

CHAPTER 2

TOOLS AND HARDWARE

Each year, Modern jet engines suffer major damage due to even small birds being sucked into the engine. The result is thousands of dollars of damage to aircraft engines, while causing serious injuries to personnel. Using the wrong type of hardware or improper safetying of hardware may cause flight controls to jam or come loose. Engines experience foreign object damage (FOD) because of the improper control of tools and hardware. Tools are found in aircraft fuel cells and engine bays, even though a Tool Control Program guards against these mistakes. With so much at stake, we must continually emphasize basic tool and hardware use.

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to:

1. Identify the purpose and procedures of the tool control program.
2. Discuss the use and safety procedures for common hand tools.
3. Discuss the use and safety procedures for special tools (torque wrenches and micrometers).
4. Recognize the selection, identification, and proper use of different aircraft hardware.

TOOLS

You must have a well-rounded knowledge of many different types of tools. You must know the purpose for which the tools were designed. An important attribute that a mechanic must have is the ability to use the right tool for the job. The correct tool must be used whether that job is a minor adjustment or a major engine overhaul.

You have often heard that a mechanic is only as good as his tools. That is a half-truth. The mechanic must not only have the correct tools but must know the proper use of these tools. You cannot drive spikes with a tack hammer; yet, some may try. It is your responsibility to keep your tools in good condition and ready for use. A screwdriver that has been damaged by use as a chisel or pry bar has no place in a mechanic's toolbox. Damaged tools may cause damage to parts or injury to the worker.

The material in this chapter emphasizes information from other training manuals and should be studied with them. For a complete description of different tools and their uses, refer to *Tools and Their Uses*, Naval Education and Training (NAVEDTRA) 10085 (series).

Tool Control Program (TCP)

The Tool Control Program (TCP) was established to reduce FOD-related mishaps. The program is intended to ensure tool accountability both before and following the performance of aircraft-related maintenance tasks.

The Chief of Naval Operations (CNO) is the overall sponsor. Naval Air Systems Command (NAVAIRSYSCOM) is the responsible agent for development and issuance of a Tool Control Plan for each type of aircraft and engine. This TCP is a guide to aviation maintenance activities in the implementation of their own TCP. The following information is part of each TCP:

- An allowance list for tool containers
- A standard tool list and layout diagram for each container
- Procurement information necessary to procure tool containers and other associated hardware

Aircraft Controlling Custodians (ACCs) are required to implement each TCP after it has been formulated and released. Each ACC sets forth a specific policy by means of instructions. The Naval Air Engineering Center will process revisions to the tool allowance list, as well as error lists. Each local command, ship, and squadron should prepare a local command maintenance instruction (MI) to assign the responsibilities for the TCP. The Material Control Officer is responsible for ensuring that tools are procured and issued on a controlled basis. Some commands may establish a tool control center under the Material Control Officer. In activities operating aboard ships, where a tool control center is not practical, the Commanding Officer designates, in writing, a tool control coordinator.

The TCP contains the listing of each tool container. The TCP acts as an inventory for each type, model, and series of aircraft and equipment worked on. The container exterior will clearly identify the work center, tool container number, and organization. The tools in each container will have the work center code, organization code, and container number etched onto them. Special accountability procedures will be established locally for those tools not suitable for etching. Drill bits (too hard), jeweler's screwdrivers (too small), and beryllium hand tools (dust is hazardous to personnel) are not suitable for etching.

Tool pouches are to be considered as tool containers, and most are manufactured locally. The position for each tool in the container will be silhouetted against a contrasting background. The silhouetted tool outline will highlight each tool location within the container. Those containers not silhouetted will contain a diagram of the tool locations. Containers will include an inventory as well as a separate listing of tools in calibration or requiring replacement.

NOTE

Broken or damaged tools can damage equipment, hardware, and parts. They can also cause personal injury to the worker or others.

