare on the tubing must be properly shaped or the connection will leak or fail. A flare made too small produces a weak joint, which may leak or pull apart; if made too large, it interferes with the proper engagement of the screw thread on the fitting and will cause leakage. A crooked flare is the result of the tubing not being cut squarely. If a flare is not made properly, flaws cannot be corrected by applying additional torque when tightening the fitting. The flare and tubing must be free from cracks, dents, nicks, scratches, or any other defects.

The flaring tool used for aircraft tubing has male and female dies ground to produce a flare of 35° to 37°. Under no circumstance is it permissible to use an automotive-type flaring tool which produces a flare of 45°. [Figure 7-8]

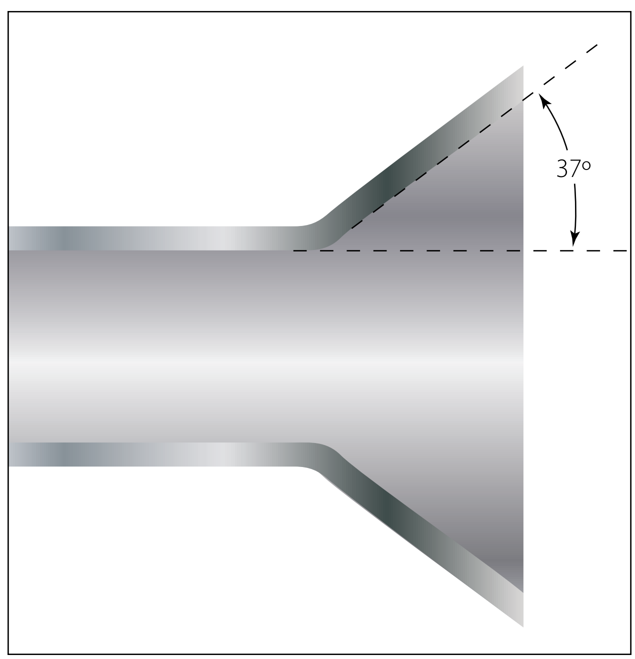



**Figure 7-8. Flaring tool.**

Figure 7-9. Hand flaring tool.

The single-flare hand flaring tool, similar to that shown in Figure 7-9, is used for flaring tubing. The tool consists of a flaring block or grip die, a yoke, and a flaring pin. The flaring block is a hinged double bar with holes corresponding to various sizes of tubing. These holes are countersunk on one end to form the outside support against which the flare is formed. The yoke is used to center the flaring pin over the end of the tube to be flared. Two types of flaring tools are used to make flares on tubing: the impact type and the rolling type.

### Instructions for Rolling-Type Flaring Tools

Use these tools only to flare soft copper, aluminum, and brass tubing. Do not use with corrosion resistant steel or titanium. Cut the tube squarely and remove all burrs. Slip the fitting nut and sleeve on the tube. Loosen clamping screw used for locking the sliding segment in the die holder. This will permit their separation. The tools are self-gauging; the proper size flare is produced when tubing is clamped flush with the top of the die block. Insert tubing between the segments of the die block that correspond to the size of the tubing to be flared. Advance the clamp screw against the end segment and tighten firmly. Move the yoke down over the top of the die holder and twist it clockwise to lock it into position. Turn the feed screw down firmly, and continue until a slight resistance is felt. This indicates an accurate flare has been completed. Always read the tool manufacturer's instructions, because there are several different types of rolling-type flaring tools that use slightly different procedures.

### Double Flaring

A double flare is used on soft aluminum alloy tubing $^{3}/_{8}$" outside diameter and under. This is necessary to prevent cutting off the flare and failure of the tube assembly under operating pressures. A double flare is smoother and more concentric than a single flare and therefore seals better. It is also more resistant to the shearing effect of torque.

### Double Flaring Instructions

Deburr both the inside and outside of the tubing to be flared. Cut off the end of the tubing, if it appears damaged. Anneal brass, copper, and aluminum by heating to a dull red and cool rapidly in cold water. Open the flaring tool by unscrewing both clamping screws. Select the hole in the flaring bar that matches the tubing diameter and place the tubing with the end you have just prepared, extending above the top of the bar by a distance equal to the thickness of the shoulder of the adapter insert. Tighten clamping screws to hold tubing securely. Insert pilot of correctly sized adapter into tubing. Slip yoke over the flaring bars and center over adapter. Advance the cone downward until the shoulder of the adapter rests on the flaring bar. This bells out the end of the tubing. Next, back off the cone just enough to remove the adapter. After removing the adapter, advance the cone directly into the belled end of the tubing. This folds the tubing on itself and forms

Figure 7-10. Double flare tool.

an accurate double flare without cracking or splitting the tubing. To prevent thinning out of the flare wall, do not overtighten. [Figure 7-10]

### *Fittings*

Rigid tubing may be joined to either an end item (such as a brake cylinder), another section of either rigid tubing, or to a flexible hose (such as a drain line). In the case of connection to an end item or another tube, fittings are required, which may or may not necessitate flaring of the tube. In the case of attachment to a hose, it may be necessary to bead the rigid tube so that a clamp can be used to hold the hose onto the tube.

### Flareless Fittings

Although the use of flareless tube fittings eliminates all tube flaring, another operation, referred to as presetting, is necessary prior to installation of a new flareless tube assembly. *Flareless* tube assemblies should be preset with the proper size presetting tool or operation. Figure 7-11 (steps 1, 2, and 3) illustrates the presetting operation, which is performed as follows: Cut the tube to the correct length, with the ends perfectly square. Deburr the inside and outside of the tube. Slip the nut, then the sleeve, over the tube (step 1), lubricate the threads of the fitting and nut with hydraulic fluid. Place the fitting in a vise (step 2), and hold the tubing firmly and squarely on the seat in the fitting. (The tube must bottom firmly in the fitting.) Tighten the nut until the cutting edge of the sleeve grips the tube. To determine this point, slowly turn the tube back and forth while tightening the nut. When the tube no longer turns, the nut is ready for tightening. Final tightening depends upon the tubing (step 3). For aluminum alloy tubing up to and including ½" outside diameter, tighten the nut from 1 to 1⅙ turns. For steel tubing and aluminum alloy tubing over ½" outside diameter, tighten from 1⅙ to 1½ turns.

After presetting the sleeve, disconnect the tubing from the fitting and check the following points: The tube should extend 3⁄32" to ⅛" beyond the sleeve pilot; otherwise, blowoff may occur. The sleeve pilot should contact the tube or have a maximum clearance of 0.005" for aluminum alloy tubing or 0.015" for steel tubing. A slight collapse of the tube at the sleeve cut is permissible. No movement of the sleeve pilot, except rotation, is permissible.

### *Beading*

Tubing may be beaded with a hand beading tool, with machine beading rolls, or with grip dies. The method to be used depends on the diameter and wall thickness of the tube and the material from which it was made.

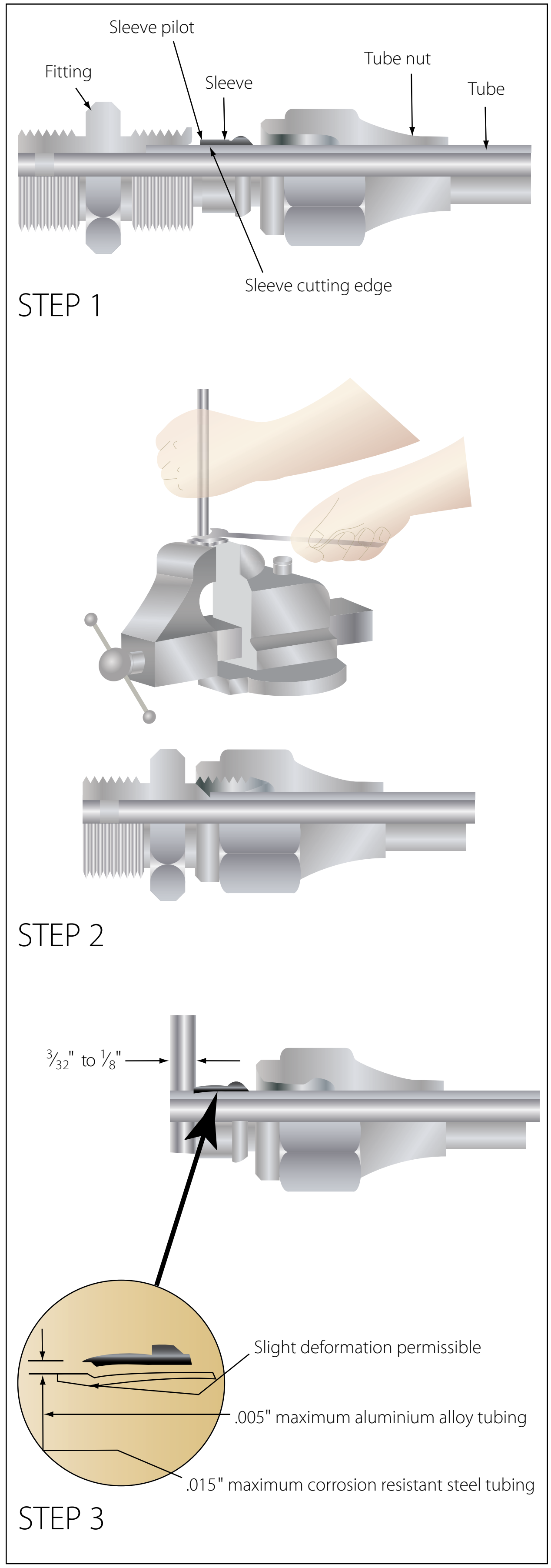



**Figure 7-11. Presetting flareless tube assembly.**

**Figure 7-12. Hand beading tool.**

The hand beading tool is used with tubing having ¼" to 1" outside diameter. The bead is formed by using the beader frame with the proper rollers attached. The inside and outside of the tube is lubricated with light oil to reduce the friction between the rollers during beading. The sizes, marked in sixteenths of an inch on the rollers, are for the outside diameter of the tubing that can be beaded with the rollers. [Figure 7-12]

Separate rollers are required for the inside of each tubing size, and care must be taken to use the correct parts when beading. The hand beading tool works somewhat like the tube cutter in that the roller is screwed down intermittently while rotating the beading tool around the tubing. In addition, a small vise (tube holder) is furnished with the kit.

