Aircraft general engineering and maintenance practices

COURSE CODE : **Ao307**

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NEHRU GROUP OF INSTITUTION

Module II

- Aircraft Hardware-Aircraft Bolts and Nuts, Washers, Aircraft Screws, Control cables, Turn Buckles, Rivets
- Fluid lines And Fittings-Flexible Hose, Rubber Hose, Rigid tubes
- Identification of Fluid Lines
- Plumbing Connectors. American and British Systems for Identification

LEARNING OBJECTIVES

- Describe the various types of rivets and fasteners and the cable and cable guides used in the construction and repair of naval aircraft.
- State the different types of common electrical hardware used on naval aircraft.
- Recognize the importance of the proper torqueing of fasteners. Identify the required torqueing procedures.
- Identify the various safety methods used for aircraft hardware.

Aircraft Hardware

- Because of the small size of most hardware items, their importance is often overlooked. The safe and efficient operation of any aircraft is greatly dependent upon correct selection and use of aircraft structural hardware and seals.
- You must make sure that items of aircraft hardware remain tightly secured in the aircraft. Therefore, we will discuss proper safetying methods in this chapter

THREADED FASTENERS

- Some joints require greater strength and rigidity than can be provided by riveting. We use various types of bolts, screws, and nuts to solve this problem.
- In modern aircraft construction, thousands of rivets are used, but many parts require frequent dismantling or replacement. It is more practical for you to use some form of threaded fastener.

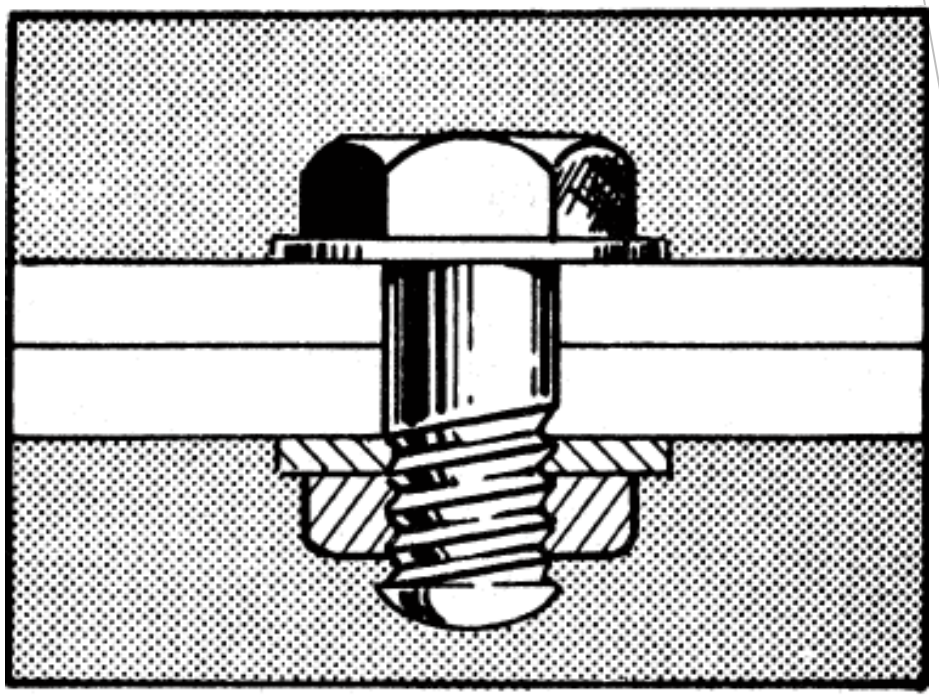
Bolts and screws

Threads on aircraft bolts and screws are of the American National Aircraft Standard type. This standard contains two series of threads—national coarse (NC) and national fine (NF). Most aircraft threads are of the NF series.

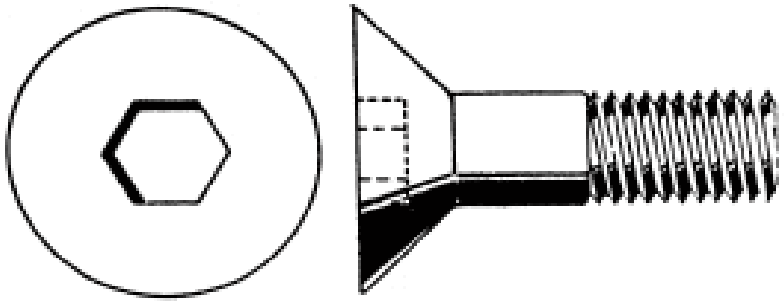
Bolts and screws may have right- or left-hand threads. A right-hand thread advances into engagement when turned clockwise. A left-hand thread advances into engagement when turned counterclockwise.

AIRCRAFT BOLTS

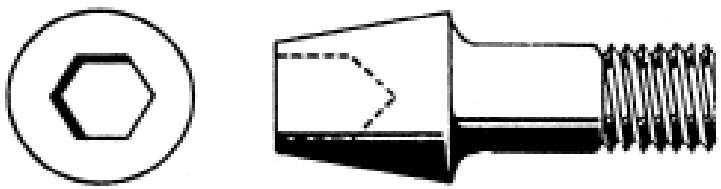
- The three principal parts of a bolt are the *head*, *grip*, and *threads*, as shown in figure. Two of these parts might be well known to you, but perhaps grip is an unfamiliar term. The grip is the unthreaded part of the bolt shaft. It extends from the threads to the bottom of the bolt head. The head is the larger diameter of the boltand may be one of many shapes or designs.
- The bolt may act like a reamer when the material is vibrating. To prevent this, make certain that no more than two threads extend into the bolt hole



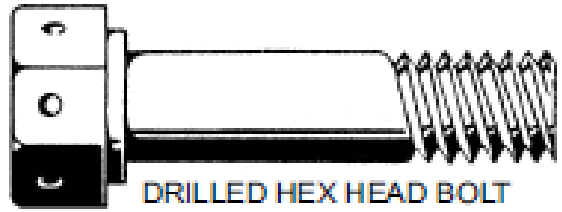
BOLT GRIP LENGTH CORRECT



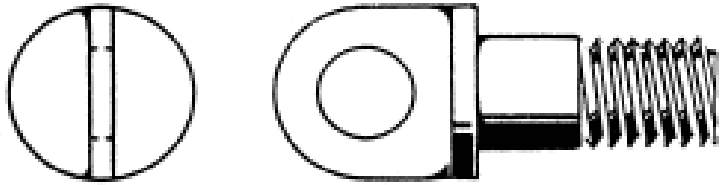
COUNTERSUNK HEAD BOLT



INTERNAL WRENCHING BOLT



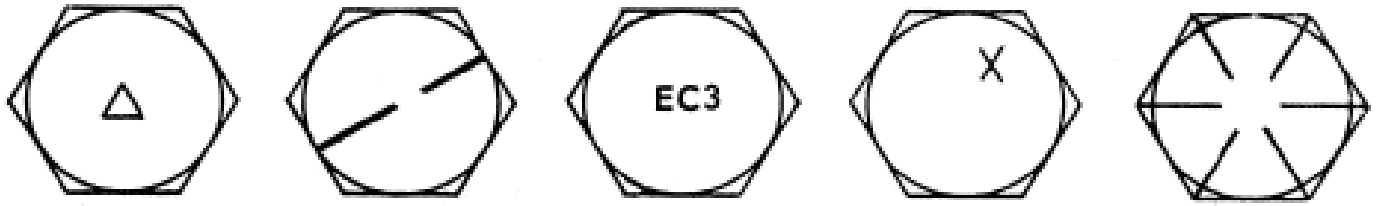
DRILLED HEX HEAD BOLT



EYEBOLT

CLEVIS BOLT

HEAD MARKINGS



CLOSE TOLERANCE (STEEL OR ALUMINUM ALLOY)

ALUMINUM ALLOY (62,000 P.S.I.)

CORROSION RESISTANT STEEL (125,000 P.S.I.)

STEEL 125,000 P.S.I)

STEEL (150,000 P.S.I.)

ANP0503

Figure 5-3.—Types of bolts and bolt head markings.

SCREWS

- The most common threaded fastener used in aircraft construction is the screw. The three most used types are the machine screw, structural screw, and the self-tapping screw,

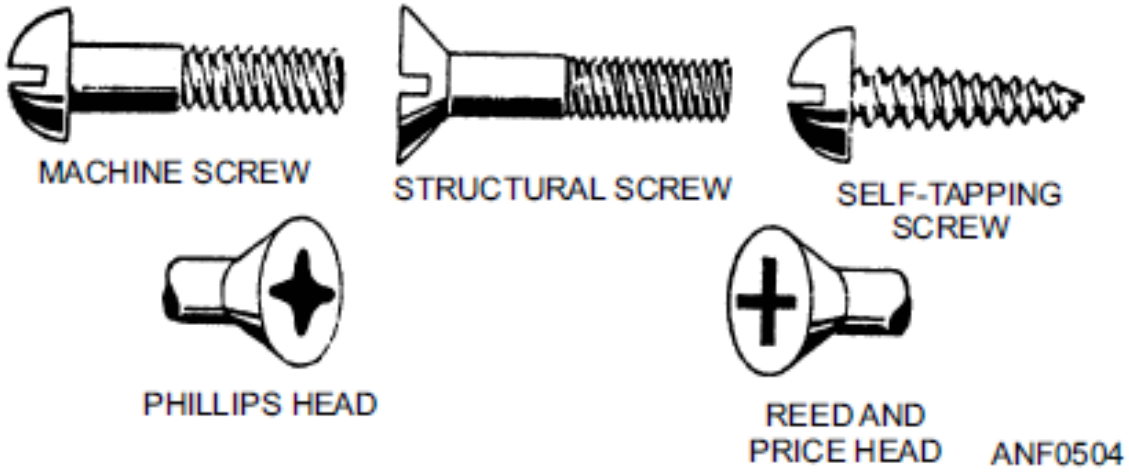


Figure 5-4.—Screws.

STRUCTURAL SCREWS

- Structural screws are used for assembling structural parts.
- They are made of alloy steel and are heat-treated.
- Structural screws have a definite grip length and the same shear and tensile strengths as the equivalent size bolt.
- They differ from structural bolts only in the type of head.
- These screws are available in round-head, countersunk-head, and brazier-head types, either slotted or recessed for the various types of screwdrivers

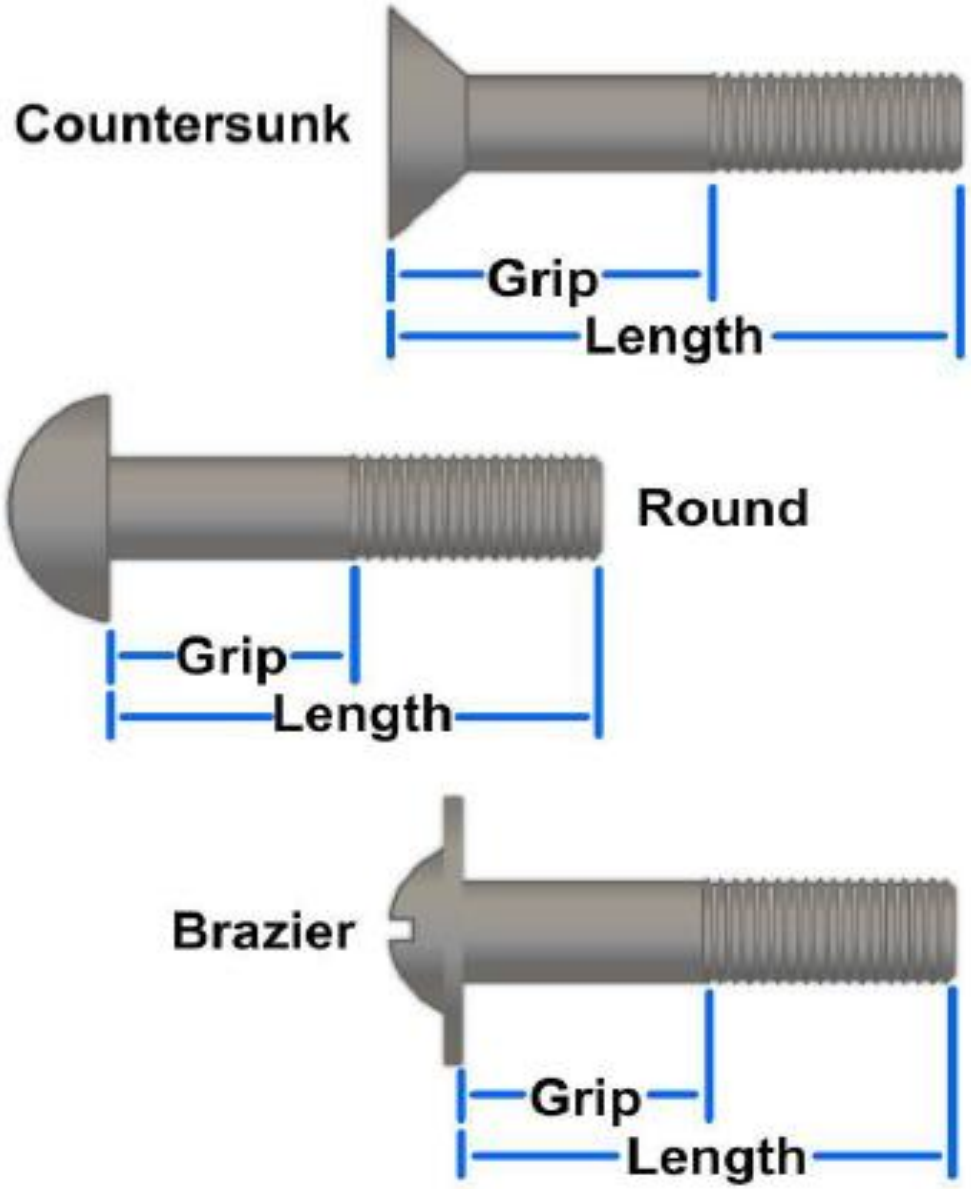


Figure 6-21 — Structural screws.

MACHINE SCREWS

The commonly used machine screws are the flush-head, round-head, fillister-head, socket-head, pan-head, and truss-head type

- **Flush-Head** — Flush-head machine screws are used in countersunk holes where a flush finish is desired. These screws are available in 82 and 100 degrees of head angle and have various types of recesses and slots for driving
- **Round-Head** — Round-head machine screws are frequently used to assemble highly stressed aircraft components.
- **Fillister-Head** — Fillister-head machine screws are used as general-purpose screws. They may also be used as cap screws in light applications, such as the attachment of cast aluminum gearbox cover plates.
- **Socket-Head** — Socket-head machine screws are designed to be screwed into tapped holes by internal wrenching. They are used in applications that require high-strength precision products, compactness of the assembled parts, or sinking of the head into holes.
- **Pan- and Truss-Head** — Pan-head and truss-head screws are general-purpose screws used where head height is unimportant. These screws are available with cross-recessed heads only

SELF-TAPPING SCREWS

A self-tapping screw is one that cuts its own internal threads as it is turned into the hole. Self-tapping screws can be used only in comparatively soft metals and materials. Self-tapping screws may be further divided into two classes or groups:

- Machine self-tapping screws are usually used for attaching removable parts, such as nameplates, to castings. The threads of the screw cut mating threads in the casting after the hole has been predrilled.
- Sheet metal self-tapping screws are used for such purposes as temporarily attaching sheet metal in place for riveting. They may also be used for permanent assembly of nonstructural parts, where it is necessary to insert screws in blind applications

Washers

- Ball socket and seat washers are used where a bolt is installed at an angle to the surface, or where perfect alignment with the surface is required at all times. These washers are used together
- Taper pin washers are used in conjunction with threaded taper pins. They are installed under the nut to effect adjustment where a plain washer would distort.
- Washers for internal-wrenching nuts and bolts are used in conjunction with NAS internal-wrenching bolts. The washer used under the head is countersunk to seat the bolt head or shank radius. A plain washer is used under the nut.