The Aviation Machinist's Mate (AD) who has custody of a toolbox must prevent the loss of the tools or the toolbox through neglect or misuse. Although hand tools are normally classified as consumable items, they are expensive and must be paid for when lost or damaged. Naval Aviation Maintenance Program (NAMP) Commander, Naval Air Forces Instruction (COMNAVAIRFORINST) 4790.2 (series) outlines the policies and procedures for control of hand tools.

Your activity will have a local MI concerning the inventory interval and methods for reporting lost or damaged tools.

All personnel have specific responsibilities under the TCP. All tool containers should have a lock and key as part of their inventory. When work is to be completed away from the work spaces, complete tool containers should be taken to the job. If you need more tools than the tool container contains, tool tags may be used to check out additional tools. These tools come from other tool containers in the work center or from another work center. The following list contains some of your responsibilities under the work center TCP:

1. Upon task assignment, note the number of the tool container on copy 1 of the Visual Information Display System (VIDS)/Maintenance Action Form (MAF). Place this note to the left of the Accumulated Work Hours section. Conduct a sight inventory before beginning each task. All shortages must be noted. Every measure must be taken to make sure missing tools do not become a cause of FOD:
2. Perform inventories before a shift change, when work stoppage occurs, and after maintenance has been completed. Perform an inventory before conducting an operational systems check on the equipment. After you account for all tools and complete all maintenance actions, the work center supervisor signs the VIDS/MAF.

3. If any tool is found to be missing during the required inventories, conduct an immediate search. The search should occur before reporting the work completed or signing off the VIDS/MAF. If the tool cannot be located, notify maintenance control to ensure that the aircraft or equipment is not released.

If the tool cannot be located, the person doing the investigation will sign a lost tool statement and the VIDS/MAF. The statement indicates that a lost tool investigation was conducted and that the tool was not found. After the investigation, follow the normal VIDS/MAF completion process.

COMMON HAND TOOLS

In this chapter the term *common hand tools* is used to refer to small, non-powered hand tools that are common to the AD rating. This term includes such common tools as hammers, socket sets, wrenches, screwdrivers, and pliers.

Hammers

Hammers are dangerous tools when used carelessly and without consideration. Practice will help the inexperienced to learn how to use a hammer properly. Hold the handle near the end with your fingers underneath and your thumb along the side or on top of the handle. Your thumb should rest on the handle and never overlap your fingers. Oils on the face of the hammer will cause it to glance off the work. Wipe the oil off with a rag and rub the face with coarse sandpaper or emery cloth. Never use a hammer that has a loose head or cracked handle. Most hammer accidents are caused by a loose head or a slippery handle. So remember these tips when using any kind of striking tool. Tighten the loose hammerhead by driving a wedge in the end of the handle. The wedge spreads the handle tightly inside the head. Do not strike a hardened steel surface with a steel hammer. Small pieces of steel may break and injure someone or damage the work. Use a soft hammer in striking hardened steel or highly polished stock. If a soft hammer is not available, use a piece of copper, brass, lead, or wood to protect the hardened steel. It is permissible to strike a punch or chisel directly with the ball peen hammer because the steel in the heads of punches and chisels is slightly softer than that of the hammerhead.

There are various types of hammers, all of which are used to apply a striking force where the force of the hand alone is insufficient. Each of these hammers has a head and a handle, even though these parts differ greatly from hammer to hammer. So that you may have a better idea of their differences and uses, let's consider the types of hammers used most frequently (*Figure 2-1*).