Other methods and types of beading tools and machines are available, but the hand beading tool is used most often. As a rule, beading machines are limited to use with large diameter tubing, over 1 15⁄16", unless special rollers are supplied. The grip-die method of beading is confined to small tubing.

### Fluid Line Identification

Fluid lines in aircraft are often identified by markers made up of color codes, words, and geometric symbols. These markers identify each line's function, content, and primary hazard. Figure 7-13 illustrates the various color codes and symbols used to designate the type of system and its contents.

Fluid lines are marked, in most instances with 1" tape or decals, as shown in Figure 7-14(A). On lines 4" in diameter (or larger), lines in oily environment, hot lines, and on some cold lines, steel tags may be used in place of tape or decals, as shown in Figure 7-14(B). Paint is used on lines in engine compartments, where there is the possibility of tapes, decals, or tags being drawn into the engine induction system.

In addition to the above-mentioned markings, certain lines may be further identified regarding specific function within a system; for example, drain, vent, pressure, or return. Lines conveying fuel may be marked FLAM; lines containing toxic materials are marked TOXIC in place of FLAM. Lines containing physically dangerous

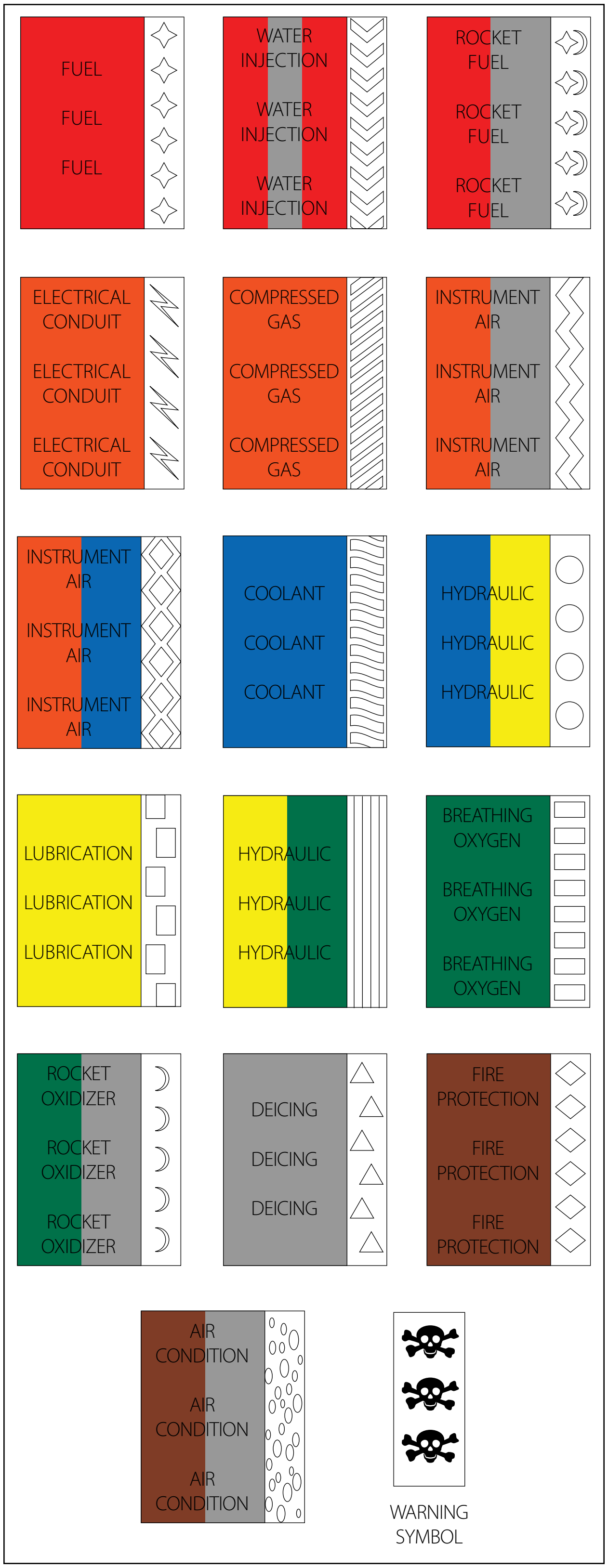



**Figure 7-13. Identification of aircraft fluid lines.**

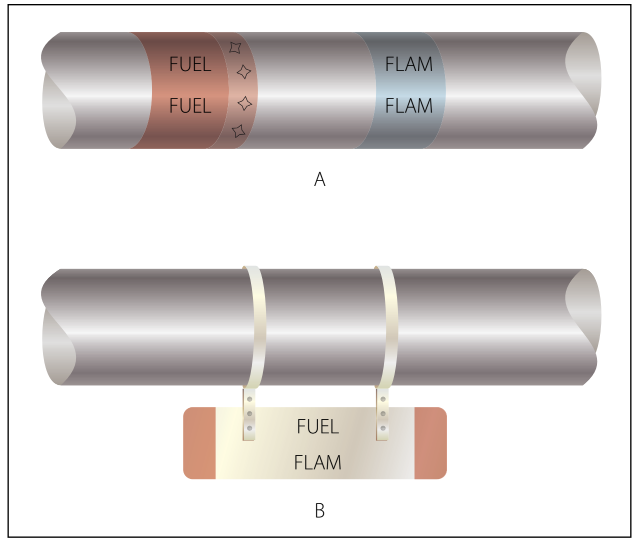



**Figure 7-14. Fluid line identification using: (A) tape and decals and (B) metal tags.**

materials, such as oxygen, nitrogen, or Freon™, may be marked PHDAN. [Figure 7-14]

Aircraft and engine manufacturers are responsible for the original installation of identification markers, but the aviation mechanic is responsible for their replacement when it becomes necessary. Tapes and decals are generally placed on both ends of a line and at least once in each compartment through which the line runs. In addition, identification markers are placed immediately adjacent to each valve, regulator, filter, or other accessory within a line. Where paint or tags are used, location requirements are the same as for tapes and decals.

## Fluid Line End Fittings

Depending on the type and use, fittings will have either pipe threads or machine threads. Pipe threads are similar to those used in ordinary plumbing and are tapered, both internal and external. External threads are referred to as male threads and internal threads are female threads.

When two fittings are joined, a male into a female, the thread taper forms a seal. Some form of pipe thread lubricant approved for the particular fluid application should be used when joining pipe threads to prevent seizing and high-pressure leakage. Use care when applying thread lubricant so that the lubricant will not enter and contaminate the system. Do not use lubricants on oxygen lines. Oxygen will react with petroleum products and can ignite (special lubricants are available for oxygen systems).

Machine threads have no sealing capability and are similar to those used on common nuts and bolts. This type of fitting is used only to draw connections together or for attachment through bulkheads. A flared tube connection, a crush washer, or a synthetic seal is used to make the connection fluid tight. Machine threads have no taper and will not form a fluid-tight seal. The size of these fittings is given in dash numbers, which equal the nominal o.d. in sixteenths of an inch.

### *Universal Bulkhead Fittings*

When a fluid line passes through a bulkhead, and it is desired to secure the line to the bulkhead, a bulkhead fitting should be used. The end of the fitting that passes through the bulkhead is longer than the other end(s), which allows a locknut to be installed, securing the fitting to the bulkhead.

Fittings attach one piece of tubing to another, or to system units. There are four types: (1) bead and clamp, (2) flared fittings, (3) flareless fittings, and (4) permanent fittings (Permaswage™, Permalite™, and Cyrofit™). The amount of pressure that the system carries and the material used are usually the deciding factors in selecting a connector.

The beaded type of fitting, which requires a bead and a section of hose and hose clamps, is used only in low- or medium-pressure systems, such as vacuum and coolant systems. The flared, flareless, or permanent-type fittings may be used as connectors in all systems, regardless of the pressure.

### *AN Flared Fittings*

A flared tube fitting consists of a sleeve and a nut, as shown in Figure 7-15. The nut fits over the sleeve and, when tightened, draws the sleeve and tubing flare tightly against a male fitting to form a seal. Tubing used with this type of fitting must be flared before installation. The male fitting has a cone-shaped surface with the same angle as the inside of the flare. The sleeve supports the tube so that vibration does not concentrate at the edge of the flare, and distributes the shearing action over a wider area for added strength.

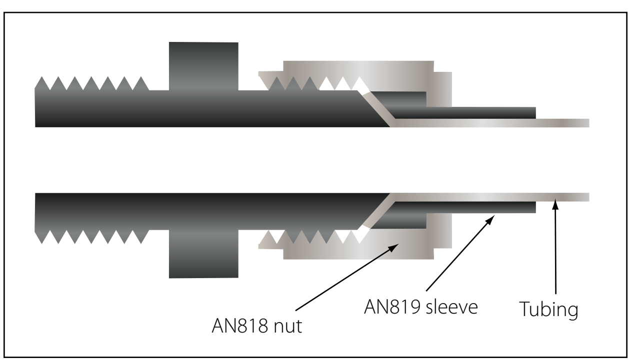



**Figure 7-15. Flared tube fitting.**

Fitting combinations composed of different alloys should be avoided to prevent dissimilar metal corrosion. As with all fitting combinations, ease of assembly, alignment, and proper lubrication should be assured when tightening fittings during installation.