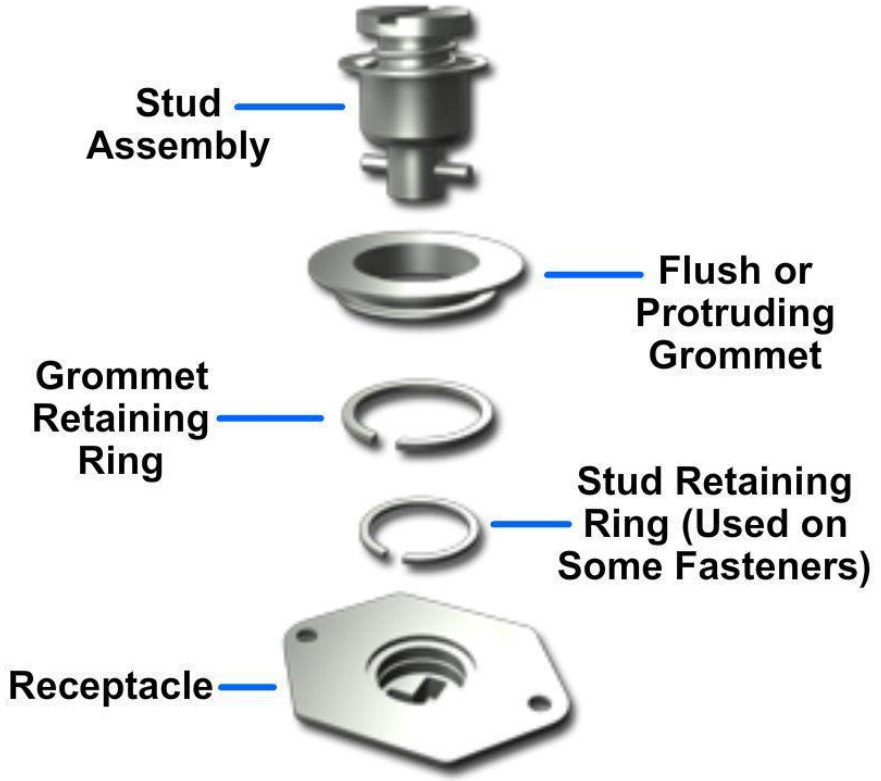
Turn lock Fasteners

- Turn lock fasteners are used to secure panels that require frequent removal. These fasteners are available in several different styles and are usually referred to by the manufacturer's trade name

CAMLOC FASTENERS

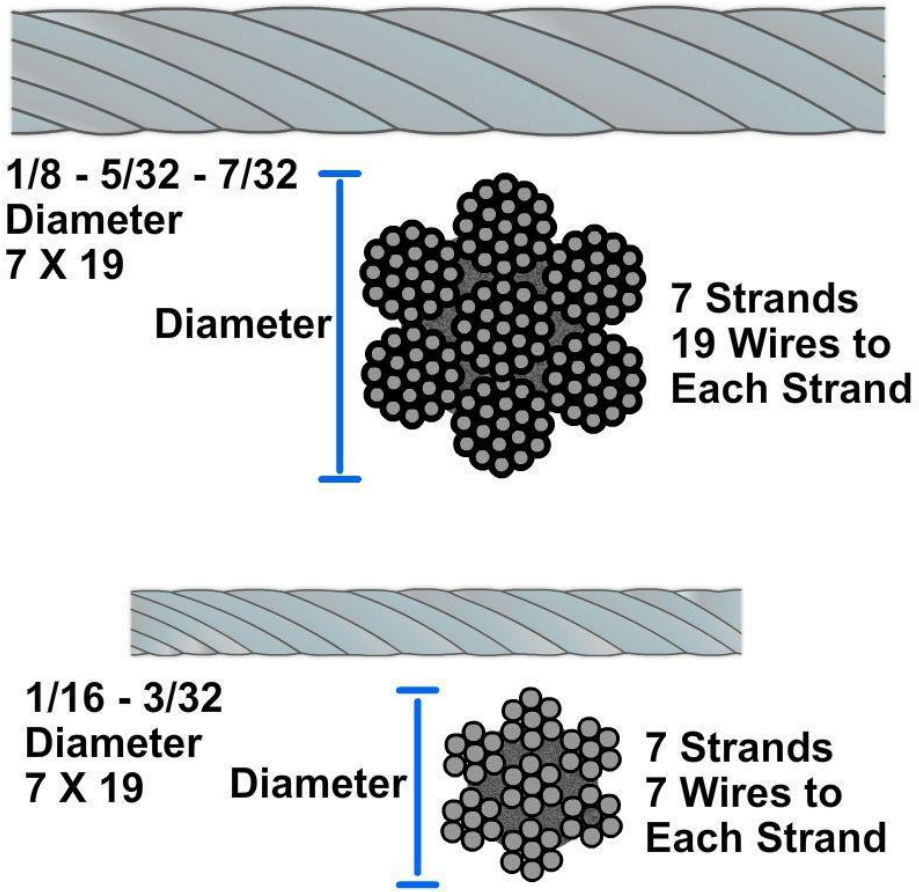
The 4002 series Camloc fastener consists of four principal parts: the receptacle, the grommet, the retaining ring, and the stud assembly.

The receptacle is an aluminum alloy forging mounted in a stamped sheet metal base. The receptacle assembly is riveted to the access door frame, which is attached to the structure of the aircraft. The grommet is a sheet metal ring held in the access panel with the retaining ring. Grommets are furnished in two types: the flush type and the protruding type. Besides serving as a grommet for the hole in the access panel, it also holds the stud assembly. The stud assembly consists of a stud, a cross pin, a spring, and a spring cup. The assembly is designed so it can be quickly inserted into the grommet by compressing the spring. Once installed in the grommet, the stud assembly cannot be removed unless the spring is again compressed.



CABLES

A cable is a group of wires or a group of strands of wires twisted together into a strong wire rope. The wires or strands may be twisted in various ways. The relationship of the direction of twist of each strand to each other and to the cable as a whole is called the *lay*.



RIVETS

- There are hundreds of thousands of rivets in the airframe of a modern aircraft. This is an indication of how important rivets are in the construction of aircraft.
- In addition to being used in the skin, rivets are used in joining spar and rib sections. They are also used for securing fittings to various parts of the aircraft, and for fastening bracing members and other parts together.
- Two of the major types of rivets used in aircraft construction are
  - The solid rivet
  - The blind rivet

SOLID RIVETS

- Solid rivets are classified by their head shape, size and the material from which they are manufactured. Rivet head shapes and their identifying code numbers are shown in figure
- The prefix MS identifies hardware under the control of the Department of Defense and that the item conforms to military standards
- Solid rivets have five different head shapes. They are the round head, flat head, countersunk head, brazier head, and universal head rivets.

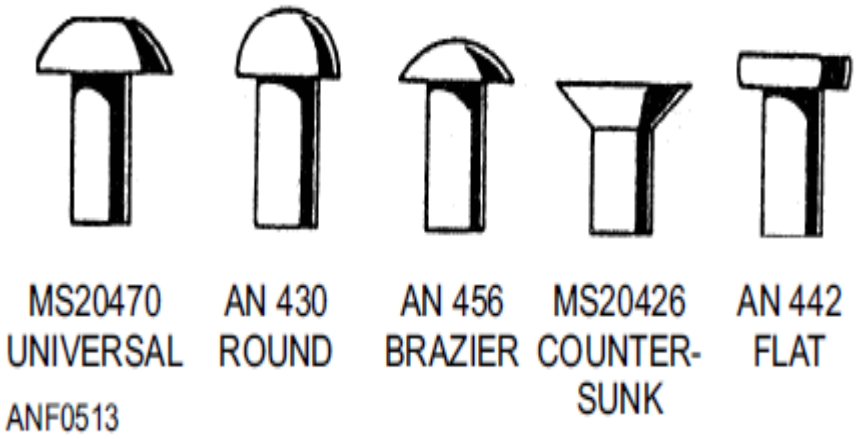


Figure 5-13.—Rivet head shapes and code numbers.

SOLID RIVETS

Flat Head Rivets

- Flat head rivets, like round head rivets, are used in the assembly of internal structures where maximum strength is required. They are used where interference of nearby members does not permit the use of round head rivets.

Countersunk Head Rivets

- Countersunk head rivets, often referred to as flush rivets, are used where streamlining is important. On combat aircraft practically all external surfaces are flush riveted. Countersunk head rivets are obtainable with heads having an inclined angle of 78 and 100 degrees. The 100-degree angle rivet is the most commonly used type.

SOLID RIVETS

Brazier Head Rivets

- Brazier head rivets offer only slight resistance to the airflow and are used frequently on external surfaces, especially on noncombat-type aircraft.

Universal Head Rivets

- Universal head rivets are similar to brazier head rivets. They should be used in place of all other protruding
- -head rivets when existing stocks are depleted.

BLIND RIVETS

There are many places on an aircraft where access to both sides of a riveted structural part is impossible. When attaching many nonstructural parts, the full strength of solid-shank rivets is not necessary and their use adds extra weight. For use in such places, rivets have been designed that can be formed from the outside. They are lighter than solid-shank rivets but are amply strong. Such rivets are referred to as blind rivets or self-plugging because of the self-heading feature.

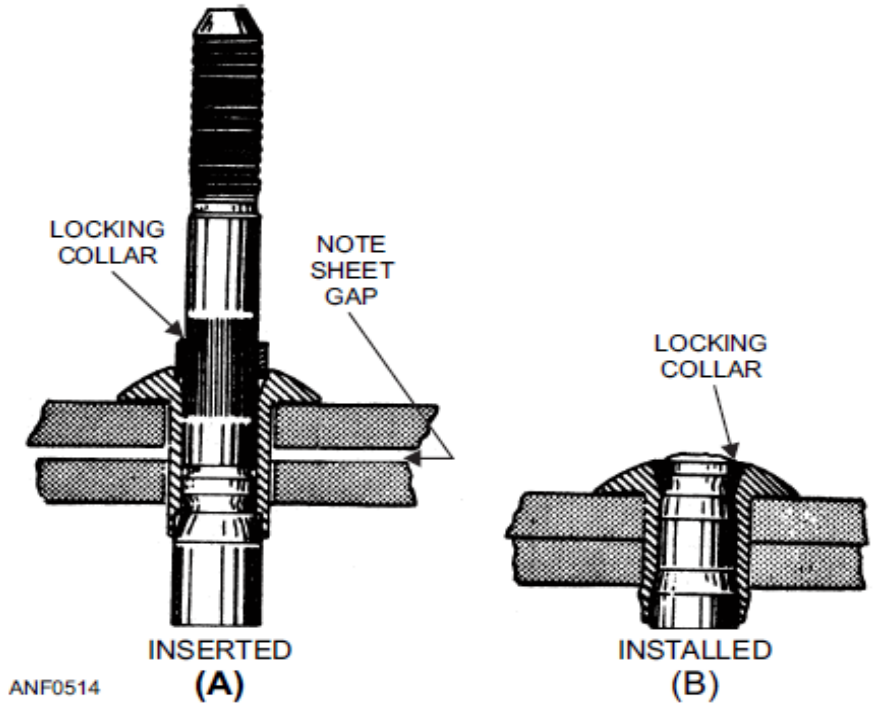


Figure 5-14.—Self-plugging rivet (mechanical lock).

RIVNUTS

- The rivnut is a hollow aluminum rivet that is counterbored and threaded on the inside. The rivet is installed with the aid of a special tool. Rivnuts are used primarily as a nut plate. They may be used as rivets in secondary structures such as instruments, brackets, and soundproofing materials. After rivnuts are installed, accessories can be fastened in place with screws.
- Rivnuts are manufactured in two head styles, countersunk and flat, and in two shank designs, open and closed ends

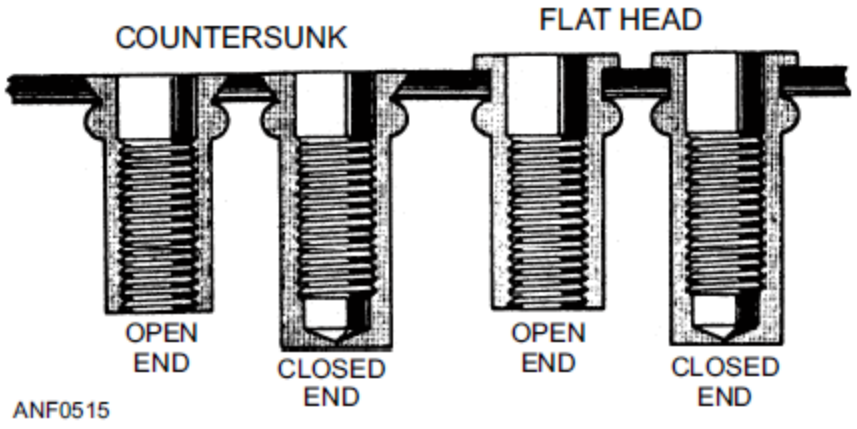


Figure 5-15.—Sectional view of rivnut showing head and end designs.

TURNBUCKLES

- A turnbuckle is a mechanical screw device consisting of two threaded terminals and a threaded barrel.
- Turnbuckles are fitted in the cable assembly for the purpose of making minor adjustments in cable length and for adjusting cable tension. One of the terminals has right-hand threads and the other has left-hand threads. The barrel has matching right- and left-hand internal threads. The end of the barrel with the left-hand threads can usually be identified by a groove or knurl around that end.

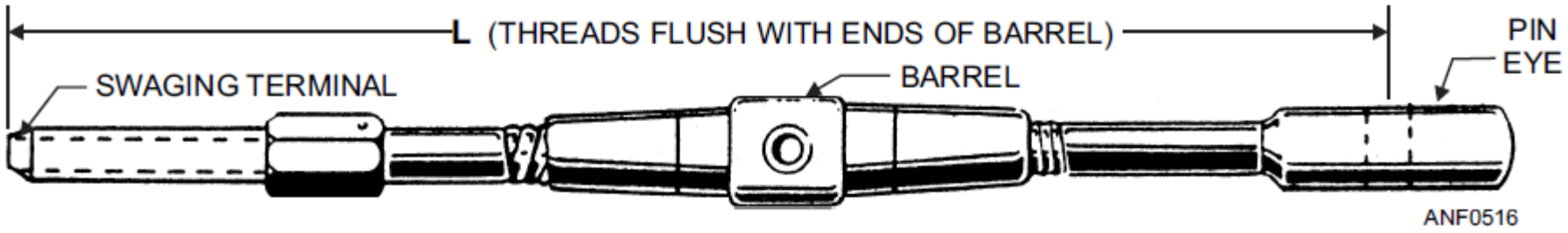


Figure 5-16.—Typical turnbuckle assembly.

Fluid Lines and Fittings

- The control and application of fluid power would be impossible without suitable means of transferring the fluid between the reservoir, the power source, and the points of application. Fluid lines are used to transfer the fluid, and fittings are used to connect the lines to the power source and the points of application.
  - Types of Lines
  - Pipes and Tubing
  - Flexible Hose
  - Types of Fittings and Connectors
  - Connectors for Flexible Hose

Types of Lines

The three types of lines used in fluid power systems are

- pipe (rigid),
- tubing (semirigid), and
- hose (flexible).

A number of factors are considered when the type of line is selected for a particular fluid system. These factors include the type of fluid, the required system pressure, and the location of the system

Pipes and Tubing

- There are three important dimensions of any tubular product — outside diameter (OD), inside diameter (ID), and wall thickness. Sizes of pipe are listed by the nominal (or approximate) ID and the wall thickness. Sizes of tubing are listed by the actual OD and the wall thickness

Selection of Pipes and Tubing:

The ID of a line is important, since it determines how much fluid can pass through the line in a given time period (rate of flow) without loss of power due to excessive friction and heat. The velocity of a given flow is less through a large opening than through a small opening. If the ID of the line is too small for the amount of flow, excessive turbulence and friction heat cause unnecessary power loss and overheated fluid.