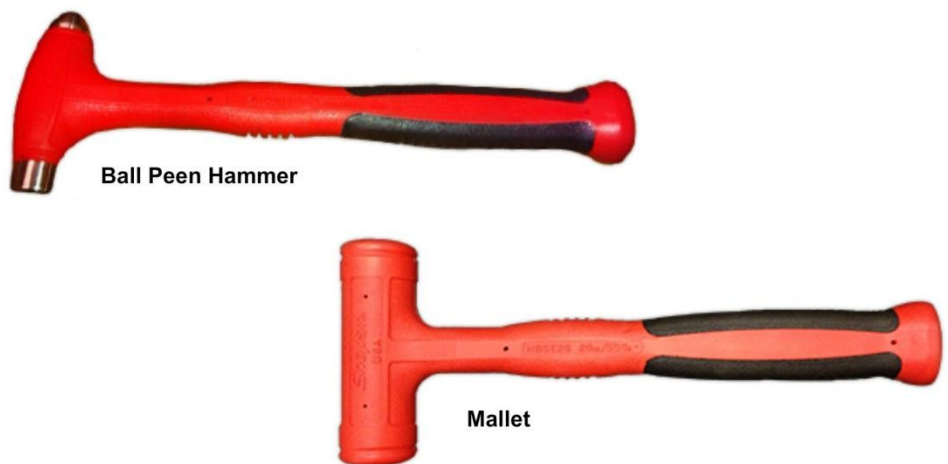


Figure 2-1 — hammers.

Ball Peen Hammer

The ball peen hammer is sometimes referred to as a machinist's hammer. It is a hard-faced hammer made of forged tool steel.

The flat end of the head is called the face. This end is used for most hammering jobs. The other end of the hammer is called the peen. The peen end is smaller in diameter than the face and is useful for striking areas that are too small for the face to enter.

Ball peen hammers are made in different weights, usually 4, 6, 8, and 12 ounces and 1, 1 1/2, and 2 pounds. For most work, a 1 1/2-pound or a 24-ounce hammer will do.

Mallet

A mallet is a soft-faced hammer. Mallets are made with brass, lead, tightly rolled strips of rawhide, and plastic heads. Sometimes the plastic head has a lead core for added weight.

Plastic mallets similar to the one shown in *Figure 2-1* are the type normally found in your toolbox. The weight of the plastic head may range from a few ounces to a few pounds. Use the plastic mallet for straightening thin sheet ducting or when installing clamps.

NOTE

Always be aware of tool control, a major part of FOD prevention designed to ensure each tool that goes onboard an aerospace vehicle comes back from the vehicle. Tools should be controlled in a safe, effective and relatively simple manner

Socket Sets

The socket set is one of the most versatile tools in the toolbox. Basically, it consists of a handle and a socket-type wrench that can be attached to the handle. A complete socket wrench set consists of several types of handles along with bar extensions, universals, adapters, and a variety of sockets (*Figure 2-2*).

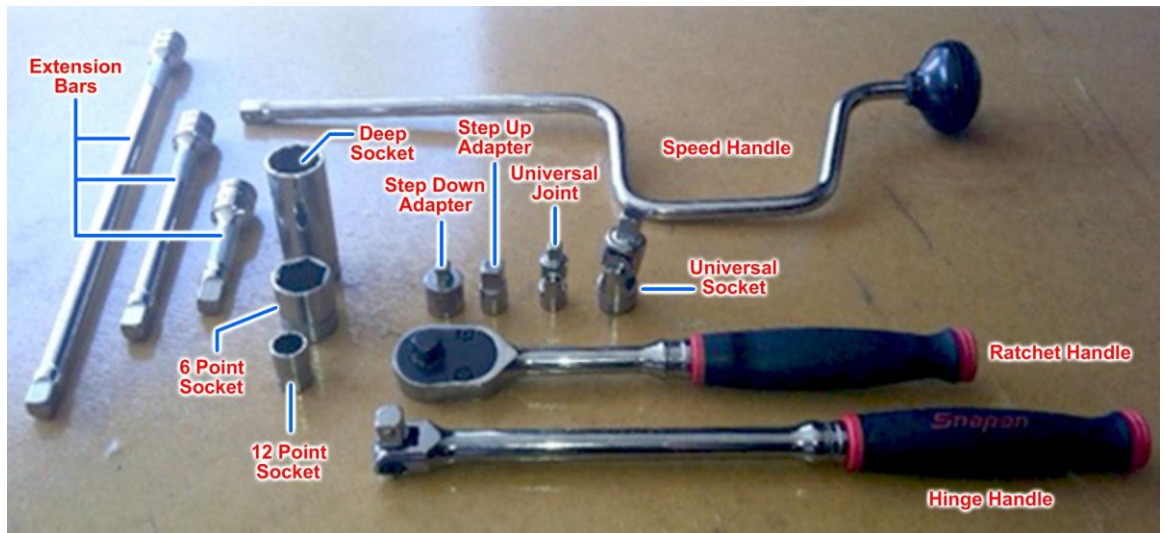


Figure 2-2 — typical socket wrench set.