Standard AN fittings are identified by their black or blue color. All AN steel fittings are colored black, all AN aluminum fittings are colored blue, and aluminum bronze fittings are cadmium plated and natural in appearance. A sampling of AN fittings is shown in Figure 7-16. Table 7-2 contains additional information on sizes, torques, and bend radii.

## MS Flareless Fittings

MS flareless fittings are designed primarily for high-pressure (3,000 psi) hydraulic systems that may be subjected to severe vibration or fluctuating pressure. Using this type of fitting eliminates all tube flaring, yet provides a safe and strong, dependable tube connection. [Figure 7-17] The fitting consists of three parts: a body, a sleeve, and a nut. [Figure 7-18] The internal design of the body causes the sleeve to cut into the outside of the tube when the body and nut are joined. The counterbore shoulder within the body is designed with a reverse angle of 15° for steel connectors and 45° for aluminum fittings. This reverse angle prevents inward collapse of the tubing when tightened and provides a partial sealing force to be exerted against the periphery of the body counterbore.

### *Swaged Fittings*

A popular repair system for connecting and repairing hydraulic lines on transport category aircraft is the use of Permaswage™ fittings. Swaged fittings create a permanent connection that is virtually maintenance free. Swaged fittings are used to join hydraulic lines in areas where routine disconnections are not required and are often used with titanium and corrosion resistant steel tubing. The fittings are installed with portable hydraulically powered tooling, which is compact enough to be used in tight spaces. [Figure 7-19] If the fittings need to be disconnected, cut the tubing with a tube cutter. Special installation tooling is available in portable kits. Always use the manufacturer's instructions to install swaged fittings. One of the latest developments is the Permalite™ fitting. Permalite™ is a tube fitting that is mechanically attached to the tube by axial swaging. The movement of the ring along the fitting body results in deformation of the tube with a leak-tight joint. [Figure 7-20]

— —AN744 to AN932— —

Material:

Aluminum alloy ........ (code D)
Steel ........ (code, absence of letter)
Brass ........ (code B)
Aluminum bronze ........ (code Z - for AN819 sleeve)

Size:

The dash number following the AN number indicates the size of the tubing (or hose) for which the fitting is made, in 16ths of an inch. This size measures the od of tubing and the id of hose. Fittings having pipe threads are coded by a dash number, indicating the pipe size in 8ths of an inch. The material code letter, as noted above, follows the dash number.