Sizing of Pipes and Tubing

- Pipes are available in three different weights: standard (STD) or Schedule 40, extra strong (XS) or Schedule 80, and double extra strong (XXS). The schedule numbers range from 10 to 160 and cover 10 distinct sets of wall thickness

Table 5-1: Wall thickness schedule designations for pipe

Nominal Size	Pipe OD	Inside Diameter [inch]									
		Sched. 10	Sched. 20	Sched. 30	Sched. 40	Sched. 60	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160
1/8	0.405				0.269		0.215				
1/4	0.540				0.364		0.302				
3/8	0.675				0.493		0.423				
1/2	0.840				0.622		0.546				0.466
3/4	1.050				0.824		0.742				0.614
1	1.315				1.049		0.957				0.815
1 1/4	1.660				1.380		1.278				1.160
1 1/2	1.900				1.610		1.500				1.388
2	2.375				2.067		1.939				1.689

Sizing of Pipes and Tubing

- It is important to note that the IDs of all pipes of the same nominal size are not equal. This difference is because the OD remains constant and the wall thickness increases as the schedule number increases.
- The wall thickness, material used, and ID determine the bursting pressure of a line or fitting. The greater the wall thickness in relation to the ID and the stronger the metal, the higher the bursting pressure. However, the greater the ID for a given wall thickness, the lower the bursting pressure, because force is the product of area and pressure.

Table 5-2: Tubing size designation

Tube OD	Wall Thickness	Tube ID
1/8	0.028	0.069
	0.032	0.061
	0.035	0.055
3/16	0.032	0.1235
	0.035	0.1175
1/4	0.035	0.180
	0.042	0.166
	0.049	0.152
	0.058	0.134
	0.065	0.120

Materials

- The pipe and tubing used in fluid power systems are commonly made from steel, copper, brass, aluminum, and stainless steel. Each of these metals has its own distinct advantages or disadvantages in certain applications.
- Steel pipe and tubing are relatively inexpensive and are used in many hydraulic and pneumatic systems. Steel is used because of its strength, suitability for bending and flanging, and adaptability to high pressures and temperatures. Its chief disadvantage is its comparatively low resistance to corrosion.
- Copper pipe and tubing are sometimes used for fluid power lines. Copper has high resistance to corrosion and is easily drawn or bent. However, it is unsatisfactory for high temperatures and has a tendency to harden and break due to stress and vibration.

Materials

- Aluminum has many of the characteristics and qualities required for fluid power lines. It has high resistance to corrosion and is easily drawn or bent. In addition, it has the outstanding characteristic of light weight. Since weight elimination is a vital factor in the design of aircraft, aluminum alloy tubing is used in the majority of aircraft fluid power systems
- Stainless steel tubing is used in certain areas of many aircraft fluid power systems. As a general rule, exposed lines and lines subject to abrasion or intense heat are made of stainless steel.
  - The lines must have the correct ID to provide the required volume and velocity of flow with the least amount of turbulence during all demands on the system.
  - The lines must be made of the proper material and have the wall thickness to provide sufficient strength to both contain the fluid at the required pressure and withstand the surges of pressure that may develop in the system.

Preparation of Pipes and Tubing

- Fluid power systems are designed as compactly as possible, to keep the connecting lines short. Every section of line should be anchored securely in one or more places so that neither the weight of the line nor the effects of vibration are carried on the joints. The aim is to minimize stress throughout the system.
- Lines should normally be kept as short and free of bends as possible. However, tubing should not be assembled in a straight line, because a bend tends to eliminate strain by absorbing vibration and also compensates for thermal expansion and contraction.

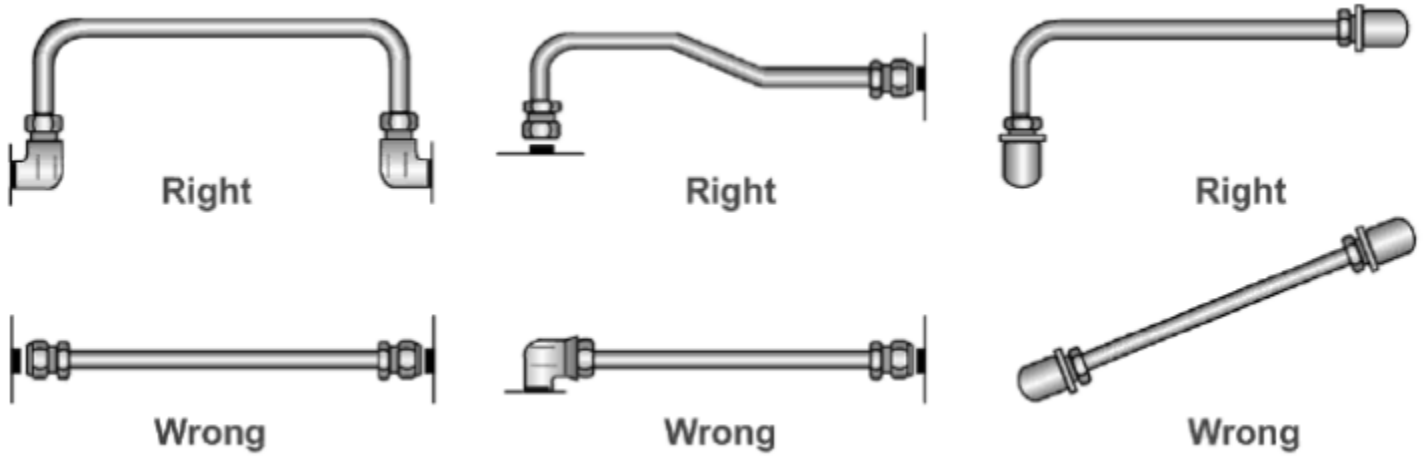
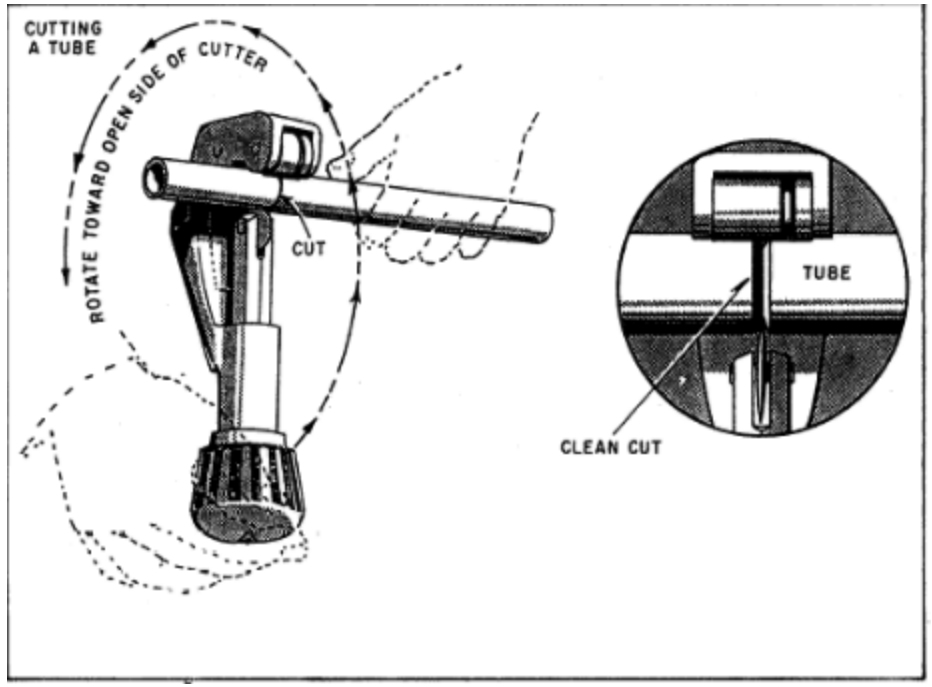


Figure 5-1: Correct and incorrect methods of installing tubing.

Tube Cutting and Deburring

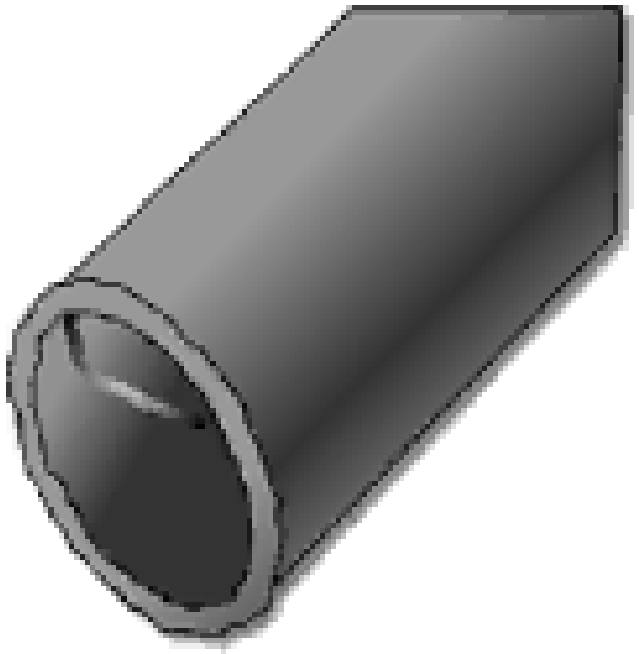
- The objective of cutting tubing is to produce a square end that is free from burrs. Tubing may be cut using a tube cutter, or a chipless cutter.



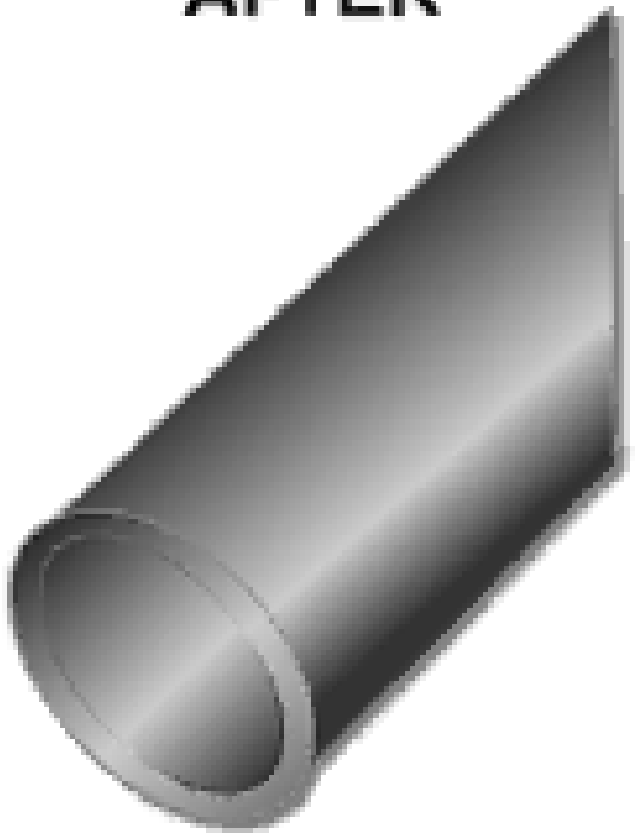
The following steps should be taken when using a chipless cutter

- Select the chipless cutter according to tubing size.
- Rotate the cutter head to accept the tubing in the cutting position. Check that the cutter ratchet is operating freely and that the cutter wheel is clear of the cutter head opening (Figure 5-4).
- Center the tubing on two rollers and the cutting blade.
- Use the hex key provided to turn the drive screw in until the cutter touches the tube.
- Tighten the drive screw 1/8 to 1/4 turn. Do not overtighten the drive screw. Overtightening can damage soft tubing or cause excessive wear or breakage of the cutter wheel in hard tubing.
- Swing the ratchet handle back and forth through the available clearance until there is a noticeable ease of rotation. Avoid putting side force on the cutter handle. Side force will cause the cutter wheel to break.
- Tighten the drive screw an additional 1/8 to 1/4 turn and swing the ratchet handle back and forth, retightening the drive screw as needed until the cut is completed. The completed cut should be 1/2 degree square to the tube centerline

BEFORE



AFTER

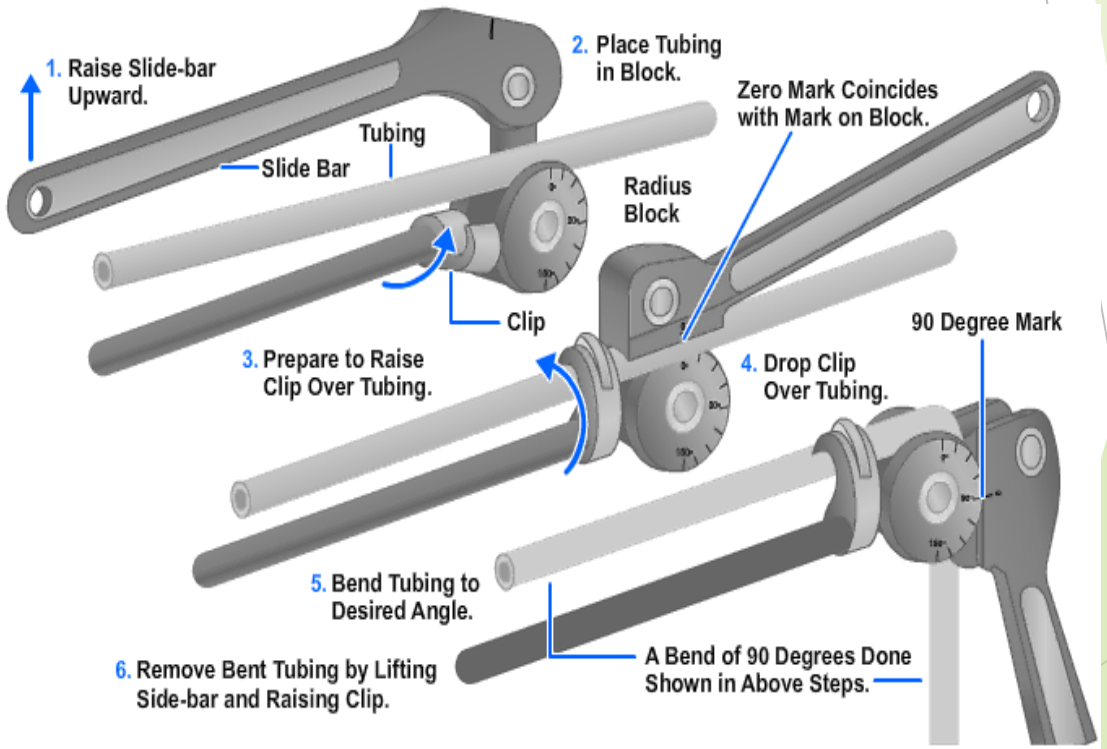


Tube Bending

- The objective in tube bending is to obtain a smooth bend without flattening the tube. Tube bending is usually done with either a hand tube bender or a mechanically-operated bender.
  - **Hand Tube Bender**
  - **Mechanical Tube Bender**

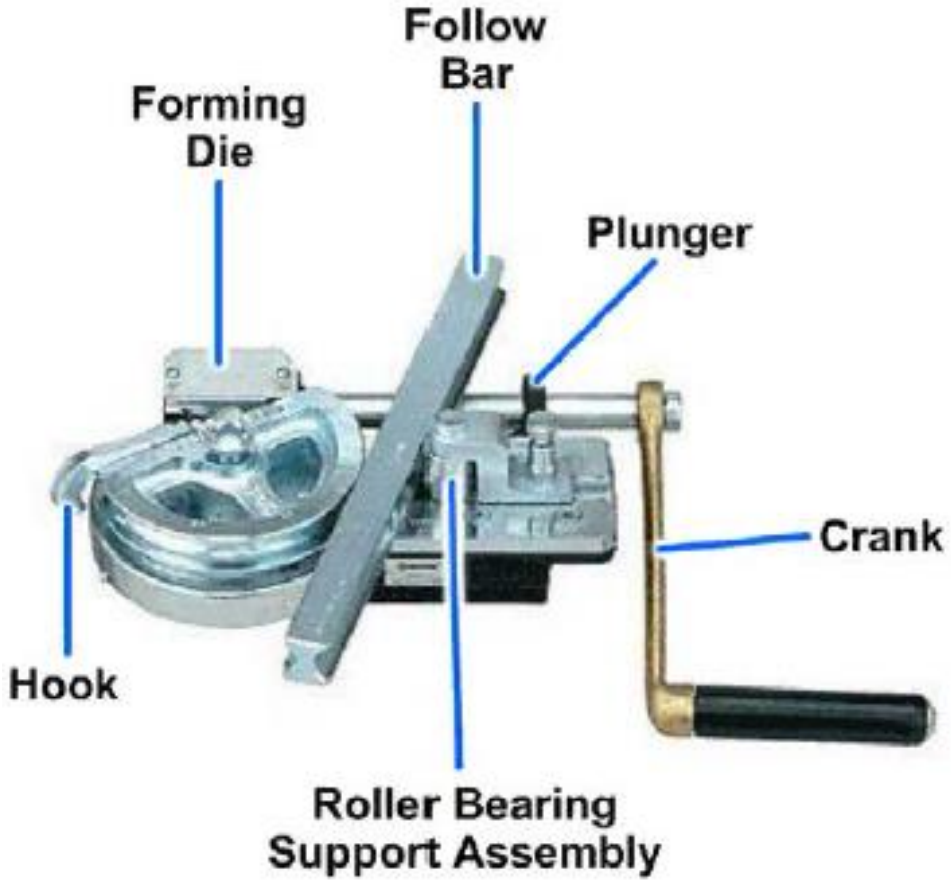
Hand Tube Bender

The hand tube bender shown in Figure 5-6 consists of a handle, a radius block, a clip, and a slide bar. The handle and slide bar are used as levers to provide the mechanical advantage necessary to bend the tubing. The radius block is marked in degrees of bend ranging from 0 to 180 degrees.