Sockets

A socket has an opening cut in one end to fit a drive on a detachable handle. The handle drive is usually square. On the other end of the socket is a 6- or 12-point opening very much like the opening in the box-end wrench. The 12-point socket needs to be swung only half as far as the 6-point socket, and if using a hinge handle tool it may be lifted and fitted on the nut for a new grip. It can be used in closer quarters where there is less room to move the handle. Most sockets have 12 points. Use the 6-point socket with nuts made of stainless steel. Stainless steel is a harder metal than that of the wrench. Extensive use of a 12-point socket on such nuts or bolts can cause excessive wear on the 12 points. The socket might fail to hold. By contrast, because of the greater holding surface, a 6-point socket holds the stainless steel nut better. The 6-point socket offers less chance for wear of the wrench.

Sockets are classified for size according to two factors. One is the drive size or square opening, which fits on the square drive of the handle. The other is the size of the opening in the opposite end,

which fits the nut or bolt. The standard toolbox has sockets that have 1/4- and 3/8-inch-square drivers. The openings that fit the bolt or nut are graduated in 1/16-inch sizes. Sockets are also made in deep lengths to fit over spark plugs and long bolt ends.

There are four types of handles used with these sockets. Each type has special advantages, and a good mechanic chooses the one best suited to the job at hand. The square driving lug on the socket wrench handle has a spring-loaded ball that fits into a recess in the socket receptacle. The tool design holds the assembly together. This mated ball-recess feature prevents the parts of the wrench from falling apart during normal usage, but a slight pull disassembles any wrench connection (*Figure 2-2*).

Ratchet Handle

The ratchet handle has a reversing lever that operates a pawl (or dog) inside the head of the tool. Pulling the handle in one direction causes the pawl to engage in the ratchet teeth and to turn the socket. Moving in the opposite direction causes the pawl to slide over the teeth, permitting the handle to back up without moving the socket. This feature allows rapid turning of the nut or bolt after each partial turn of the handle. With the reversing lever in one position, the handle can be used for tightening. In the other position, it can be used for loosening.

Hinged Handle

The hinged handle is also very convenient. To loosen a tight nut, swing the handle at right angles to the socket. This gives the greatest possible leverage. After loosening the nut to the point where it turns easily, move the handle into the vertical position, and then turn the handle with your fingers.

Speed Handle

After the nuts are loosened with the sliding bar handle or the ratchet handle, the speed handle will help remove the nuts in a hurry. In many instances, the speed handle is not strong enough to be used for breaking loose or tightening. Use the speed socket wrench carefully to avoid damaging the nut threads.

Accessories

Several accessory items complete the socket wrench set. Extension bars of different lengths are made to extend the handles to any length needed. A universal joint allows the nut to be turned with the wrench handle at an angle. A universal socket is also available, and universal socket joints, bar extensions, and universal sockets in combination with appropriate handles make it possible to form a variety of tools that will reach otherwise inaccessible nuts and bolts.

Another accessory item that comes in handy is an adapter, which allows you to use a handle having one size drive with a socket having a different size drive. For example, a 3/8- by 1/4-inch adapter would make it possible to turn all 1/4-inch-square drive sockets with any 3/8-inch-square drive handle.

There are special sockets that are used to adapt various types of screwdriver bits to a speed handle (*Figure 2-3*). This socket-type screwdriver is used to remove recessed head screws from access panels on equipment.