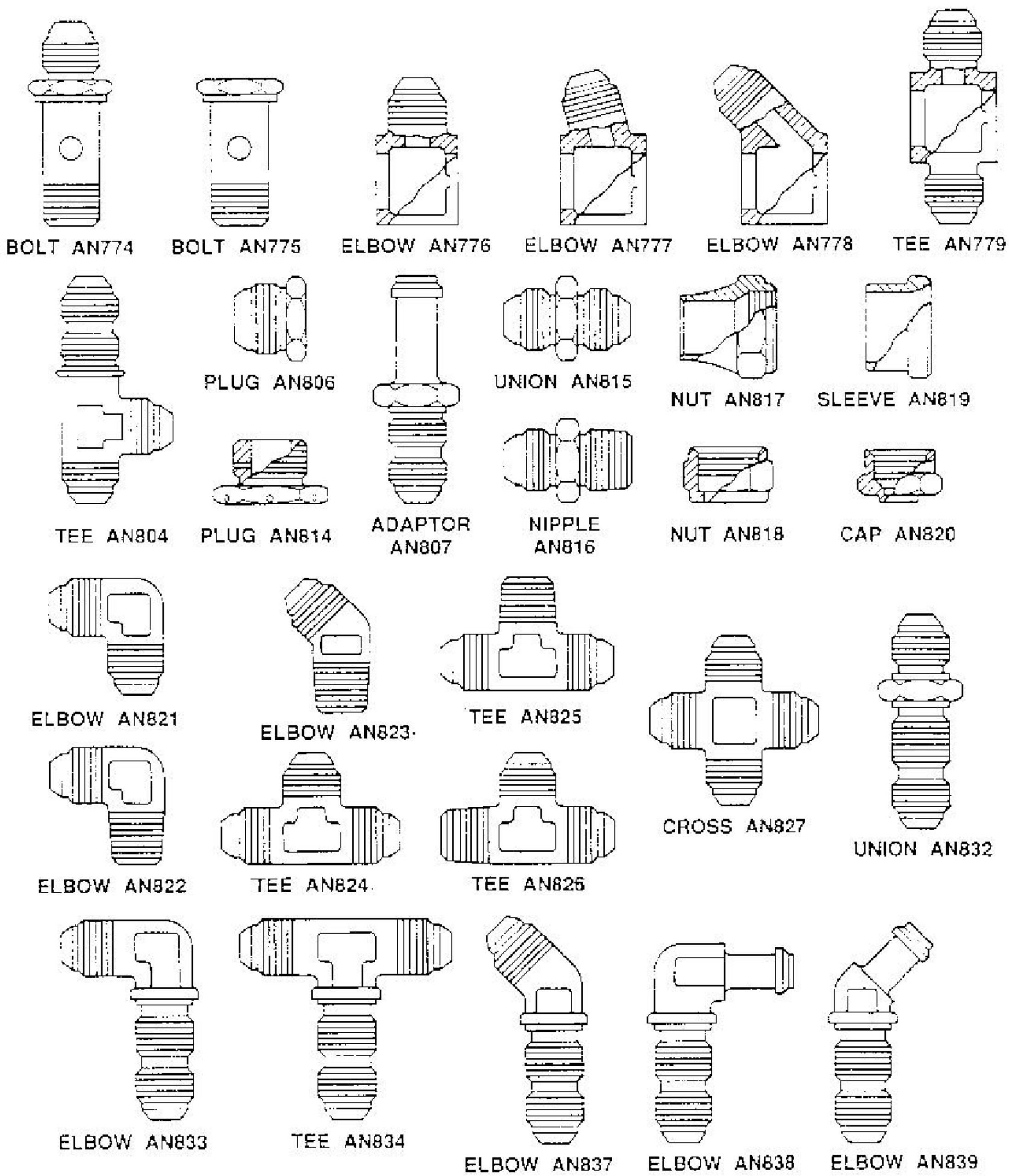



**Figure 7-16. AN standard fittings.**

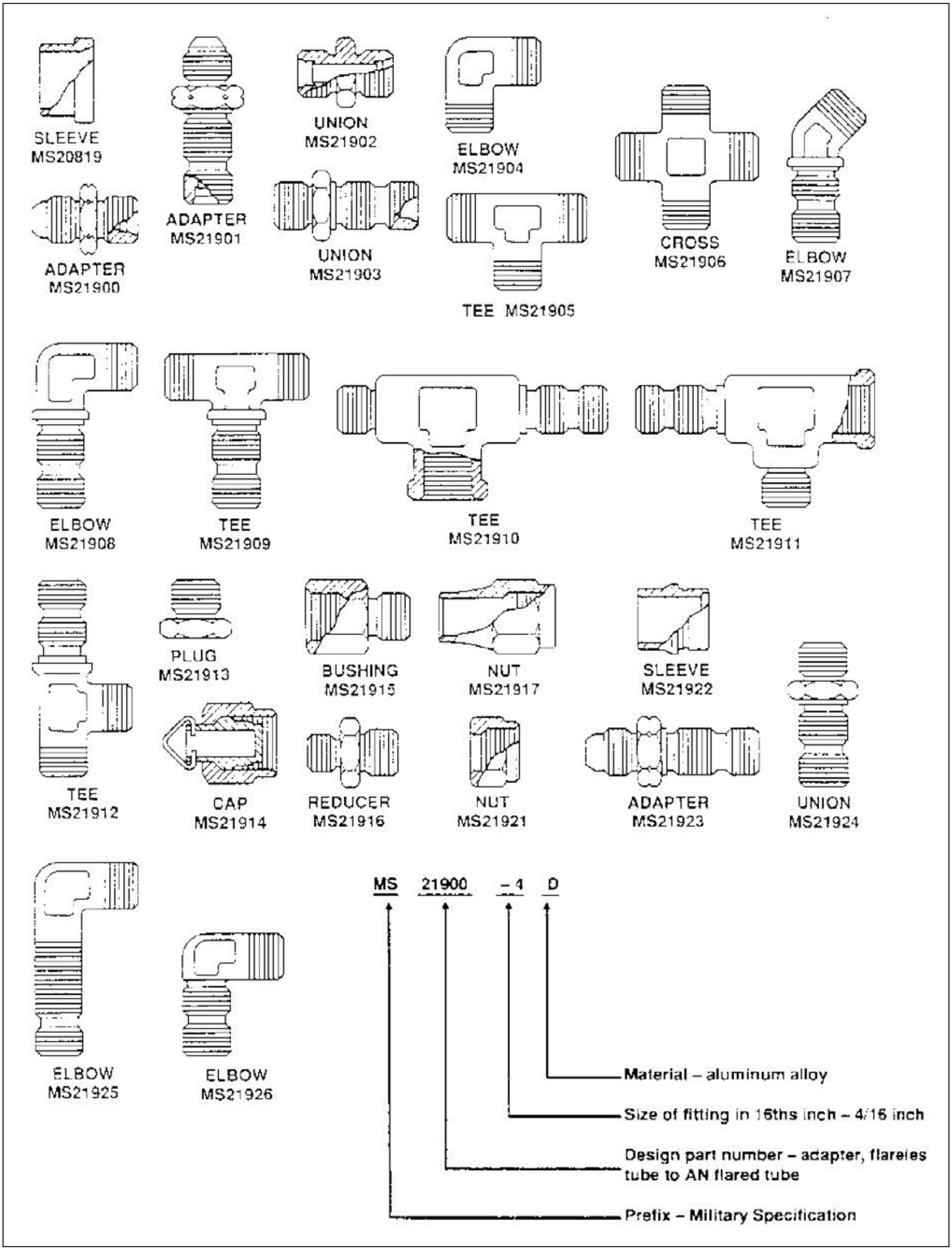



**Figure 7-17. Typical MS flareless tube fittings.**

| Tubing o.d. (inches) | Fitting Bolt or Nut Size | Aluminium Alloy Tubing, Bolt, Fitting, or Nut Torque (in–lb) | Steel Tubing, Bolt Fitting, or Nut Torque (in–lb) | Hose End Fittings and Hose Assemblies | | Minimum bend radii (inches) | |
|---|---|---|---|---|---|---|---|
| | | | | MS28740 or Equivalent End Fitting | | Alum. alloy 1100-H14 5052-0 | Steel |
| | | | | Minimum | Maximum | | |
| 1⁄8 | –2 | 20–30 | | | | 3⁄8 | |
| 3⁄16 | –3 | 30–40 | 90–100 | 70 | 120 | 7⁄16 | 21⁄32 |
| 1⁄4 | –4 | 40–65 | 135–150 | 100 | 250 | 9⁄16 | 7⁄8 |
| 5⁄16 | –5 | 60–85 | 180–200 | 210 | 420 | 3⁄4 | 1 1⁄8 |
| 3⁄8 | –6 | 75–125 | 270–300 | 300 | 480 | 15⁄16 | 1 5⁄16 |
| 1⁄2 | –8 | 150–250 | 450–500 | 500 | 850 | 1 1⁄4 | 1 3⁄4 |
| 5⁄8 | –10 | 200–350 | 650–700 | 700 | 1,150 | 1 1⁄2 | 2 3⁄16 |
| 3⁄4 | –12 | 300–500 | 900–1,000 | | | 1 3⁄4 | 2 5⁄8 |
| 7⁄8 | –14 | 500–600 | 1,000–1,100 | | | | |
| 1 | –16 | 500–700 | 1,200–1,400 | | | 3 | 3 1⁄2 |
| 1 1⁄4 | –20 | 600–900 | 1,200–1,400 | | | 3 3⁄4 | 4 3⁄8 |
| 1 1⁄2 | –24 | 600–900 | 1,500–1,800 | | | 5 | 5 1⁄4 |
| 1 3⁄4 | –28 | 850–1,050 | | | | 7 | 6 1⁄8 |
| 2 | –32 | 950–1,150 | | | | 8 | 7 |

**Table 7-2. Flared fitting data.**

*Cryofit Fittings*

Many transport category aircraft use Cryofit fittings to join hydraulic lines in areas where routine disconnections are not required. Cryofit fittings are standard fittings with a cryogenic sleeve. The sleeve is made of a shape memory alloy, Tinel™. The sleeve is manufactured 3 percent smaller, frozen in liquid nitrogen, and expanded to 5 percent larger than the line. During installation, the fitting is removed from the liquid nitrogen and inserted onto the tube. During a 10 to 15 second warming up period, the fitting contracts to its original size (3 percent smaller), biting down on the tube, forming a permanent seal. Cryofit fittings can only be removed by cutting the tube at the sleeve, though this leaves enough room to replace it with a swaged fitting without replacing the hydraulic line. It is frequently used with titanium tubing. The shape memory technology is also used for end fittings, flared fittings, and flareless fittings. [Figure 7-21]

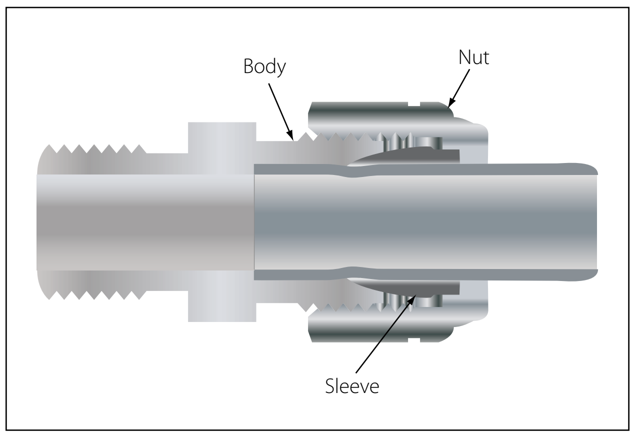



**Figure 7-18. Flareless fitting.**

## Rigid Tubing Installation and Inspection

Before installing a line assembly in an aircraft, inspect the line carefully. Remove dents and scratches, and be sure all nuts and sleeves are snugly mated and securely fitted by proper flaring of the tubing. The line assembly should be clean and free of all foreign matter.

*Connection and Torque*

Never apply compound to the faces of the fitting or the flare, for it will destroy the metal-to-metal contact between the fitting and flare, a contact which is necessary to produce the seal. Be sure that the line assembly is properly aligned before tightening the fittings. Do

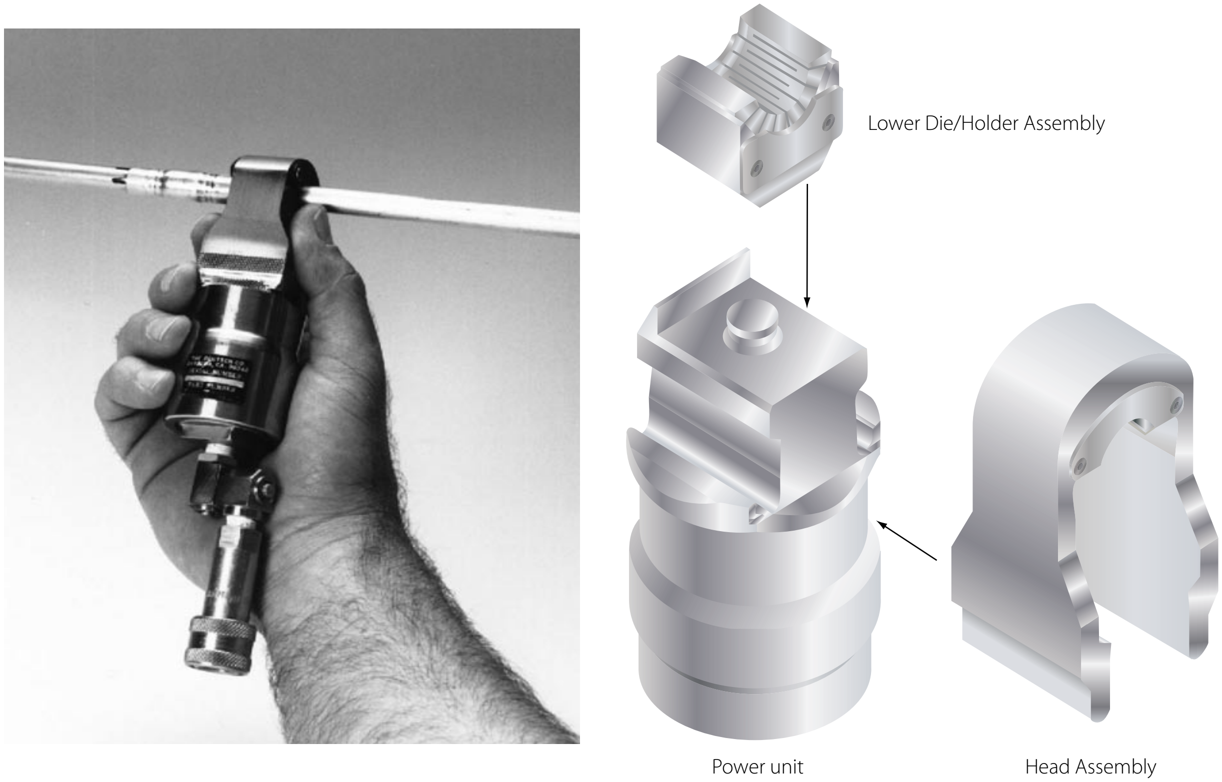



**Figure 7-19. Swaged fitting tooling.**

**Figure 7-20. Permalite™ fittings.**

**Figure 7-21. Cryofit fittings.**

not pull the installation into place with torque on the nut. Correct and incorrect methods of installing flared tube assemblies are illustrated in Figure 7-22. Proper torque values are given in Table 7-2. Remember that these torque values are for flared-type fittings only. Always tighten fittings to the correct torque value when installing a tube assembly. Overtightening a fitting may badly damage or completely cut off the tube flare, or it may ruin the sleeve or fitting nut. Failure to tighten sufficiently also may be serious, as this condition may allow the line to blow out of the assembly or to leak under system pressure. The use of torque wrenches and the prescribed torque values prevents overtightening or undertightening. If a tube fitting assembly is tightened properly, it may be removed and retightened many times before reflaring is necessary.