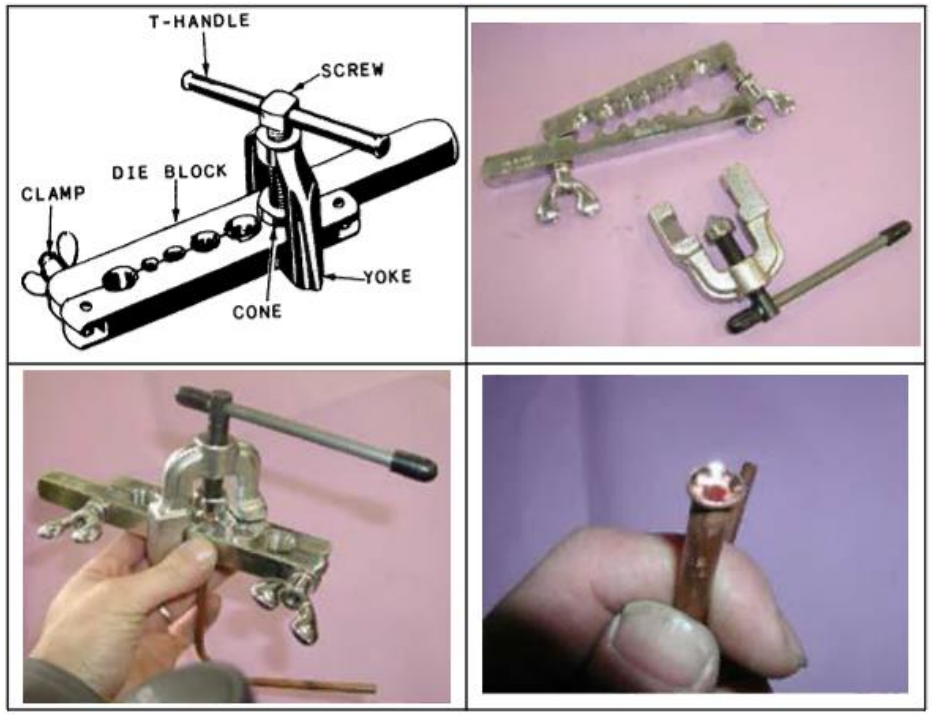
Mechanical Tube Bender

These benders are manufactured in many different sizes. When a tube is placed in the bender, the right handle of the bender should be raised as far as it will go so that it rests in a horizontal position. The clip should be raised and the tubing placed in the space between the handle and slide block and the bending form



Tube Flaring

- Flaring is an easy and satisfactory method of joining copper tubing. The ends of the tubing should be flared and pressed against the tapered surface of the flared fitting. Next, the flare nut should be screwed over the end of the fitting.

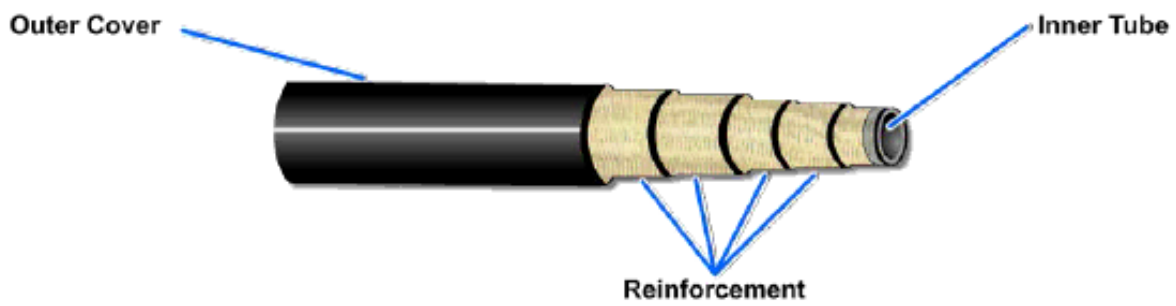


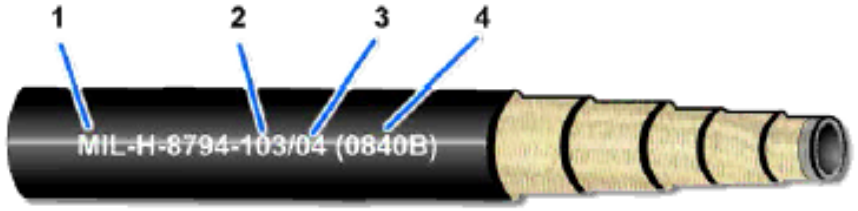
Flexible Hose

- Shock-resistant, flexible hose assemblies are required to absorb the movements of mounted equipment under both normal operating conditions and extreme conditions. They are also used for their noise-attenuating properties and to connect moving parts of certain equipment. There are two basic types of hoses used in military aircraft and related equipment.
  - synthetic rubber and
  - polytetrafluoroethylene (PTFE)

Synthetic rubber

- Rubber hoses are designed for specific fluid, temperature, and pressure ranges and are provided in various specifications. Rubber hoses consist of a minimum of three layers; a seamless synthetic rubber tube reinforced with one or more layers of braided or spiraled cotton, wire, or synthetic fiber; and an outer cover.
- The inner tube is designed to withstand the attack of the fluid that passes through it. The braided or spiraled layers determine the strength of the hose; the greater the number of these layers, the greater the pressure rating. Hoses are provided in three pressure ranges: low, medium, and high. The outer cover is designed to withstand external abuse and contains identification markings.





Synthetic Rubber Hose

1. Military specification of hose
2. Size indicated by a dash (-) No. or fraction of an inch for MIL-DTL-6000 hose
3. Cure date for age control
4. Manufacturer's Federal Supply Code No.

Wire Braid Covered Synthetic Rubber Hose

Manufacturer	ACME
Manufacturer's code	0840B
Part No. with dash (size) No.	AB123-10
Lot No.	16160
Operating pressure	3000 PSI
Military specification	MIL-H-83298

Wire Braid Covered PTFE Hose Label

Figure 5-10: Synthetic rubber hose identification.

Polytetrafluoroethylene (PTFE) (Teflon) Hose

- The PTFE hose is a flexible hose designed to meet the requirements of higher operating pressures and temperatures in present fluid power systems. This type of hose is made from a chemical resin, which is processed and extruded into a tube shaped to a desired size. It is reinforced with one or more layers of braided stainless steel wire or with an even number of spiral wrap layers with an outer wire braid layer.

Application

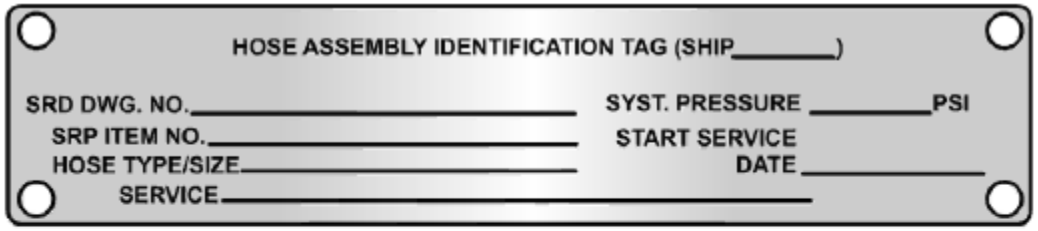
- Be compatible with the system fluid,
- Have a rated pressure greater than the design pressure of the system,
- Be designed to give adequate performance and service for infrequent transient pressure peaks up to 150 percent of the working pressure of the hose, and
- Have a safety factor with a burst pressure at a minimum of 4 times the rated working pressure

Fabrication and Testing

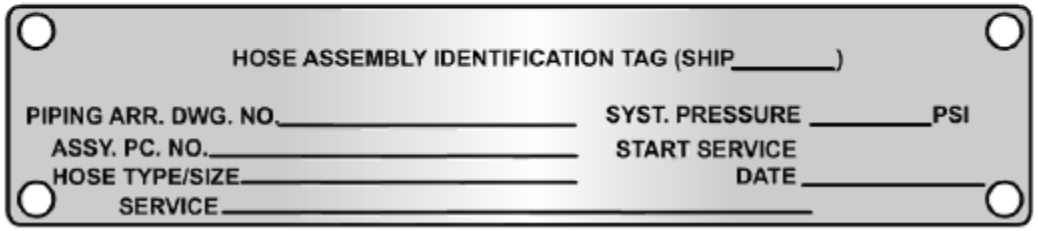
- The fabrication of flexible hose assemblies is covered in applicable training manuals, technical publications, and the Aviation Hose and Tube Manual, NAVAIR 01-1A-20. After a hose assembly has been completely fabricated, it must be cleaned, visually inspected for foreign materials, and proof tested.

Identification

- The final step after fabrication and satisfactory testing of a hose assembly is the attachment of identification tags as shown in Figure 5-11 (for ships). Hose assemblies to be installed in aircraft fuel and oil tanks are marked with an approved electric engraver on the socket-wrench flats with the required information.



ID Tag When Selected Record Drawing Is Available



ID Tag When Selected Record Drawing Does Not Exist

Installation

- Flexible hose must not be twisted during installation, since this reduces the life of the hose considerably and may cause the fittings to loosen as well. To determine whether a hose is twisted or not, the lay line that runs along the length of the hose should be straight. If the lay line does not spiral around the hose, the hose is not twisted. If the lay line does spiral around the hose, the hose is twisted (Figure 5-12) and must be untwisted.

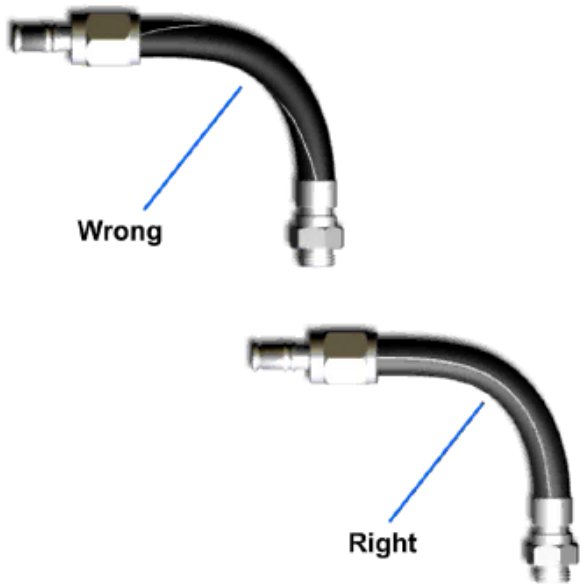


Figure 5-12: Hose twist.

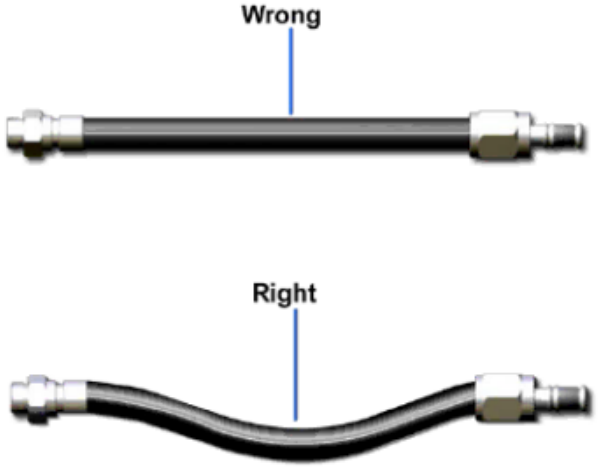


Figure 5-13: Hose slack.

Types of Fittings and Connectors

- Some type of connector or fitting must be provided to attach the lines to the components of the system and to connect sections of line to each other. There are many different types of connectors and fittings provided for this purpose. The type of connector or fitting required for a specific system depends on several factors.
  - **Threaded Connectors**
  - **Flange Connectors**
  - **Welded Connectors**
  - **Brazed Connectors**
  - **Flared Connectors**

Threaded Connectors

- In the type discussed in this section, both the connector and the end of the fluid line (pipe) are threaded. These connectors are used in some low-pressure fluid power systems and are usually made of steel, copper, or brass, and are available in a variety of designs.
- Threaded connectors are made with standard pipe threads cut on the inside surface. The end of the pipe is threaded with outside threads. Standard pipe threads are tapered slightly to ensure tight connections. The amount of taper is approximately 3/4-inch in diameter per foot of thread.
- Another material used on pipe threads is sealant tape. This tape, which is made of PTFE, provides an effective means of sealing pipe connections and eliminates the necessity of torqueing connections to excessively high values in order to prevent pressure leaks.

Flange Connectors

- Bolted flange connectors (Figure 5-14) are suitable for most pressures now in use. The flanges are attached to the piping by welding, brazing, tapered threads (for some low-pressure systems), or rolling and bending into recesses. Those illustrated are the most common types of flange joints used. The same types of standard fitting shapes (tee, cross, elbow, and so forth) are manufactured for flange joints. Suitable gasket material must be used between the flanges.

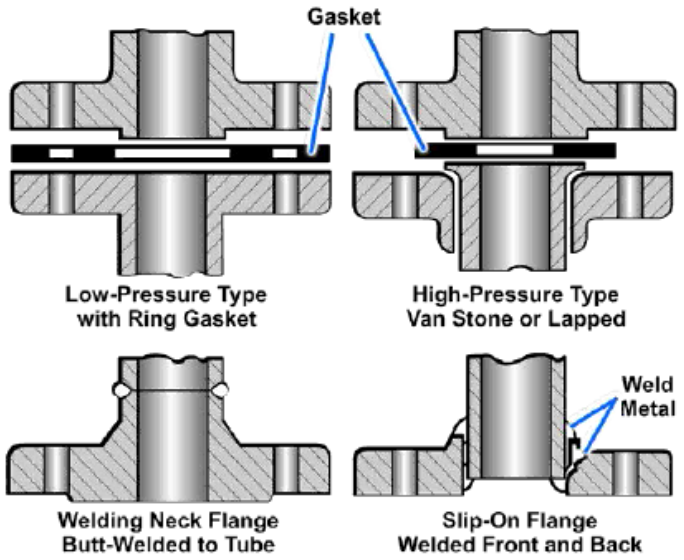


Figure 5-14: Four types of bolted flange connectors.