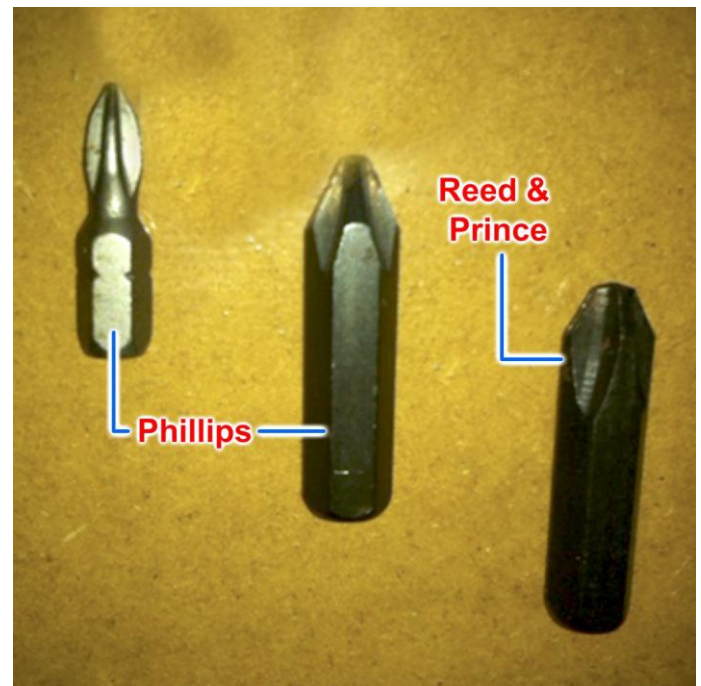


Figure 2-3 — screwdriver bits.

Combination Wrenches

Most toolboxes contain a set of combination wrenches. As shown in *Figure 2-4* and *Figure 2-5*, the combination wrench has an open-end wrench on one end and a box-end wrench (of the same size) on the other end. For speed and light stress operations, use the open end. Then switch to the box end for safety under stress. For ease of explanation, each end of the wrench is discussed separately. Adjustable wrenches are also briefly discussed.

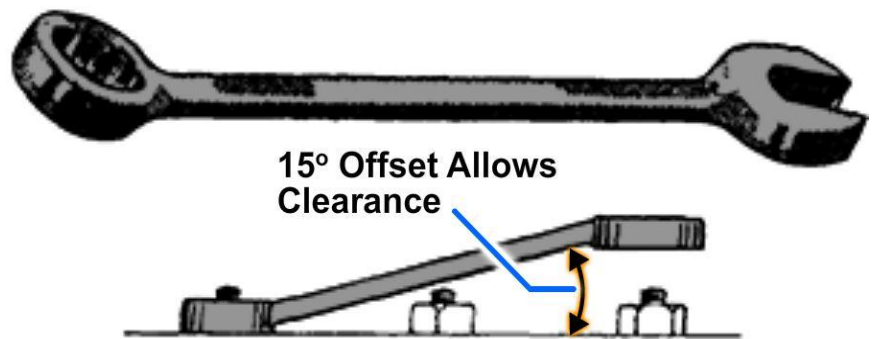


Figure 2-4 — box end combination wrench.

Box-End Wrench

The box end fits completely around the nut or bolt head. The box end is usually constructed with 12 points. The advantage of the 12-point construction is that the wrench will operate between obstructions where space for the swing angle is limited. A very short swing of the handle will turn the nut far enough to allow the wrench to be lifted and the next set of points to be fitted to the corners of the nut. It is possible to use this wrench in places where the swing angle is limited to as little as 30 degrees.

The box-end portion of the wrench is designed with an offset in the handle. Notice in *Figure 2-4* how the 15-degree offset will allow clearance over nearby parts. One of the best features of the box end is that there is little or no chance that the wrench will slip off the nut or bolt. However, there is the disadvantage of slow work with the box end of the combination wrench. Each time the wrench is backed off, it has to be lifted up and refitted to the head of the work. To save time, use the nonslip box end of the wrench to break loose tight bolts or to snug up work after the bolt has been seated with a faster type of wrench that might slip under stress.