### *Flareless Tube Installation*

Tighten the nut by hand until an increase in resistance to turning is encountered. Should it be impossible to run the nut down with the fingers, use a wrench, but be alert for the first signs of bottoming. It is important that the final tightening commence at the point where the nut just begins to bottom. Use a wrench and turn the nut one-sixth turn (one flat on a hex nut). Use a wrench on the connector to prevent it from turning while tightening the nut. After the tube assembly is

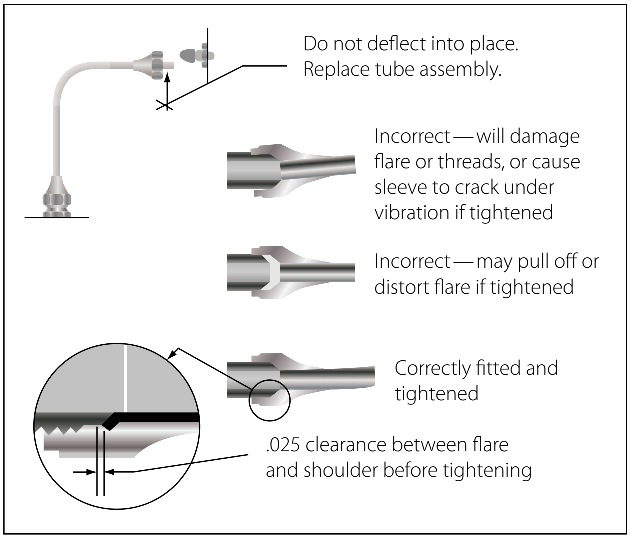



**Figure 7-22. Correct and incorrect methods of tightening flared fittings.**

installed, the system should be pressure tested. It is permissible to tighten the nut an additional one-sixth turn (making a total of one-third turn), should a connection leak. If leakage still occurs after tightening the nut a total of one-third turn, remove the assembly and inspect the components for scores, cracks, presence of foreign material, or damage from overtightening. Several aircraft manufacturers include torque values in their maintenance manuals to tighten the flareless fittings.

The following notes, cautions, and faults apply to the installation of rigid tubing.

*Note:* Overtightening a flareless tube nut drives the cutting edge of the sleeve deeply into the tube, causing the tube to be weakened to the point where normal in-flight vibration could cause the tube to shear. After inspection (if no discrepancies are found), reassemble the connections and repeat the pressure test procedures.

*Caution:* Never tighten the nut beyond one-third turn (two flats on the hex nut); this is the maximum the fitting may be tightened without the possibility of permanently damaging the sleeve and nut.

*Common faults:* Flare distorted into nut threads; sleeve cracked; flare cracked or split; flare out of round; inside of flare rough or scratched; and threads of nut or union dirty, damaged, or broken.

### *Rigid Tubing Inspection and Repair*

Minor dents and scratches in tubing may be repaired. Scratches or nicks not deeper than 10 percent of the wall thickness in aluminum alloy tubing, which are not in the heel of a bend, may be repaired by burnishing with hand tools. The damage limits for hard, thin-walled corrosion-resistant steel and titanium tubing are considerably less than for aluminum tubing, and might depend on the aircraft manufacturer. Consult the aircraft maintenance manual for damage limits. Replace lines with severe die marks, seams, or splits in the tube. Any crack or deformity in a flare is unacceptable and is cause for rejection. A dent of less than 20 percent of the tube diameter is not objectionable, unless it is in the heel of a bend. To remove dents, draw a bullet of proper size through the tube by means of a length of cable, or push the bullet through a short straight tube by means of a dowel rod. In this case, a bullet is a ball bearing or slug normally made of steel or some other hard metal. In the case of soft aluminum tubing, a hard wood slug or dowel may even be used as a bullet. [Figure 7-23] A severely damaged line should be replaced. However, the line may be repaired by cutting out the damaged section and inserting a tube section of the same size and material. Flare both ends of the undamaged and replacement tube sections and make the connection by using standard unions, sleeves, and tube nuts. Aluminum 6061-T6, corrosion resistant steel 304-1/8h and Titanium 3AL-2.5V tubing can be repaired by swaged fittings. If the damaged portion is short enough, omit the insert tube and repair by using one repair union. [Figure 7-24] When repairing a damaged line, be very careful to remove all chips and burrs. Any open line that is to be left unattended for some time should be sealed, using metal, wood, rubber, or plastic plugs or caps.

When repairing a low-pressure line using a flexible fluid connection assembly, position the hose clamps carefully to prevent overhang of the clamp bands or chafing of the tightening screws on adjacent parts. If chafing can occur, the hose clamps should be repositioned on the hose. Figure 7-25 illustrates the design of a flexible fluid connection assembly and gives the maximum allowable angular and dimensional offset.

When replacing rigid tubing, ensure that the layout of the new line is the same as that of the line being replaced. Remove the damaged or worn assembly, taking care not to further damage or distort it, and use it

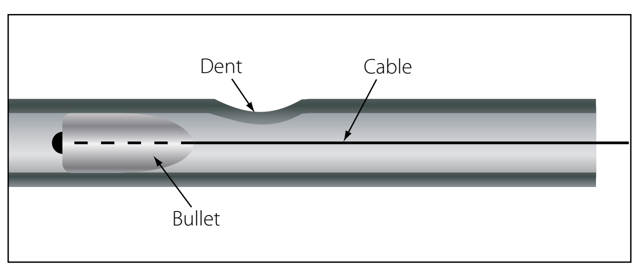



**Figure 7-23. Dent removal using a bullet.**

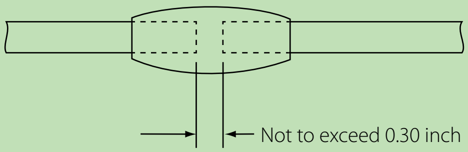
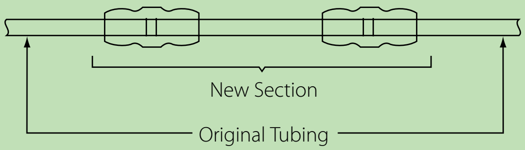
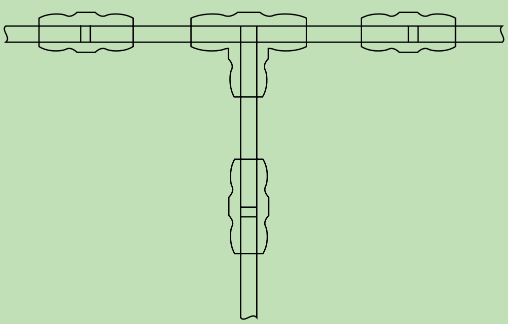
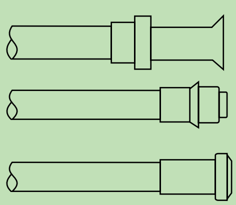
| Type of Failure | Repair Method |
|---|---|
| 1. Pin hole leak or circumferential crack in tubing.<br><br> | 1. a. Make 1 or 2 cuts as necessary, to remove damaged section. If 2 cuts are required, the distance between them shall not exceed 0. 30". If distance is more than 0.30 inch, go to repair method 2.<br>b. Swage 1 tube-to-tube union in tube section under repair. |
| 2. Longitudinal crack in tubing (crack length in excess of 0.30").<br><br> | 2. a. Make 2 cuts to enable removal of damaged section.<br>b. Remove damaged section and duplicate.<br>c. Swage replacement section into tubing under repair using 2 tube-to-tube unions. |
| 3. Leaking tee or elbow (permanent tube connection type).<br> | 3. a. Cut out defective tee or elbow.<br>b. Duplicate tubing sections for each branch.<br>c. Swage splice sections to tee or elbow.<br>d. Connect each splice section to tubing under repair using a tube to tube union. |
| 4. Leaking flared, flareless, or lipseal end fittings.<br> | 4. a. Cut tubing to remove defective fitting.<br>b. Swage appropriate end fitting to tube end.<br>c. Connect new end fitting to mating connection, torquing nut as required. |

**Figure 7-24. Permaswage™ repair.**

as a forming template for the new part. If the old length of tubing cannot be used as a pattern, make a wire template, bending the pattern by hand as required for the new assembly. Then bend the tubing to match the wire pattern. Never select a path that does not require bends in the tubing. A tube cannot be cut or flared accurately enough so that it can be installed without bending and still be free from mechanical strain. Bends are also necessary to permit the tubing to expand or contract under temperature changes and to absorb vibration. If the tube is small (under ¼") and can be hand formed, casual bends may be made to allow for this. It the tube must be machine formed, definite bends must be made to avoid a straight assembly. Start all bends a reasonable distance from the fittings because the sleeves and nuts must be slipped back during the fabrication of flares and during inspections. In all cases, the new tube assembly should be so formed prior

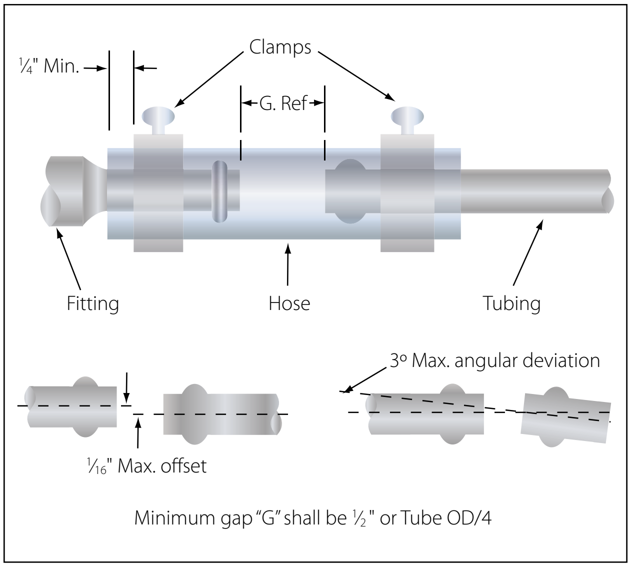



**Figure 7-25. Flexible fluid connection assembly.**

to installation that it will not be necessary to pull or deflect the assembly into alignment by means of the coupling nuts.

## Flexible Hose Fluid Lines

Flexible hose is used in aircraft fluid systems to connect moving parts with stationary parts in locations subject to vibration or where a great amount of flexibility is needed. It can also serve as a connector in metal tubing systems.

### Hose Materials and Construction

Pure rubber is never used in the construction of flexible fluid lines. To meet the requirements of strength, durability, and workability, among other factors, synthetics are used in place of pure rubber. Synthetic materials most commonly used in the manufacture of flexible hose are Buna-N, neoprene, butyl, ethylene propylene diene rubber (EPDM) and Teflon™. While Teflon™ is in a category of its own, the others are synthetic rubber.