Welded Connectors

- The subassemblies of some fluid power systems are connected by welded joints, especially in high-pressure systems which use pipe for fluid lines. The welding is done according to standard specifications which define the materials and techniques.

Brazed Connectors:

Silver-brazed connectors are commonly used for joining nonferrous (copper, brass, and soon) piping in the pressure and temperature range where their use is practical. Use of this type of connector is limited to installations in which the piping temperature will not exceed 425 °F and the pressure in cold lines will not exceed 3,000 pounds per square inch (psi). The alloy is melted by heating the joint with an oxyacetylene torch. This causes the alloy insert to melt and fill the few thousandths of an inch annular space between the pipe and the fitting

Flared Connectors

- Flared connectors are commonly used in fluid power systems containing lines made of tubing. These connectors provide safe, strong, dependable connections without the need for threading, welding, or soldering the tubing. The connector consists of a fitting, a sleeve, and a nut

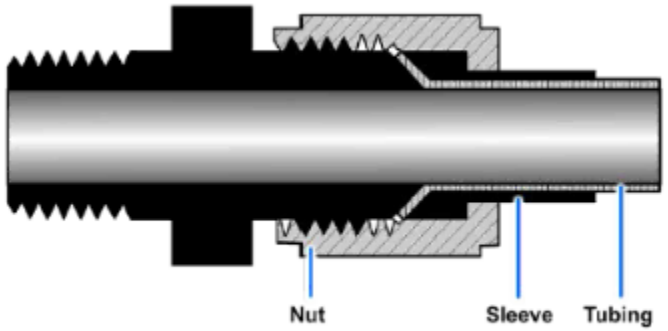


Figure 5-15: Flared-tube fitting.

Flareless-Tube Connectors

- This type of connector eliminates all tube flaring, yet provides a safe, strong, and dependable tube connection. This connector consists of a fitting, a sleeve or ferrule, and a nut.
- Flareless-tube fittings are available in many of the same shapes and thread combinations as flared-tube fittings. The fitting has a counterbore shoulder for the end of the tubing to rest against. The angle of the counterbore causes the cutting edge of the sleeve or ferrule to cut into the outside surface of the tube when the two are assembled.

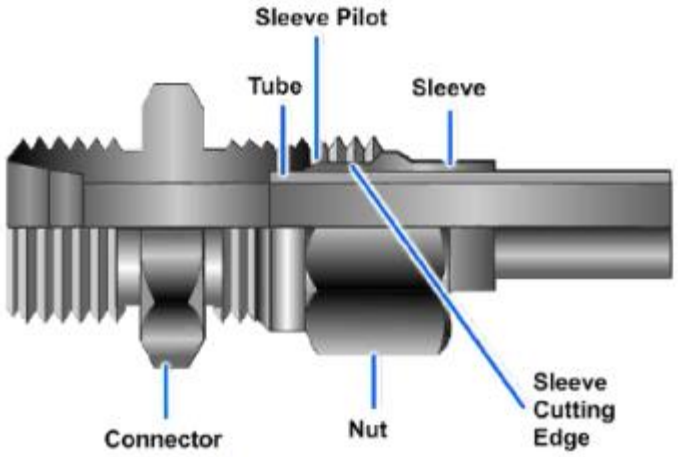


Figure 5-18: Flareless-tube connector.

- Lubricate all threads with a liquid that is compatible with the fluid to be used in the system.
- Place the tube assembly in position and check for alignment.
- Tighten the nut by hand until you feel an increase in resistance to turning. This indicates that the sleeve or ferrule pilot has contacted the fitting.
- If possible, use a torque wrench to tighten flareless tubing nuts. Torque values for specific installations are usually listed in the applicable technical publications. If it is not possible to use a torque wrench, the following discussion describes a process for tightening the nuts

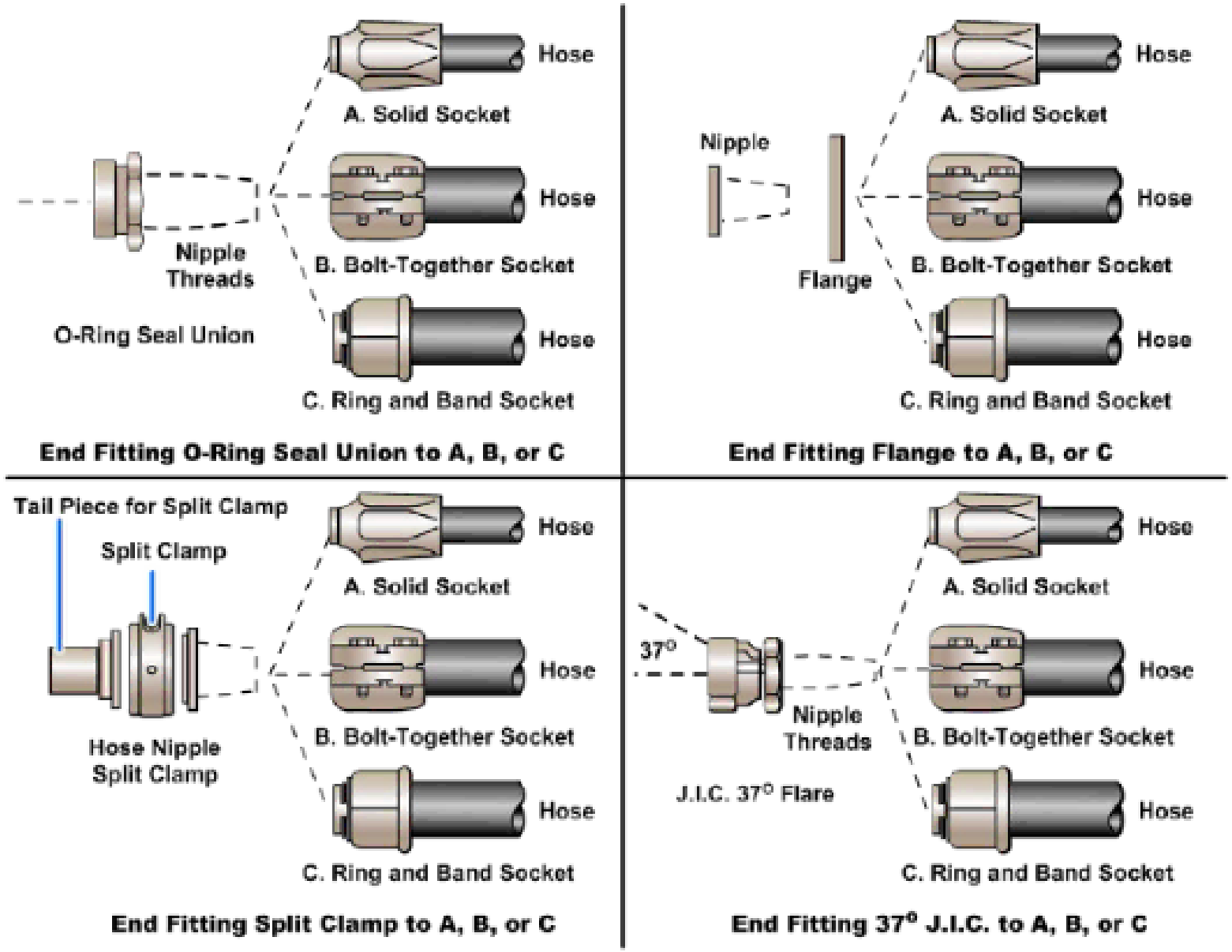


Figure 5-22: End fittings and hose fittings.

Piping Connection Side of Hose Fitting

The piping side of an end fitting comes with several connecting variations: flange, Joint Industry Council (JIC) 37-degree flare, O-ring union, and split clamp, to name a few. Not all varieties are available for each hose. Therefore, installers must consult the military specification and manufacturer's data to determine the specific end fittings available.

Hose Connection Side of Hose Fitting

Hose fittings are attached to the hose by several methods. Each method is determined by the fitting manufacturer and takes into consideration such things as size, construction, wall thickness, and pressure rating. Hoses used for flexible connections use one of the following methods for attachment of the fitting to the hose.

One-Piece Reusable Socket

The socket component of the fitting is fabricated as a single piece. One-piece reusable sockets are screwed or rocked onto the hose OD, followed by insertion of the nipple component.

Segmented, Bolted Socket

The segmented, bolted socket consists of two or more segments which are bolted together on the hose after insertion of the nipple component.

Segmented Socket, Ring and Band Attached

The segmented, ring and band attached socket consists of three or more segments. As with the bolt-together segments, the segments, ring and band are put on the hose after insertion of the nipple. A special tool is required to compress the segments.

Solid Socket, Permanently Attached

This type of socket is permanently attached to the hose by crimping or swaging. It is not reusable and is only found on hose assemblies where operating conditions preclude the use of other fitting types. Hose assemblies with this type of fitting attachment are purchased as complete hose assemblies from the manufacturer.

Manifolds

Some fluid power systems are equipped with manifolds in the pressure supply and/or return lines. A manifold is a fluid conductor that provides multiple connection ports. Manifolds eliminate piping, reduce joints (which are often a source of leakage), and conserve space. For example, manifolds may be used in systems that contain several subsystems. One common line connects the pump to the manifold. There are outlet ports in the manifold to provide connections to each subsystem. A similar manifold may be used in the return system. Lines from the control valves of the subsystem connect to the inlet ports of the manifold, where the fluid combines into one outlet line to the reservoir.

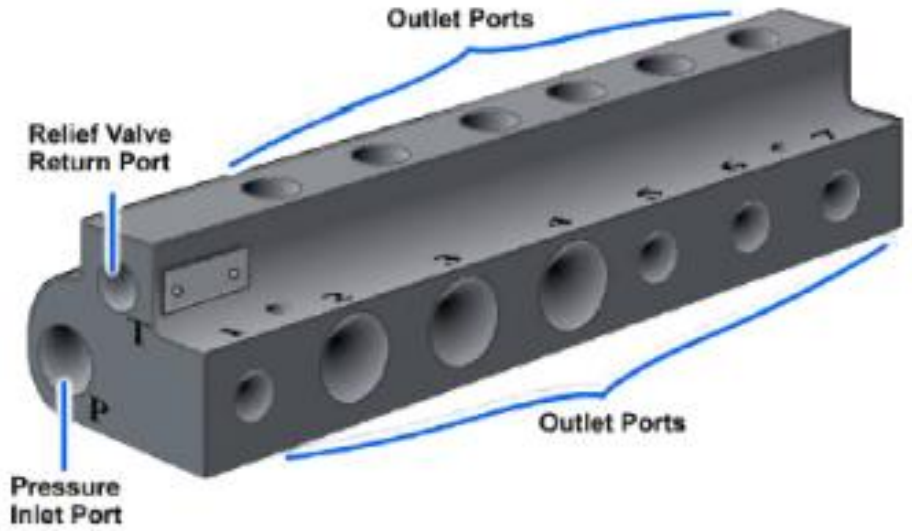
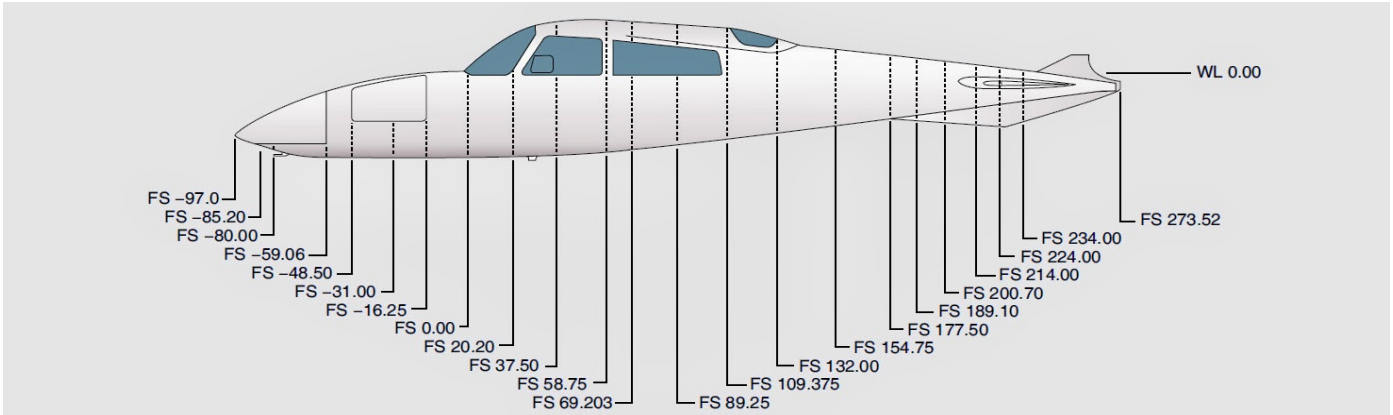
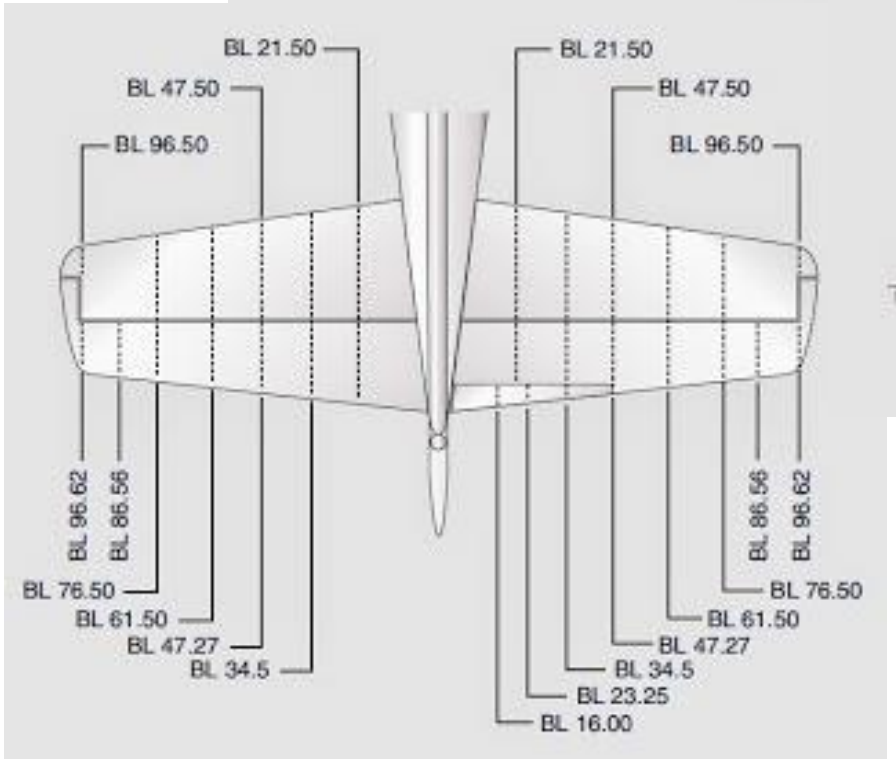


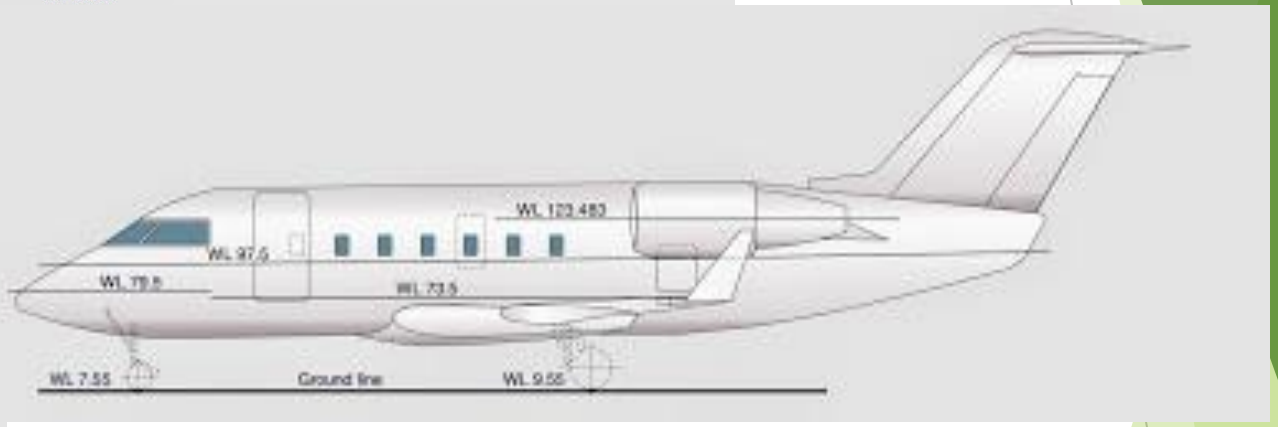
Figure 5-24: Fluid manifold.