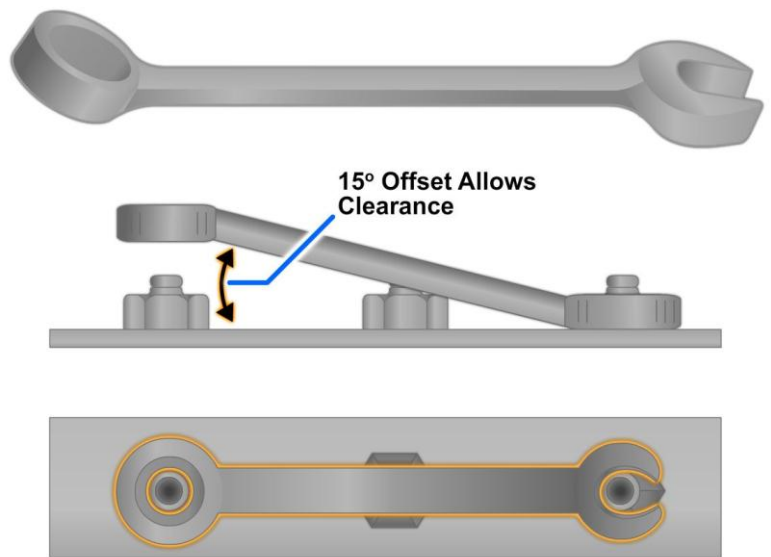


Figure 2-5 — open end combination wrench.

Open-End Wrench

The jaws of the open-end portion of the combination wrench are machined at 15 degrees from parallel in respect to the center line of the handle. This permits the use of the wrench where there is room to make only a part of a complete turn. If the wrench is turned over after the first swing, it will fit on the same flats and turn the nut farther. After two swings on the wrench, the nut is turned far enough so that a new set of flats is in position for the wrench.

Use the open end of the combination wrench on tubing nuts and in cramped places. Sometimes the cramped space is too small for a socket or box end to be slipped over the nut or bolt head. When using any type of open end wrench, always make sure the wrench fits the nut or bolt head, and pull on the wrench—never push. Pushing a wrench is dangerous. The threads could break loose

unexpectedly and cause damage to adjacent equipment or injury to the person using the wrench (*Figure 2-5*).

Adjustable Wrenches

Adjustable wrenches are not intended to replace open-end or box-end wrenches, but they are useful in working in restricted areas. In addition, they can be adjusted to fit odd size nuts. Adjustable wrenches are not intended for standard use but rather for emergency use. The wrenches were not built for use on extremely hard-to-turn items. As shown in *Figure 2-6*, adjustable wrenches have an adjustable jaw, which is adjusted by a thumbscrew. By turning the thumbscrew, the jaw opening may be adjusted to fit various sizes of nuts. The size of the wrenches ranges from 4 to 18 inches in length. The maximum jaw openings vary in direct proportion to the length of the handle.

Adjustable wrenches are often called “knuckle busters” because mechanics frequently suffer the consequences of improper usage of these tools.

There are four simple steps to follow in using these wrenches. First, choose one of the correct sizes. Do not pick a large 12-inch wrench and adjust the jaw for use on a 3/8-inch nut. This could result in a broken bolt and a bloody hand. Second, be sure the jaws of the correct size wrench are adjusted to fit snugly on the nut. Third, position the wrench around the nut until the nut is all the way into the throat of the jaws. If not used in this manner, the result is apt to be as bloody as before. Fourth, pull the handle toward the side having the adjustable jaw. This will prevent the adjustable jaw from springing open and slipping off the nut. If the location of the work will not allow all four steps to be followed, select another type of wrench for the job.

Adjustable wrenches should be cleaned in a solvent, with light oil applied to the thumbscrew and the sides of the adjustable jaw. They should also be inspected often for cracks, which might result in failure of the wrench.