Buna-N is a synthetic rubber compound which has excellent resistance to petroleum products. Do not confuse with Buna-S. Do not use for phosphate ester base hydraulic fluid (Skydrol).

Neoprene is a synthetic rubber compound which has an acetylene base. Its resistance to petroleum products is not as good as Buna-N, but it has better abrasive resistance. Do not use for phosphate ester base hydraulic fluid (Skydrol).

Butyl is a synthetic rubber compound made from petroleum raw materials. It is an excellent material to use with phosphate ester base hydraulic fluid (Skydrol). Do not use with petroleum products.

Flexible rubber hose consists of a seamless synthetic rubber inner tube covered with layers of cotton braid and wire braid and an outer layer of rubber-impregnated cotton braid. This type of hose is suitable for use in fuel, oil, coolant, and hydraulic systems. The types of hose are normally classified by the amount of pressure they are designed to withstand under normal operating conditions.

*Low, Medium, and High Pressure Hoses*

- Low pressure—below 250 psi. Fabric braid reinforcement.
- Medium pressure—up to 3,000 psi. One wire braid reinforcement. Smaller sizes carry up to 3,000 psi. Larger sizes carry pressure up to 1,500 psi.
- High pressure—all sizes up to 3,000 psi operating pressures.

*Hose Identification*

Lay lines and identification markings consisting of lines, letters, and numbers are printed on the hose. [Figure 7-26] Most hydraulic hose is marked to identify its type, the quarter and year of manufacture, and a 5-digit code identifying the manufacturer. These

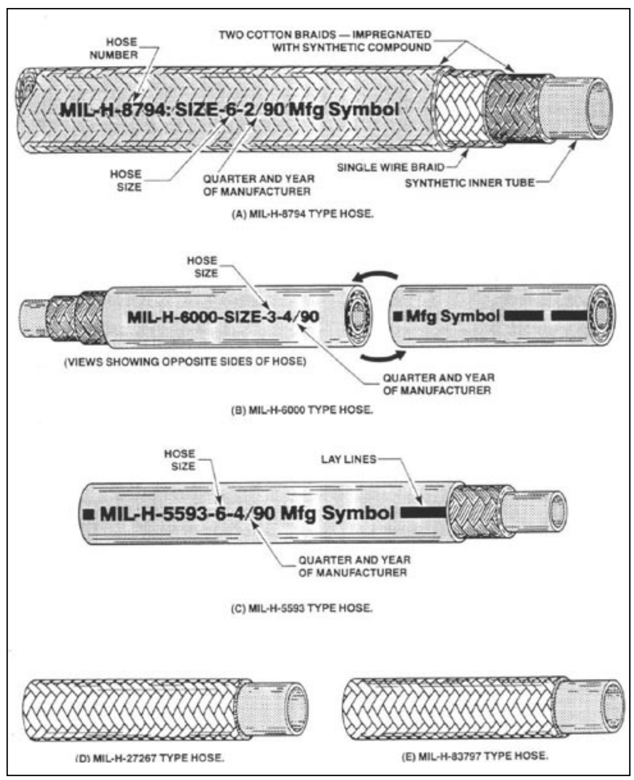



**Figure 7-26. Hose identification markings.**

markings are in contrasting colored letters and numerals which indicate the natural lay (no twist) of the hose and are repeated at intervals of not more than 9 inches along the length of the hose. Code markings assist in replacing a hose with one of the same specifications or a recommended substitute. Hose suitable for use with phosphate ester base hydraulic fluid will be marked Skydrol use. In some instances, several types of hose may be suitable for the same use. Therefore, to make the correct hose selection, always refer to the applicable aircraft maintenance or parts manual.

Teflon™ is the DuPont trade name for tetrafluoroethylene resin. It has a broad operating temperature range (−65 °F to +450 °F). It is compatible with nearly every substance or agent used. It offers little resistance to flow; sticky, viscous materials will not adhere to it. It has less volumetric expansion than rubber, and the shelf and service life is practically limitless. Teflon™ hose is flexible and designed to meet the requirements of higher operating temperatures and pressures in present aircraft systems. Generally, it may be used in the same manner as rubber hose. Teflon™ hose is processed and extruded into tube shape to a desired size. It is covered with stainless steel wire, which is braided over the tube for strength and protection. Teflon™ hose is unaffected by any known fuel, petroleum, or synthetic base oils, alcohol, coolants, or solvents commonly used in aircraft. Teflon™ hose has the distinct advantages of a practically unlimited storage time, greater operating temperature range, and broad usage (hydraulic, fuel, oil, coolant, water, alcohol, and pneumatic systems). Medium-pressure Teflon™ hose assemblies are sometimes preformed to clear obstructions and to make connections using the shortest possible hose length. Since preforming permits tighter bends that eliminate the need for special elbows, preformed hose assemblies save space and weight. Never straighten a preformed hose assembly. Use a support wire if the hose is to be removed for maintenance. [Figure 7-27]

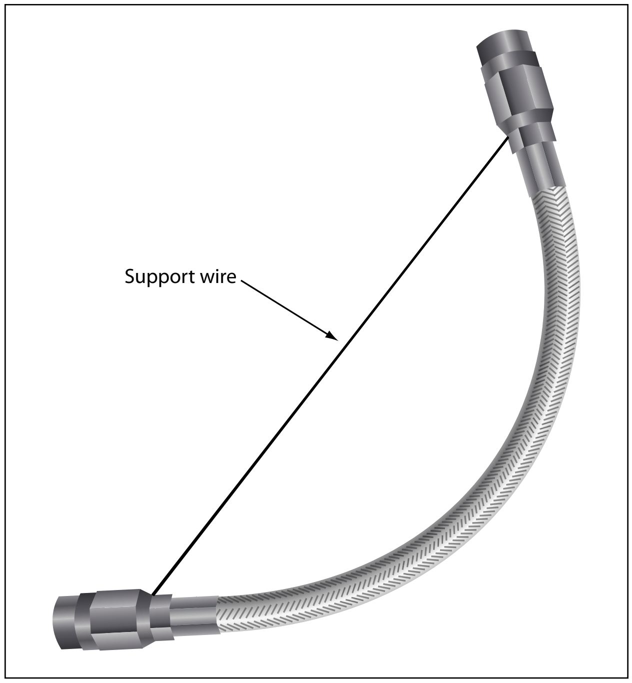



**Figure 7-27. Suggested handling of preformed hose.**

## Flexible Hose Inspection

Check the hose and hose assemblies for deterioration at each inspection period. Leakage, separation of the cover or braid from the inner tube, cracks, hardening, lack of flexibility, or excessive "cold flow" are apparent signs of deterioration and reason for replacement. The term "cold flow" describes the deep, permanent impressions in the hose produced by the pressure of hose clamps or supports.

When failure occurs in a flexible hose equipped with swaged end fittings, the entire assembly must be replaced. Obtain a new hose assembly of the correct size and length, complete with factory installed end fittings. When failure occurs in hose equipped with reusable end fittings, a replacement line can be fabricated with the use of such tooling as may be necessary to comply with the assembly instructions of the manufacturer.

## Fabrication and Replacement of Flexible Hose

To make a hose assembly, select the proper size hose and end fitting. [Figure 7-28] MS-type end fittings for flexible hose are detachable and may be reused if determined to be serviceable. The inside diameter of the fitting is the same as the inside diameter of the hose to which it is attached.

### *Flexible Hose Testing*

All flexible hose must be proof-tested after assembly and applying pressure to the inside of the hose assembly. The proof-test medium may be a liquid or gas. For example, hydraulic, fuel, and oil lines are generally tested using hydraulic oil or water, whereas air or instrument lines are tested with dry, oil-free air or nitrogen. When testing with a liquid, all trapped air is bled from the assembly prior to tightening the cap or plug. Hose tests, using a gas, are conducted underwater. In all cases, follow the hose manufacturer's instructions for proof-test pressure and fluid to be used when testing a specific hose assembly. [Table 7-3]

When a flexible hose has been repaired or overhauled using existing hardware and new hose material, and

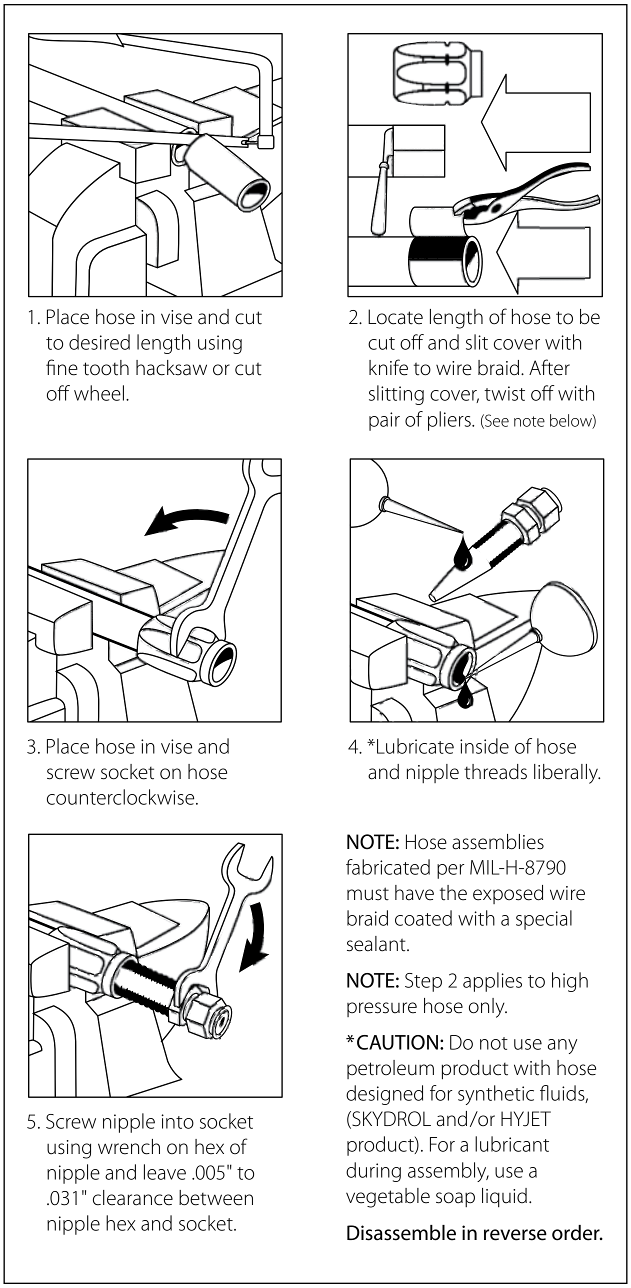



**Figure 7-28. Assembly of MS fitting to flexible hose.**

before the hose is installed on the aircraft, it is recommended that the hose be tested to at least 1.5 system pressure. A hydraulic hose burst test stand is used for testing flexible hose. [Figure 7-29] A new hose can be operationally checked after it is installed in the aircraft using system pressure.