Aircraft station number

- Even on small, light aircraft, a method of precisely locating each structural component is required. Various numbering systems are used to facilitate the location of specific wing frames, fuselage bulkheads, or any other structural members on an aircraft. Most manufacturers use some system of station marking.
- The nose of the aircraft may be designated “zero station,” and all other stations are located at measured distances in inches behind the zero station. Thus, when a blueprint reads “fuselage frame station 137,” that particular frame station can be located 137 inches behind the nose of the aircraft.


WL 0.00
FS –97.0
FS –85.20
FS –80.00
FS –59.06
FS –48.50
FS –31.00
FS –16.25
FS 0.00
FS 20.20
FS 37.50
FS 58.75
FS 69.203
FS 89.25
FS 109.375
FS 132.00
FS 154.75
FS 177.50
FS 189.10
FS 200.70
FS 214.00
FS 224.00
FS 234.00
FS 273.52


BL 21.50
BL 47.50
BL 96.50
BL 21.50
BL 47.50
BL 96.50
BL 96.62
BL 86.56
BL 76.50
BL 61.50
BL 47.27
BL 34.5
BL 16.00
BL 23.25
BL 34.5
BL 47.27
BL 61.50
BL 76.50
BL 86.56
BL 96.62


WL 123.483
WL 97.5
WL 73.5
WL 7.55
Ground line
WL 9.55

Aircraft station number

- Fuselage stations (Fus. Sta. or FS) are numbered in inches from a reference or zero point known as the reference datum. [Figure 1] The reference datum is an imaginary vertical plane at or near the nose of the aircraft from which all fore and aft distances are measured.
- Buttock line or butt line (BL) is a vertical reference plane down the center of the aircraft from which measurements left or right can be made.
- Water line (WL) is the measurement of height in inches perpendicular from a horizontal plane usually located at the ground, cabin floor, or some other easily referenced location.

Aircraft station number

- Aileron station (AS) is measured outboard from, and parallel to, the inboard edge of the aileron, perpendicular to the rear beam of the wing.
- Flap station (KS) is measured perpendicular to the rear beam of the wing and parallel to, and outboard from, the inboard edge of the flap.
- Nacelle station (NC or Nac. Sta.) is measured either forward of or behind the front spar of the wing and perpendicular to a designated water line.

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

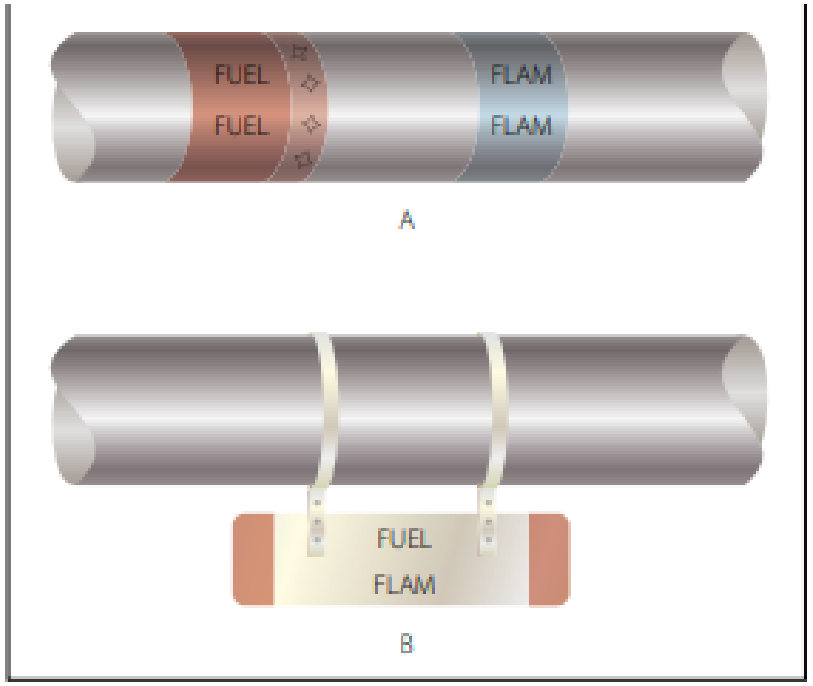
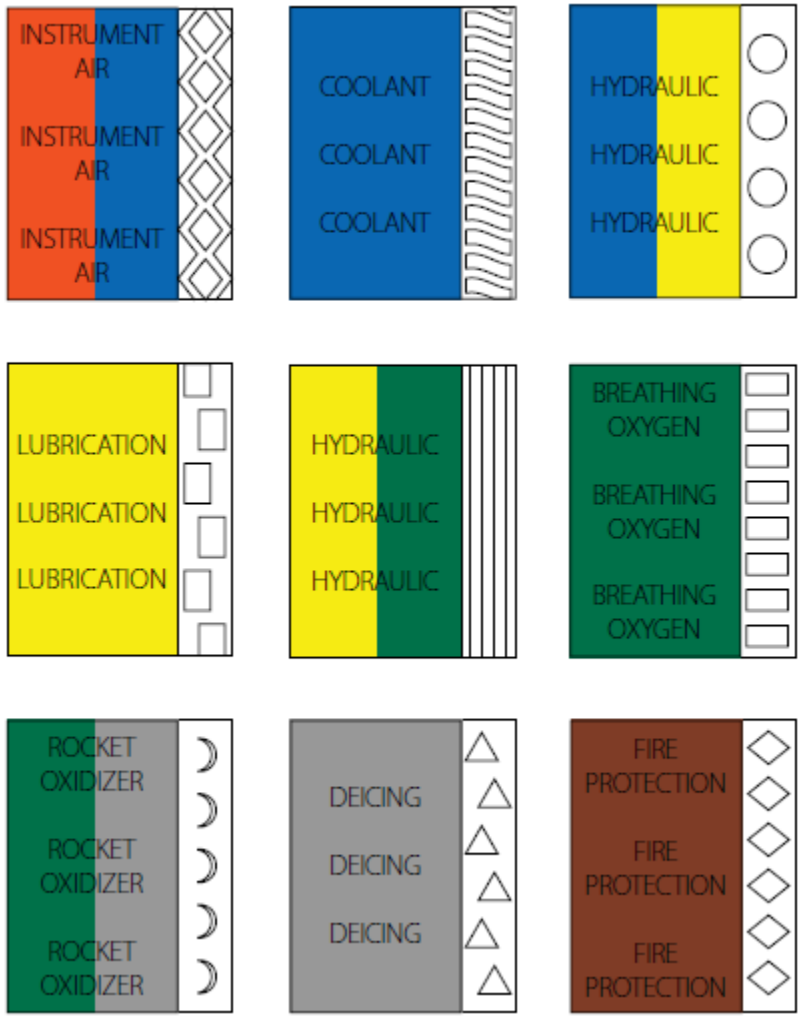


Figure 7-14. Fluid line identification using: (A) tape and decals and (B) metal tags.

Identification of aircraft fluid lines

- 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. Lin materials, such as oxygen, nitrogen, or Freon's containing physically dangerous



WORKSHOP PRACTICES

- Company own or lease all necessary tools and equipment to perform the approved scope of work. It is responsible for acceptance of tool and equipment, and the level of manufacturers recommended special tools and ground support equipment as listed in the aircraft and engine maintenance manuals, and that level is sufficient for the aircraft work to be undertaken.

Tool and Equipment Usage

All tools and equipment are classified as:

- Standard tools;
- Specific tools;
- Ground support equipment (GSE).

In other hand tools and equipment are subdivided on tools or equipment which should be:

- Calibrated;
- Inspected;
- Serviced.

TOOL / EQUIPMENT LIST

Note 1: The given change dated …… cancels all previous.

Note 2: Vertical lines are put on the left edge of pages to show the location of revised items.

No	Description of tool / equipment	P/N, S/N (if applicable)	Calibration interval (months)	Last calibration	Next calibration	Remarks

Figure 2-1. A sample (minimal) Tool / Equipment List

Rejection of Tool / Equipment

- If the tool / equipment didn't pass through acceptance the Tool / GSE unserviceable tag will be used and item placed to quarantine area till final decision will be done by Company.
- Tool and equipment (including alternate tools) are used by the competent personnel, who have been trained to use them. However, when these tools or equipment are "specific", their technical instructions or operation manual allowing knowing how to use them always accompanies them.
- When requested, a specific training is performed by Company. Only identified tool can be used during maintenance.

Tool and Equipment from Store

- When tool / GSE are served, tool register is updated by Shift Leader and signed by the Loaner.
- The "Tool distribution register" normally includes:
  - Name of the person receiving the tool;
  - Marking of the tool, part number, serial number (if applicable);
  - Where the tool is going to be used (tail number of the aircraft);
  - Date and time of delivery4;
  - Date and time of return.
- When the tool / GSE are returned to the store the Shift Leader is responsible to check number, condition and identification of the tool / GSE

Measurements and their Principles

- These measurements require estimation between marks on the rule, and estimation between marks on any measuring instrument is subject to human error.
- Experience has shown that the best the average person can do with consistency is to decide whether a measurement is more or less than halfway between marks.
- The correct way to state this fact mathematically is to say that a measurement made with an instrument marked off in tenths of an inch involves a maximum probable error of *0.05* inch (five hundredths is one-half of one tenth).
- By the same reasoning, the probable error in a measurement made with an instrument marked in thousandths of an inch is *0.0005* inch.

Precision

- In general, the probable error in any measurement is one-half the size of the smallest division on the measuring instrument. Thus the precision of a measurement depends upon how precisely the instrument is marked.
- It is important to realize that precision refers to the size of the smallest division on the scale; it has nothing to do with the correctness of the markings

Fundamental deviation	The *minimum* difference in size between a component and the basic size. This is identical to the upper deviation for shafts and the lower deviation for holes. If the fundamental deviation is greater than zero, the bolt will always be smaller than the basic size and the hole will always be wider. Fundamental deviation is a form of allowance, rather than tolerance
International Tolerance grade	A standardised measure of the *maximum* difference in size between the component and the basic size

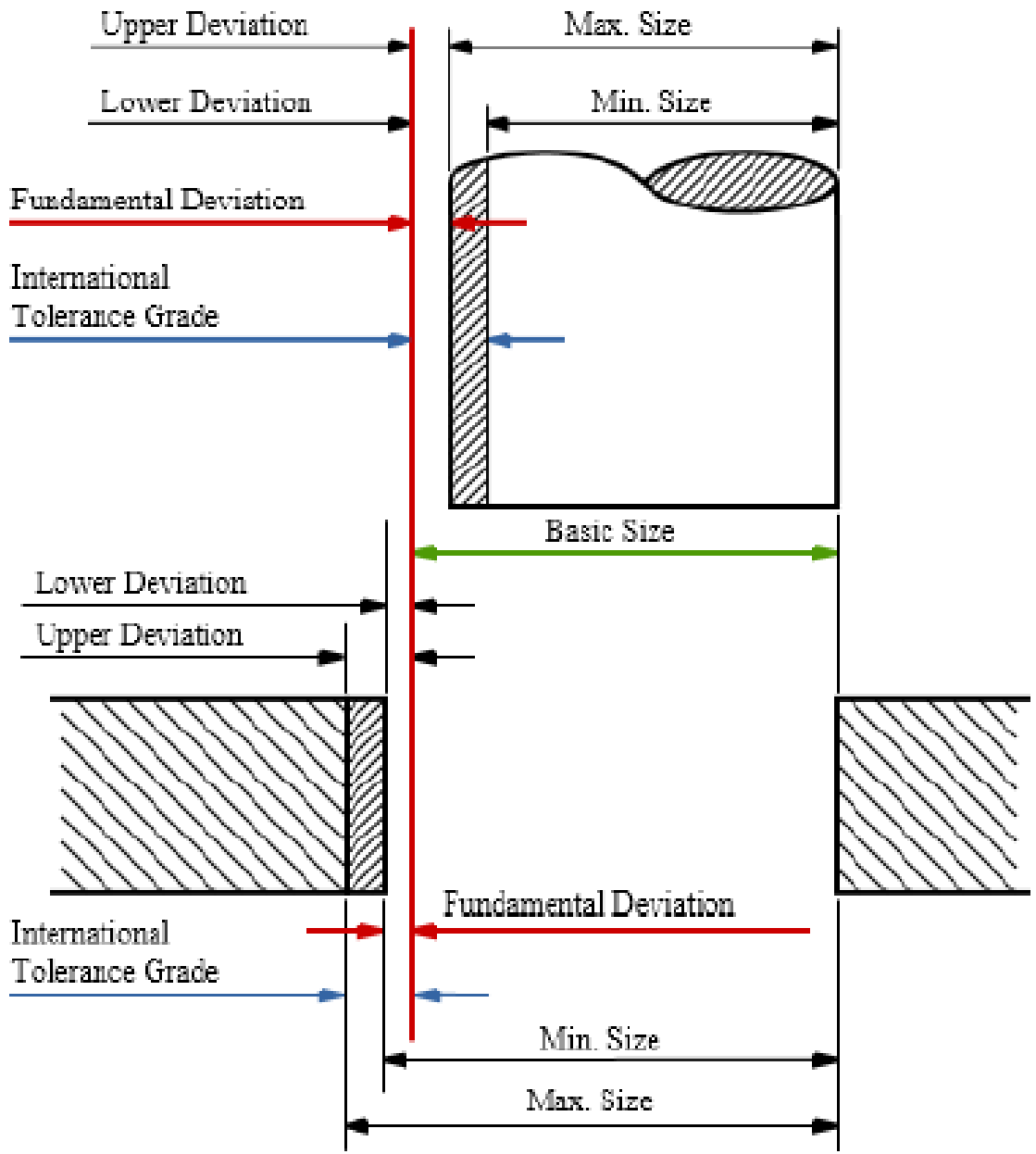
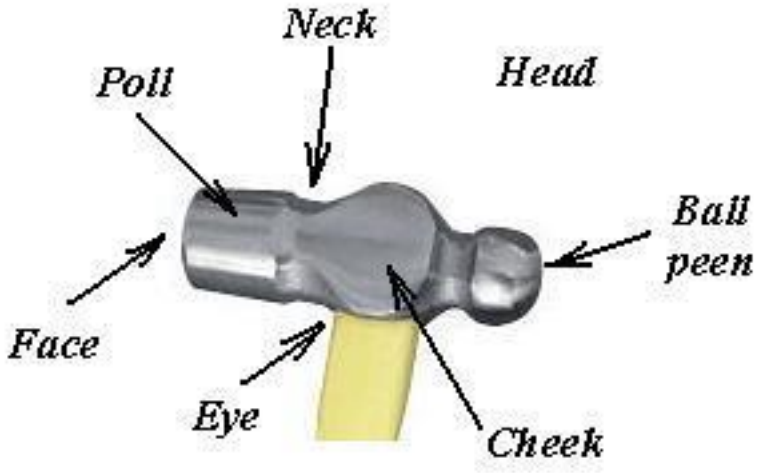