Screwdrivers

Two basic types of screwdriver blades are used: the common blade for use on conventional slotted screws, and a cross-point blade for use on the recessed head Phillips or Reed and Prince types of screws. See *Figure 2-7*. The common and cross-point blade types are used in the design of various special screwdrivers, some of which are also shown in *Figure 2-7*.



Figure 2-6 — Adjustable wrenches.



Figure 2-7 —Typical screwdrivers.



CAUTION



When using any type of screwdriver, do not hold the work in your hand. If the point slips, it can cause a bad cut. When removing a screw from an assembly that is not stationary, hold the work on a solid surface, in a vise, or with some other holding tool. Never get any part of your body in front of the screwdriver point. This precaution is a good safety rule for any sharp-pointed tool.

Common Screwdrivers

The combination length of the shank and blade identifies the size of common screwdrivers. They vary from 2 1/2 to 12 inches. The diameter of the shank and the width and thickness of the blade tip, which fits the screw slot, are in proportion to the length of the shank. The blade is hardened to prevent it from being damaged when it is used on screws. It can easily be chipped or blunted when used for other purposes. The blade of a poor-quality screwdriver will sometimes become damaged even when being used properly. Do not use damaged screwdrivers.

Cross-Point Screwdrivers

There are two types of cross-point screwdrivers in common use: the Reed and Prince and the Phillips. The Reed and Prince Screwdrivers and Phillips screwdrivers are not interchangeable. Always use a Reed and Prince Screwdriver with Reed and Prince Screws, and a Phillips screwdriver with Phillips screws. The Reed and Prince screwdrivers come to a point at the tip and the Phillips screwdrivers have a blunt end. The use of the wrong screwdriver will result in excessive wear of the screw head.

Offset Screwdrivers

An offset screwdriver may be used where vertical space is not sufficient for a standard screwdriver. See *Figure 2-7*. Offset screwdrivers are constructed with one blade forged in line with and another blade forged at right angles to the shank handle. Both blades are bent 90 degrees to the shank handle. By alternating ends, you can seat or loosen most screws, even when the swinging space is very restricted. Offset screwdrivers are made for both standard and recessed head screws.

Pliers

Many different types of pliers are in use today. Some of these are the vise grip, the channel-lock, the duckbill, the needle-nose, the diagonal, and the safety wire pliers.

Vise Grip Pliers

Vise grip pliers can be used a number of ways. See *Figure 2-8*. These pliers can be adjusted to various jaw openings by turning the knurled adjusting screw at the end of the handle. Vise grips can be clamped and locked in position by pulling the lever toward the handle. They may be used as a clamp and portable vise, and for many other uses where a locking, plier-type jaw may be employed.



Figure 2-8 — Vise grip pliers.



Vise grip pliers should be used with care since the teeth in the jaws tend to damage the object on which they are clamped. They should not be used on nuts, bolts, tube fittings, or other objects that must be reused.

Channel-Lock Pliers

Channel-lock pliers can be easily identified by the extra-long handles. See *Figure 2-9*. These pliers are very powerful gripping tools. The inner surfaces of the jaws consist of a series of coarse teeth formed by deep grooves. This construction makes a surface usable for grasping cylindrical objects. Channel-lock pliers have grooves on one jaw and lands on the other. The adjustment is effected by changing the position of the grooves and lands. Channel-lock pliers are less likely to slip from the adjustment setting when gripping an object. Use the channel-lock pliers where it is impossible to use a more adapted wrench or holding device. Many nuts, bolts, and surrounding parts have been damaged by improper use of channel-lock pliers.



Figure 2-9 —
Channel-lock pliers.

Duckbill Pliers

Duckbill pliers have long, wide jaws and slender handles. Duckbills are used in confined areas where the fingers cannot be used. The jaw faces of the pliers are scored to aid in holding an item securely. See *Figure 2-9*, view A.



Duckbill and needle-nose pliers are especially delicate. To prevent springing, breaking, or chipping the jaws, care should be exercised when using these pliers.