## Size Designations

Hose is also designated by a dash number, according to its size. The dash number is stenciled on the side of the hose and indicates the size tubing with which the hose is compatible. It does not denote inside or outside diameter. When the dash number of the hose corresponds with the dash number of the tubing, the proper size hose is being used. Dash numbers are shown in Figure 7-26.

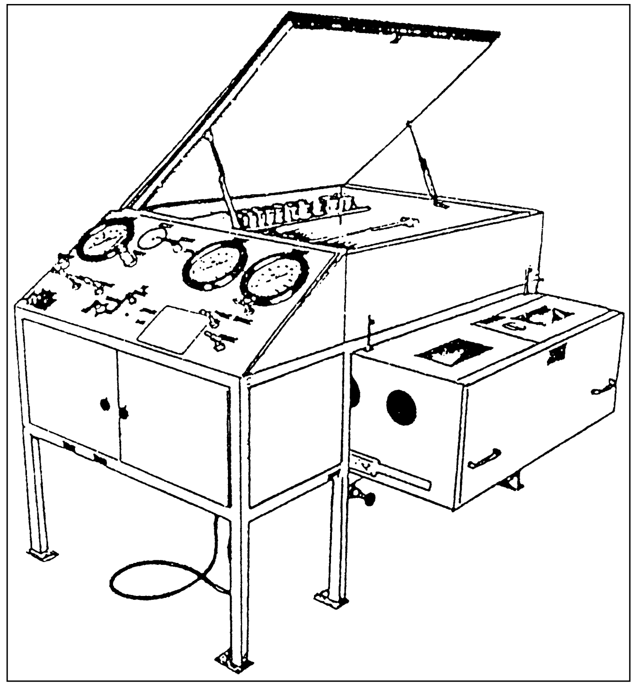


**Figure 7-29. Hydraulic hose burst test stand.**

## Hose Fittings

Flexible hose may be equipped with either swaged fittings or detachable fittings, or they may be used with beads and hose clamps. Hoses equipped with swaged fittings are ordered by correct length from the manufacturer and ordinarily cannot be assembled by the mechanic. They are swaged and tested at the factory and are equipped with standard fittings. The detachable fittings used on flexible hoses may be detached and reused if they are not damaged; otherwise, new fittings must be used. [Figure 7-30]

## Installation of Flexible Hose Assemblies

**Slack**—Hose assemblies must not be installed in a manner that will cause a mechanical load on the hose. When installing flexible hose, provide slack or bend in the hose line from 5 to 8 percent of its total length to provide for changes in length that will occur when pressure is applied. Flexible hose contracts in length and expands in diameter when pressurized. Protect all flexible hoses from excessive temperatures, either by locating the lines so they will not be affected or by installing shrouds around them.

**Flex**—When hose assemblies are subject to considerable vibration or flexing, sufficient slack must be left between rigid fittings. Install the hose so that flexure

**SINGLE WIRE BRAID FABRIC COVERED**

| MIL. Part No. | Tube Size o.d. (inches) | Hose Size i.d. (inches) | Hose Size o.d. (inches) | Recomm. Operating Pressure (PSI) | Min. Burst Pressure (PSI) | Max. Proof Pressure (PSI) | Min. Bend Radius (inches) |
|---|---|---|---|---|---|---|---|
| MIL-H-8794-3-L | 3⁄16 | 1⁄8 | .45 | 3,000 | 12,000 | 6,000 | 3.00 |
| MIL-H-8794-4-L | 1⁄4 | 3⁄16 | .52 | 3,000 | 12,000 | 6,000 | 3.00 |
| MIL-H-8794-5-L | 5⁄16 | 1⁄4 | .58 | 3,000 | 10,000 | 5,000 | 3.38 |
| MIL-H-8794-6-L | 3⁄8 | 5⁄16 | .67 | 2,000 | 9,000 | 4,500 | 4.00 |
| MIL-H-8794-8-L | 1⁄2 | 13⁄32 | .77 | 2,000 | 8,000 | 4,000 | 4.63 |
| MIL-H-8794-10-L | 5⁄8 | 1⁄2 | .92 | 1,750 | 7,000 | 3,500 | 5.50 |
| MIL-H-8794-12-L | 3⁄4 | 5⁄8 | 1.08 | 1,750 | 6,000 | 3,000 | 6.50 |
| MIL-H-8794-16-L | 1 | 7⁄8 | 1.23 | 800 | 3,200 | 1,600 | 7.38 |
| MIL-H-8794-20-L | 1 1⁄4 | 1 1⁄8 | 1.50 | 600 | 2,500 | 1,250 | 9.00 |
| MIL-H-8794-24-L | 1 1⁄2 | 1 3⁄8 | 1.75 | 500 | 2,000 | 1,000 | 11.00 |
| MIL-H-8794-32-L | 2 | 1 13⁄16 | 2.22 | 350 | 1,400 | 700 | 13.25 |
| MIL-H-8794-40-L | 2 1⁄2 | 2 3⁄8 | 2.88 | 200 | 1,000 | 300 | 24.00 |
| MIL-H-8794-48-L | 3 | 3 | 3.56 | 200 | 800 | 300 | 33.00 |

**Construction:** Seamless synthetic rubber inner tube reinforced with one fiber braid, one braid of high tensile steel wire and covered with an oil resistant rubber impregnated fiber braid.

**Identification:** Hose is identified by specification number, size number, quarter year and year, hose manufacturer's identification.

**Uses:** Hose is approved for use in aircraft hydraulic, pneumatic, coolant, fuel, and oil systems.

**Operating Temperatures:**
Sizes 3 through 12: Minus 65 °F to plus 250 °F
Sizes 16 through 48: Minus 40 °F to plus 275 °F

**Note:** Maximum temperatures and pressures should not be used simultaneously.

**MULTIPLE WIRE BRAID RUBBER COVERED**

| MIL. Part No. | Tube Size o.d. (inches) | Hose Size i.d. (inches) | Hose Size o.d. (inches) | Recomm. Operating Pressure (PSI) | Min. Burst Pressure (PSI) | Max. Proof Pressure (PSI) | Min. Bend Radius (inches) |
|---|---|---|---|---|---|---|---|
| MIL-H-8788- 4-L | 1⁄4 | 7⁄32 | .63 | 3,000 | 16,000 | 8,000 | 3.00 |
| MIL-H-8788- 5-L | 5⁄16 | 9⁄32 | .70 | 3,000 | 14,000 | 7,000 | 3.38 |
| MIL-H-8788- 6-L | 3⁄8 | 11⁄32 | .77 | 3,000 | 14,000 | 7,000 | 5.00 |
| MIL-H-8788- 8-L | 1⁄2 | 7⁄16 | .86 | 3,000 | 14,000 | 7,500 | 5.75 |
| MIL-H-8788-10-L | 5⁄8 | 9⁄16 | 1.03 | 3,000 | 12,000 | 6,000 | 6.50 |
| MIL-H-8788-12-L | 3⁄4 | 11⁄16 | 1.22 | 3,000 | 12,000 | 6,000 | 7.75 |
| MIL-H-8788-16-L | 1 | 7⁄8 | 1.50 | 3,000 | 10,000 | 5,000 | 9.63 |

**Construction:** Seamless synthetic rubber inner tube reinforced with one fiber braid, two or more steel wire braids, and covered with synthetic rubber cover (for gas applications request perforated cover).

**Identification:** Hose is identified by specification number, size number, quarter year and year, hose manufacturer's identification.

**Uses:** High pressure hydraulic, pneumatic, coolant, fuel and oil.

**Operating Temperatures:** Minus 65 °F to plus 200 °F

**Table 7-3. Aircraft hose specifications.**

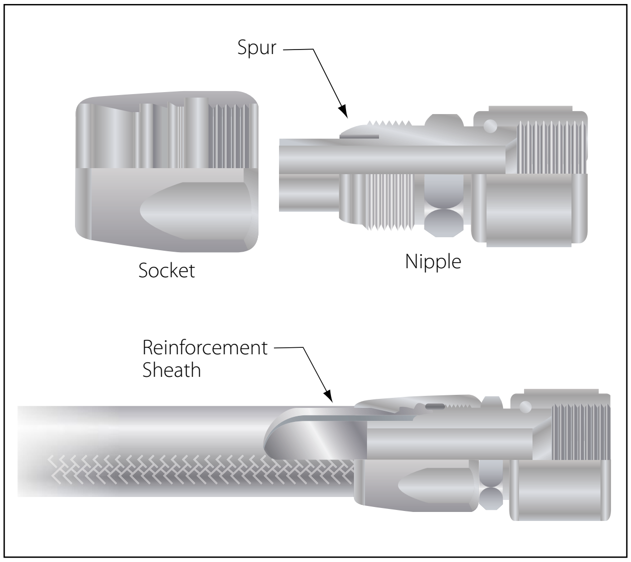



**Figure 7-30. Reusable fittings for medium-pressure hose.**

does not occur at the end fittings. The hose must remain straight for at least two hose diameters from the end fittings. Avoid clamp locations that will restrict or prevent hose flexure.