Figure 2-2. Basic size, fundamental deviation and IT grades compared to minimum and maximum sizes of the shaft and hole

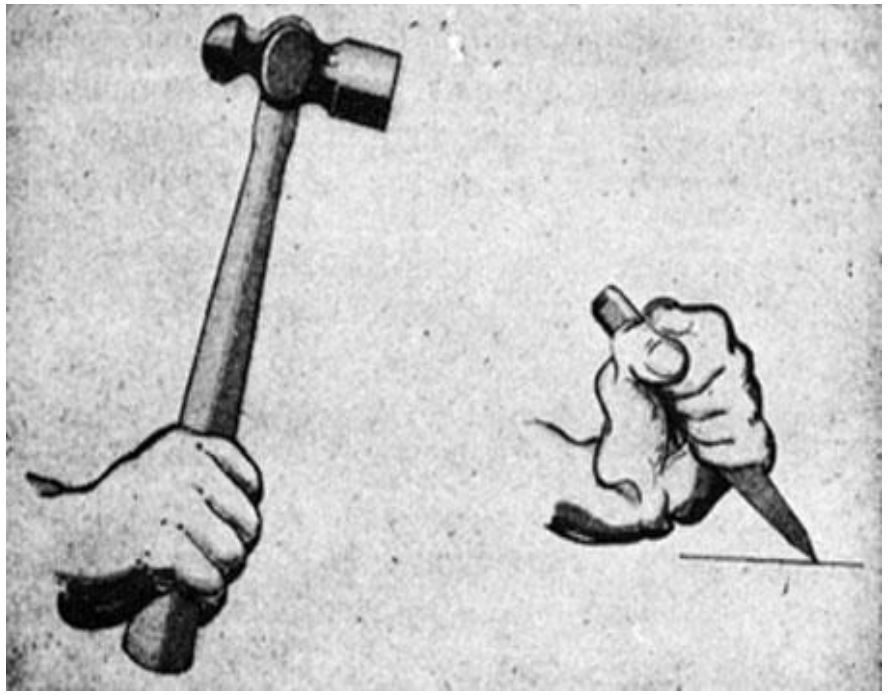
TOOLS

- The basic knowledge required in using the most common hand tools and measuring instruments used in aircraft repair work is outlined here.
- **Pounding Tools :**
  - Pounding tools include different types and weights of hammers and mallets, each with a very specific use. Since misuse of pounding tools can result in damage to aircraft components and injury to personnel, it is important to use these tools properly



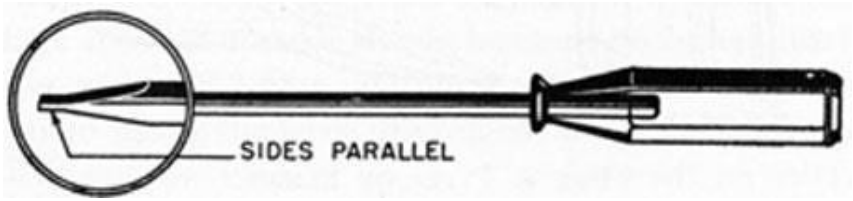
Peen Hammers

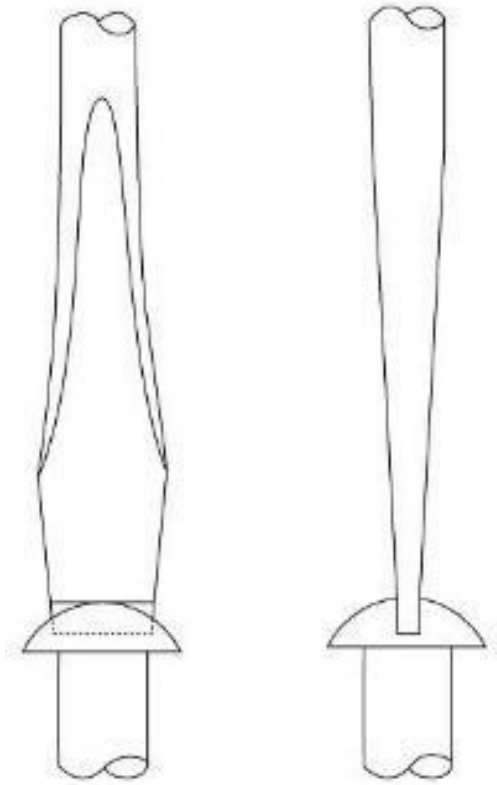
- The ball peen hammers ranges in weight from one ounce to two or three pounds. One hammer face is always flat while the other is formed into the shape of a ball. The flat hammer face is used for pounding, but should not be used to drive a nail.



Screwdrivers

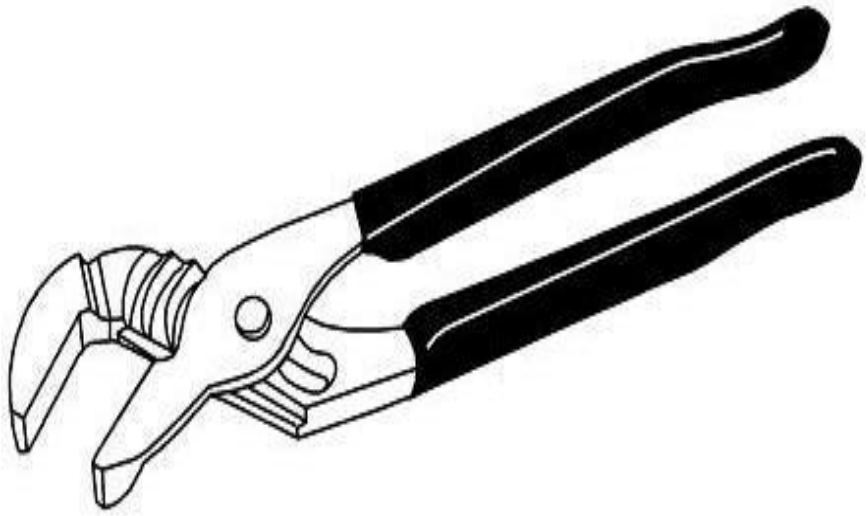
- The screwdriver can be classified by its shape, type of blade, and blade length. It is made for only one purpose, i.e., for loosening or tightening screws or screw head bolts. When using the common screwdriver, select the largest screwdriver whose blade will make a good fit in the screw which is to be turned





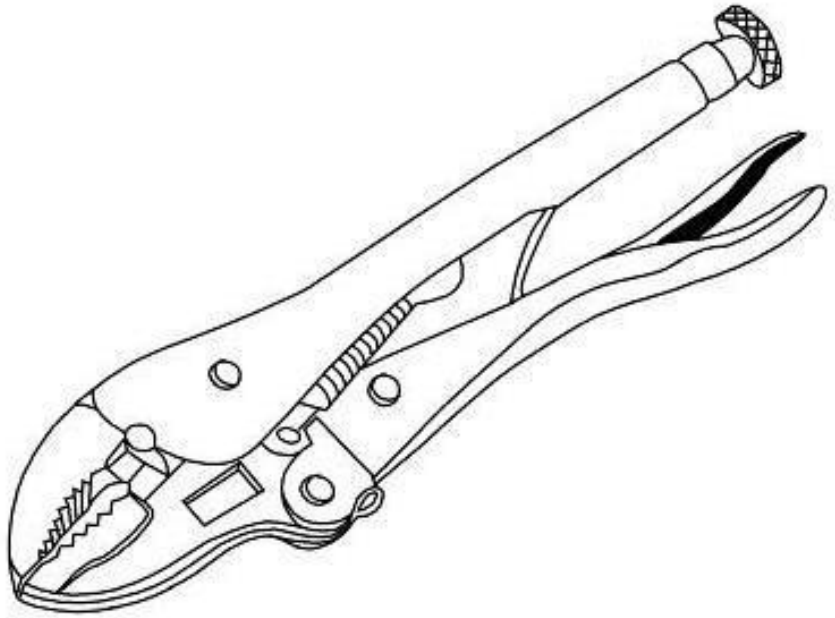
Interlocking-joint or Tongue-and-Groove Water Pump Pliers

- Interlocking-joint pliers are commonly called water pump pliers because they are often used to tighten the packing gland nut around a water pump shaft. These pliers have several curved grooves that make up a series of interlocking joints



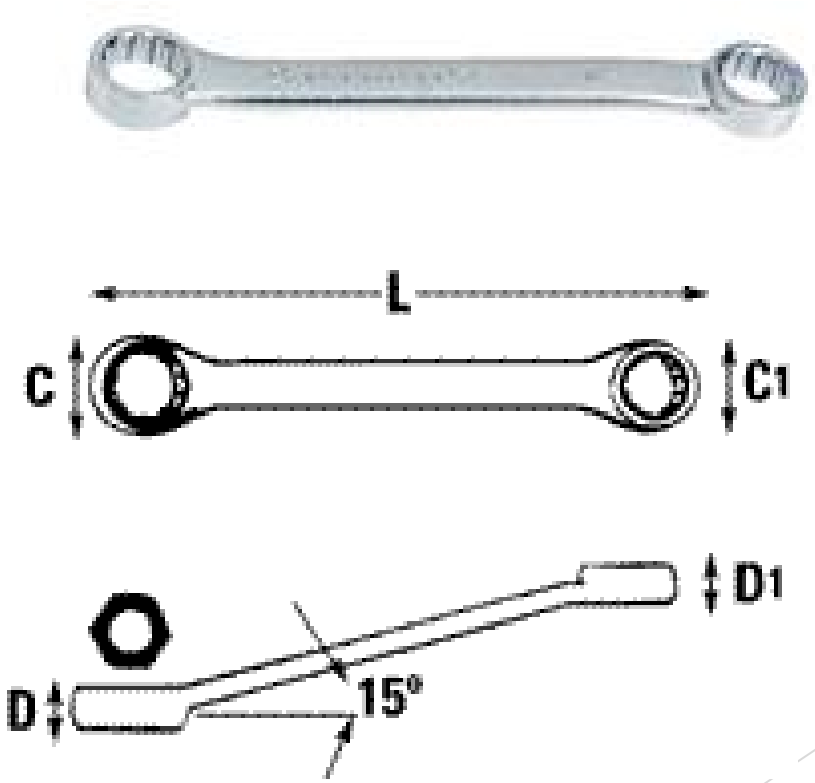
Vise-Grip TM Pliers

- Vise-Grip is the registered trade name of the Petersen Mfg. Co for special compound-action type pliers. The opening of these jaws is adjustable by a knurled screw located in the end of the pliers handles
- When these handles are squeezed together compound leverage multiplies the effort and applies a tremendous force to the jaws. A toggle action clamps the jaws together so they will not open when the handles are released. The jaws are released by a small lever in one of the handles.



Box-End Wrenches

- Exceptionally tight nuts can spread the jaws on even the best open-end wrench. To break the torque on tight nuts a box-end wrench is used. Box-end wrenches have a six-or twelve-point opening attached to each end and offset from the axis of the handle by about 15 degrees.
- Box-end wrenches are popular tools because of their usefulness in close quarters. They are called box wrenches since they box, or completely surround the nut or bolt head. Practically all box-end wrenches are made with 12 points so they can be used in places having as little as 15° swing.



Combination Wrench

- The disadvantage of a box-end wrench is the limitation of always having to lift and reposition the wrench in order to continue loosening a fastener. On the other hand, an open-end wrench is much easier to slip off and onto a nut The combination wrench has the advantage of both a box-end and an open-end wrench. This popular configuration has a box end broached on one end.

Special Wrenches

- The category of special wrenches includes the spanner, torque, and alien wrenches.

Allen Wrench

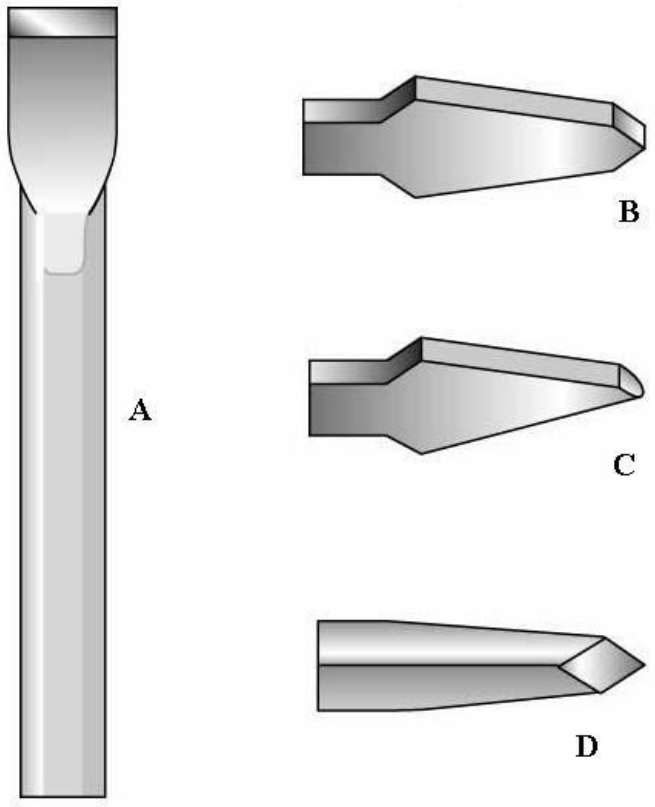
- Most headless setscrews are the alien type and must be installed and removed with an Allen wrench. Allen wrenches are six-sided bars in the shape of an L. They range in size and fit into a hexagonal recess in the setscrew.

Some features of hex keys are

- The tool is simple, small and light;
- The contact surfaces of the screw or bolt are protected from external damage;
- There are six contact surfaces between bolt and driver;
- The tool can be used with a headless screw;
- The screw can be inserted into its hole using the key;
- Torque is constrained by the length and thickness of the key;
- Very small bolt heads can be accommodated;
- The tool can be manufactured very cheaply, so one is often included with products requiring end-user assembly;
- Either end of the tool can be used to take advantage of reach or torque.

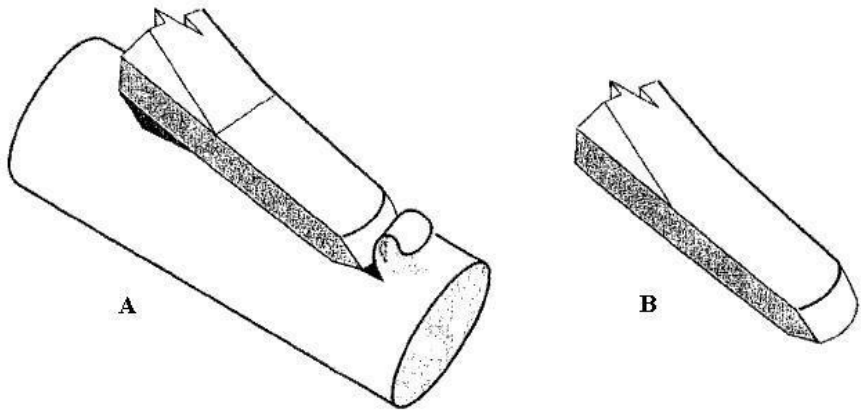
Chisels

- A chisel is a hard steel cutting tool which can be used for cutting and chipping any metal softer than the chisel itself. It can be used in restricted areas and for such work as shearing rivets, or splitting seized or damaged nuts from bolts.