**Twisting**—Hoses must be installed without twisting to avoid possible rupture of the hose or loosening of the attaching nuts. Use of swivel connections at one or both ends will relieve twist stresses. Twisting of the hose can be determined from the identification stripe running along its length. This stripe should not spiral around the hose.

**Bending**—To avoid sharp bends in the hose assembly, use elbow fittings, hose with elbow-type end fittings, or the appropriate bend radii. Bends that are too sharp will reduce the bursting pressure of flexible hose considerably below its rated value. [Figure 7-31]

**Clearance**—The hose assembly must clear all other lines, equipment, and adjacent structure under every operating condition.

Flexible hose should be installed so that it will be subject to a minimum of flexing during operation. Although hose must be supported at least every 24 inches, closer supports are desirable. Flexible hose must never be stretched tightly between two fittings. If clamps do not seal at specified tightening, examine

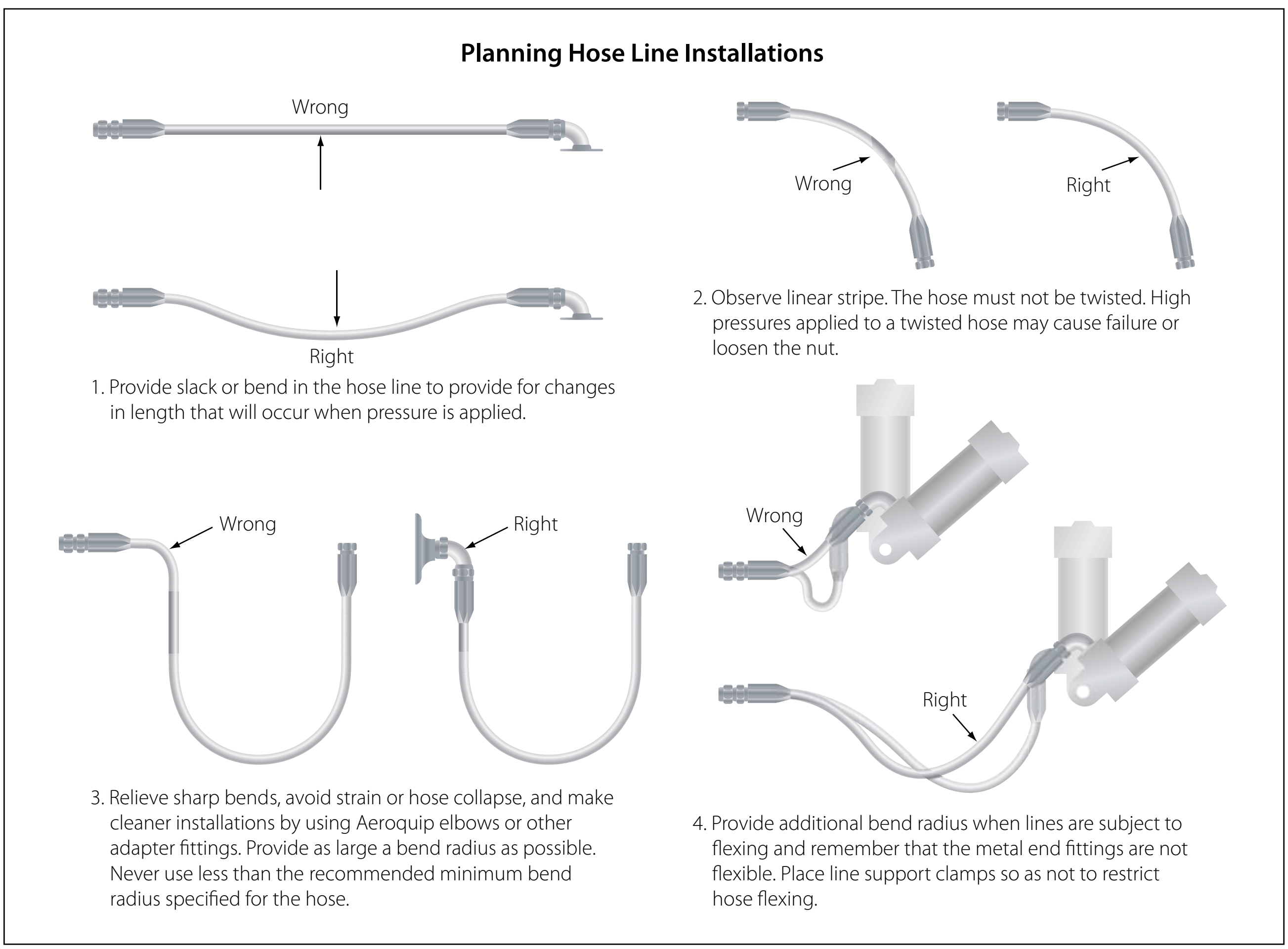



**Figure 7-31. Flexible hose installation.**

hose connections and replace parts as necessary. The above is for initial installation and should not be used for loose clamps.

For retightening loose hose clamps in service, proceed as follows: Non-self-sealing hose—if the clamp screw cannot be tightened with the fingers, do not disturb unless leakage is evident. If leakage is present, tighten one-fourth turn. Self-sealing hose—if looser than finger-tight, tighten to finger-tight and add one-fourth turn. [Table 7-4]

### Hose Clamps

To ensure proper sealing of hose connections and to prevent breaking hose clamps or damaging the hose, follow the hose clamp tightening instructions carefully. When available, use the hose clamp torque-limiting wrench. These wrenches are available in calibrations of 15 and 25 in-lb limits. In the absence of torque-limiting wrenches, follow the finger-tight-plus-turns method. Because of the variations in hose clamp design and hose structure, the values given in Table 7-4 are approximate. Therefore, use good judgment when tightening hose clamps by this method. Since hose connections are subject to "cold flow" or a setting process, a follow-up tightening check should be made for several days after installation.

Support clamps are used to secure the various lines to the airframe or powerplant assemblies. Several types of support clamps are used for this purpose. The most commonly used clamps are the rubber-cushioned and plain. The rubber-cushioned clamp is used to secure lines subject to vibration; the cushioning prevents chafing of the tubing. [Figure 7-32] The plain clamp is used to secure lines in areas not subject to vibration.

A Teflon™-cushioned clamp is used in areas where the deteriorating effect of Skydrol, hydraulic fluid, or fuel is expected. However, because it is less resilient, it does not provide as good a vibration-damping effect as other cushion materials.

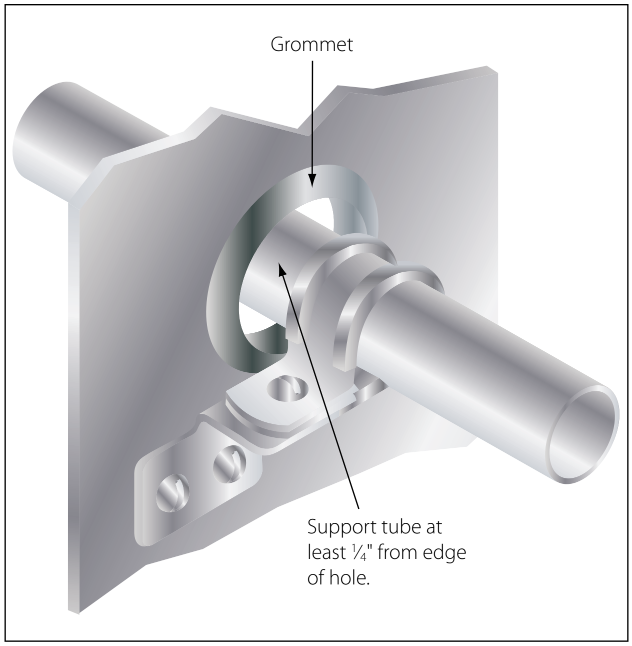



**Figure 7-32. Rubber-cushioned clamp.**

Use bonded clamps to secure metal hydraulic, fuel, or oil lines in place. Unbonded clamps should be used only for securing wiring. Remove any paint or anodizing from the portion of the tube at the bonding clamp location. Make certain that clamps are of the correct size. Clamps or supporting clips smaller than the outside diameter of the hose may restrict the flow of fluid through the hose. All fluid lines must be secured at specified intervals. The maximum distance between supports for rigid tubing is shown in Table 7-5.

| Initial Installation Only | Worm screw type clamp (10 threads per inch) | Clamps—radial and other type (28 threads per inch) |
|---|---|---|
| Self sealing hose approximately 15 in-lb | Finger-tight plus 2 complete turns | Finger-tight plus 2½ complete turns |
| All other aircraft hose approximately 25 in-lb | Finger-tight plus 1¼ complete turns | Finger-tight plus 2 complete turns |

**Table 7-4. Hose clamp tightening.**

| Tube O. D. (in.) | Distance between supports (in.) | |
|---|---|---|
| | Aluminium Alloy | Steel |
| ⅛ | 9½ | 11½ |
| 3/16 | 12 | 14 |
| ¼ | 13½ | 16 |
| 5/16 | 15 | 18 |
| ⅜ | 16½ | 20 |
| ½ | 19 | 23 |
| ⅝ | 22 | 25½ |
| ¾ | 24 | 27½ |
| 1 | 26½ | 30 |

**Table 7-5. Maximum distance between supports for fluid tubing.**