Flat Chisels

- The flat or cold chisel is the most common type of chisel used by the aviation technician. Flat chisels are made from square or octagonal stock, ranging from 5/16 inch to 11/16 inch across. The cutting edge of a flat chisel is forged so it is slightly wider than the shank and is ground to an angle of approximately 70 degrees



Procedure

1. Mark with a scriber or file, or with chalk or color pencil, the point at which the cut is to be made;

2. Hold the work in place on the anvil or other suitable support. (It is advisable to protect the anvil with a piece of scrap metal.)

3. Hold the chisel with the cutting edge on the mark and the body of the chisel in a vertical position.

4. Strike the chisel a light blow with the hammer, and then examine the chisel mark on the work to make certain that the cut is at the desired point.

5. Drive the chisel into the work with vigorous blows. The last few strokes, however, should be made lightly in order to avoid unnecessary damage to the supporting surface.

The Purpose of Washers

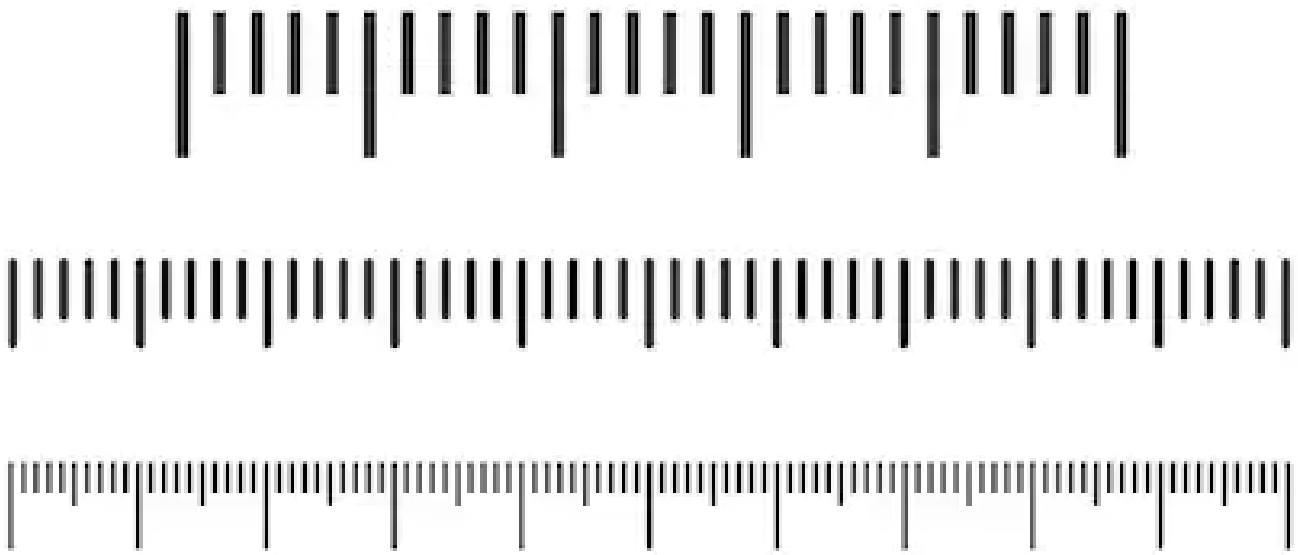
- Load Distribution
- Spacing
- Vibration Absorption
- Liquid Protection

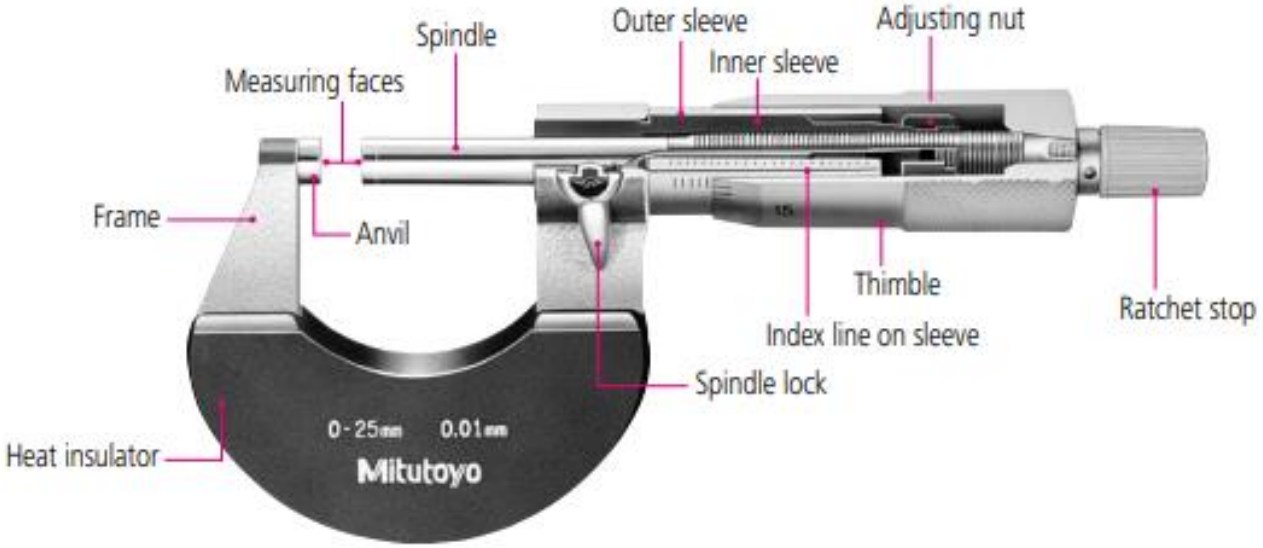
Explain the conditions at which an aircraft requires reweighing during service life

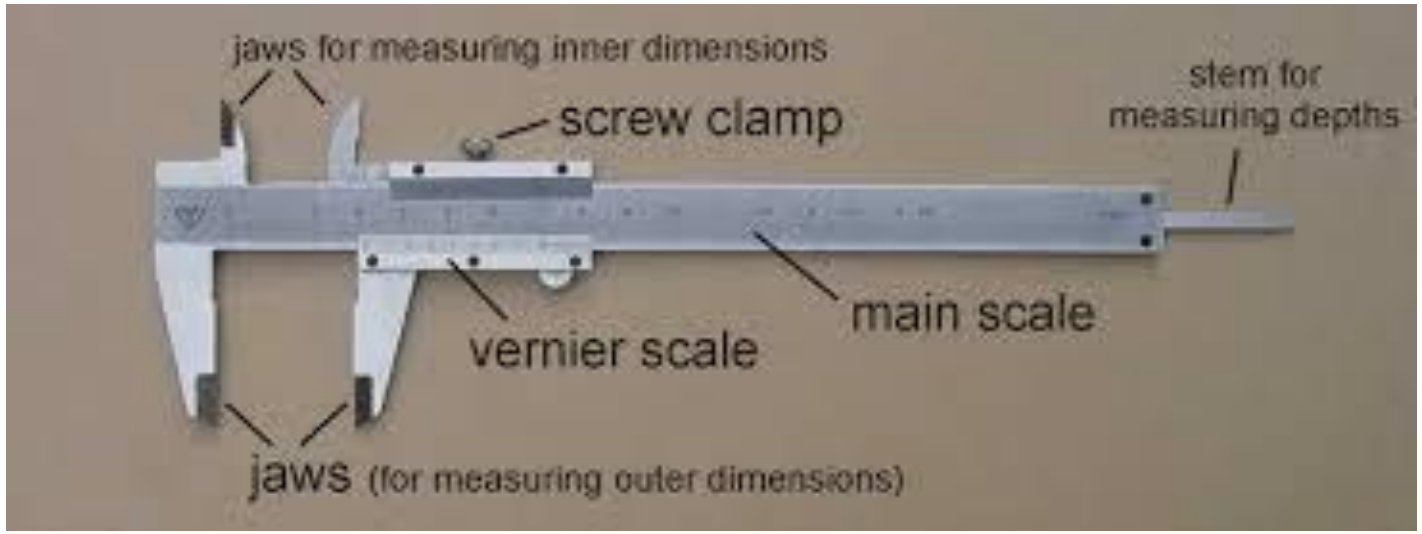
- A weight and balance extreme condition check, sometimes called an adverse condition check, involves loading the aircraft in as nose heavy or tail heavy a condition as possible, and seeing if the center of gravity falls outside the allowable limits.
- On what is called a forward extreme condition check, all useful load items in front of the forward CG limit are loaded, and all useful load items behind the forward CG limit are left empty. So if there are two seats and a baggage compartment located in front of the forward CG limit, two people weighing 170 lb each will be put in the seats, and the maximum allowable baggage will be put in the baggage compartment

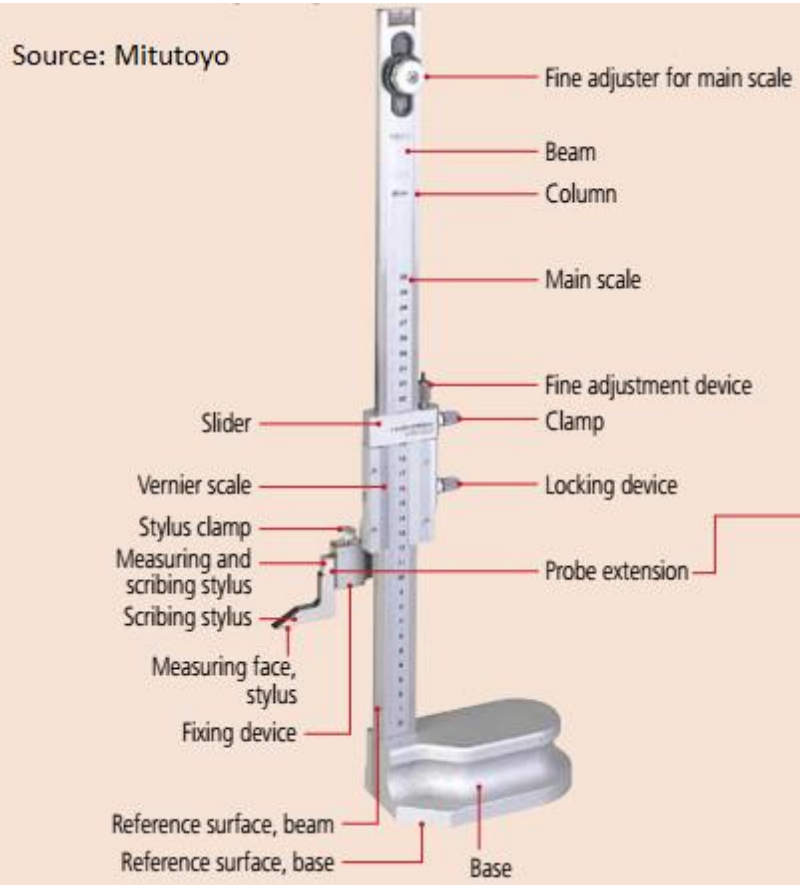
Precision instruments

- Linear measurement includes the measurement of lengths, diameters, heights and thickness. The basic principle of linear measurement (mechanical type) is that of comparison with standard dimensions on a suitably engraved instrument or device. Linear measuring instruments are categorized depending upon their accuracy. The two categories are non-precision instruments and precision instruments.




Spindle
Outer sleeve
Adjusting nut
Inner sleeve
Measuring faces
Frame
Anvil
Thimble
Ratchet stop
Index line on sleeve
Spindle lock
Heat insulator
0 - 25mm 0.01mm
Mitutoyo


jaws for measuring inner dimensions
screw clamp
stem for measuring depths
main scale
vernier scale
jaws (for measuring outer dimensions)


Source: Mitutoyo
Fine adjuster for main scale
Beam
Column
Main scale
Fine adjustment device
Slider
Clamp
Vernier scale
Locking device
Stylus clamp
Measuring and scribing stylus
Probe extension
Scribing stylus
Measuring face, stylus
Fixing device
Reference surface, beam
Reference surface, base
Base

Micrometer

- A **micrometer**, sometimes known as a **micrometer** screw gauge, is a device incorporating a calibrated screw widely used for accurate measurement of components in mechanical engineering and machining as well as most mechanical trades, along with other metrological instruments such as dial, Vernier, and digital calipers
- Micrometer is one of the most widely used precision instruments. It is primarily used to measure external dimensions like diameters of shafts, thickness of parts etc. to an accuracy of 0.01 mm

Vernier scale

- A Vernier scale is a visual aid to take an accurate measurement reading between two graduation markings on a linear scale by using mechanical interpolation; thereby increasing resolution and reducing measurement uncertainty by using Vernier acuity to reduce human estimation error.
- Vernier calipers are precision measuring instruments that give an accuracy of 0.1 mm to 0.01 mm. The main scale carries the fixed graduations, one of two measuring jaws, a vernier head having a vernier scale engraved on. The vernier head carries the other jaw and slides on main scale. The vernier head can be locked to the main scale by the knurled screw attached to its head. Enlarged diagram of the metric vernier scale is shown

Telescoping gauges

- **Telescoping gauges** are indirect measuring devices used to measure the internal diameter of a bore, hole, groove, slot, etc. This T-shaped tool consists of a handle, two **telescopic** rods and a locking screw. With the help of a micrometer, the **telescopic** rods measure the distance of the bore.

Vernier height gauges

- **Vernier height gauges** employ the use of a main scale and a **Vernier** scale to provide for greater resolution of the measured value. They are generally available in measuring size ranges from 6 inches to 6 feet. Models can have imperial (inch) or metric (mm) scales or both on them.
-

Welding

Welding is a process used for joining metal parts by either fusion or forging

- **Forge welding** is the process used by a blacksmith when heating the ends of wrought iron or steel parts in a forge fire until the ends are in a plastic state and then uniting them by the application of mechanical pressure. Even today this mechanical pressure is sometimes the result of blows from a heavy hammer.
- **Fusion welding** is the process used by welders in the aviation industry and other industries in which enough heat is applied to melt the edges or surfaces of the metal so that the molten (melted) parts flow together, leaving a single, solid piece of metal when cool

Electric-arc welding

- **Electric-arc welding**, also referred to as **stick-electrode welding** and technically referred to as **shielded metal arc welding** (SMAW), is used here to denote the standard arc process, which utilizes an electrode filler rod and is generally employed for welding heavy steel. This method requires a special generator to provide a low-voltage, high-amperage current for the arc. The power supply may be an electric motor-driven generator, an engine-driven generator, or a special transformer.

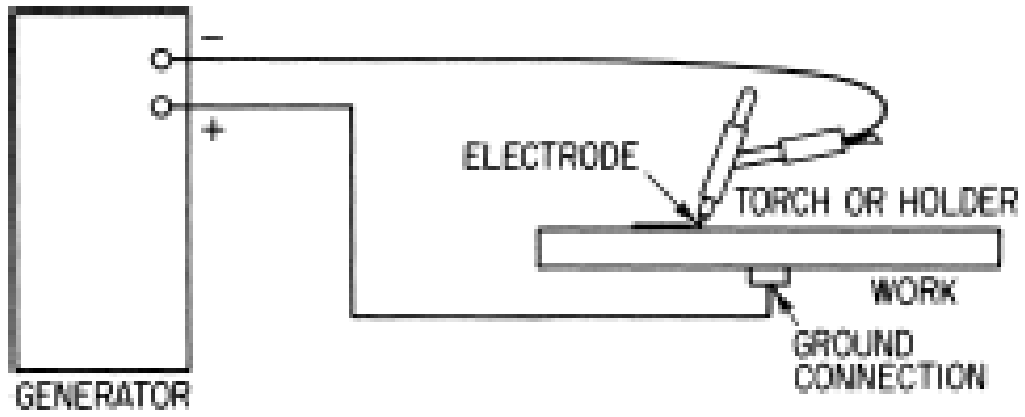


FIGURE 6-66 An arc welding circuit.