Needle-Nose Pliers

Although Needle-nose pliers are used in the same manner as duckbill pliers. See *Figure 2-10*, view B. There is a difference in the design of the jaws. Needle-nose jaws are tapered to a point, which makes them adapted to installing and removing small cotter pins. The pliers have serrations at the nose end and a side cutter near the throat. Use needle-nose pliers to hold small items steady, to cut and bend wire, or to do numerous other jobs that are too intricate or too difficult to be done by hand alone.



Figure 2-10 — Pliers (1) duckbill; (2) needle-nose.

Diagonal Pliers

Diagonal cutting pliers are an important tool for you to use. They are used for cutting small wire, cotter pins, and so forth. Since they are small, they should not be used to cut large wire or heavy

material. The pliers will be damaged by such use and will not be effective to cut what they were designed to cut. They can also be used to remove small cotter pins where a new pin is to be used when the work is finished. This is done by gripping the pin near the hinge of the pliers and lifting up on the handles, releasing the pin, getting a new grip, and repeating until the pin is removed.

The inner jaw surface is a diagonal straight cutting edge offset approximately 15 degrees. This design permits cutting objects flush with the surface. The diagonal cutting pliers are not designed to hold objects. To use enough force to hold an object, the pliers will cut or deform the object. The sizes of the diagonal pliers are indicated by the overall length of the pliers as shown in *Figure 2-11*.



Figure 2-11 — Diagonal cutters.

Safety-Wire Pliers

When installing equipment, you may need to lockwire (usually referred to as safety wire) designated parts of the installation. The process of lockwiring can be accomplished faster and more neatly with the use of special pliers (*Figure 2-12*).



Figure 2-12 — Safety-wire pliers.

Safety-wire pliers are three-way pliers—they hold, twist, and cut. They are designed to make a uniform twist and to reduce the time required in twisting the safety wire.

To operate, grasp the wire between the two diagonal jaws of the pliers. As the handles are squeezed together, the thumb and forefinger bring the outer (locking) sleeve into the locked position. A pull on the knob of the pliers can make a uniform twist. The spiral rod may be pushed back into the pliers without unlocking them, and by again pulling on the knob, you can make a tighter twist. The wire should be installed snugly but not so tightly that the wire is overstressed. A squeeze on the handles unlocks the pliers, and the wire can then be cut to the proper length with the cutting jaws.

SPECIAL TOOLS

Special tools are normally maintained in a central tool room and signed out when needed. A tool falls into the *special* category for one of the following five main reasons.

- It is an item of special support equipment. These tools are designed, manufactured, and issued for supporting or maintaining one particular model of aircraft, engine, or support equipment.
- It is a seldom used tool. When needed, its use is essential in aircraft maintenance. Most of the time it is not required and would just take up room in the toolbox.
- It is a high-cost item. A central location is necessary to permit better use or for security.
- The large size or awkward shape of the tool makes it difficult, if not impossible, to put in a toolbox.
- It is an instrument type of tool that requires calibration.

A wide variety of special tools is furnished by the manufacturers of the support equipment, engines, and related equipment. These special tools are listed in the Allowance List Registers published by the

Aviation Supply Office. Their use is explained in the manual that covers the specific support equipment, engine, or item of equipment for which they were designed. Special tools that you use frequently may be kept in your toolbox if permitted by your TCP. Torque wrenches and micrometers are special tools.

Torque Wrenches

There are times when, for engineering reasons, a definite pressure must be applied to a nut, bolt, screw, or other fastener. In such cases a torque wrench must be used. The torque wrench is a precision tool consisting of a torque-indicating handle and appropriate adapter or attachments. Use the wrench to measure the amount of turning or twisting force applied to a nut, bolt, or screw.

The three most common torque wrenches are the deflecting beam, dial indicating, and micrometer setting types (*Figure 2-13*). When using the deflecting beam and the dial-indicating torque wrenches, the torque is read visually on a dial or scale mounted on the handle of the wrench. These torque wrenches are all used in a very similar manner.

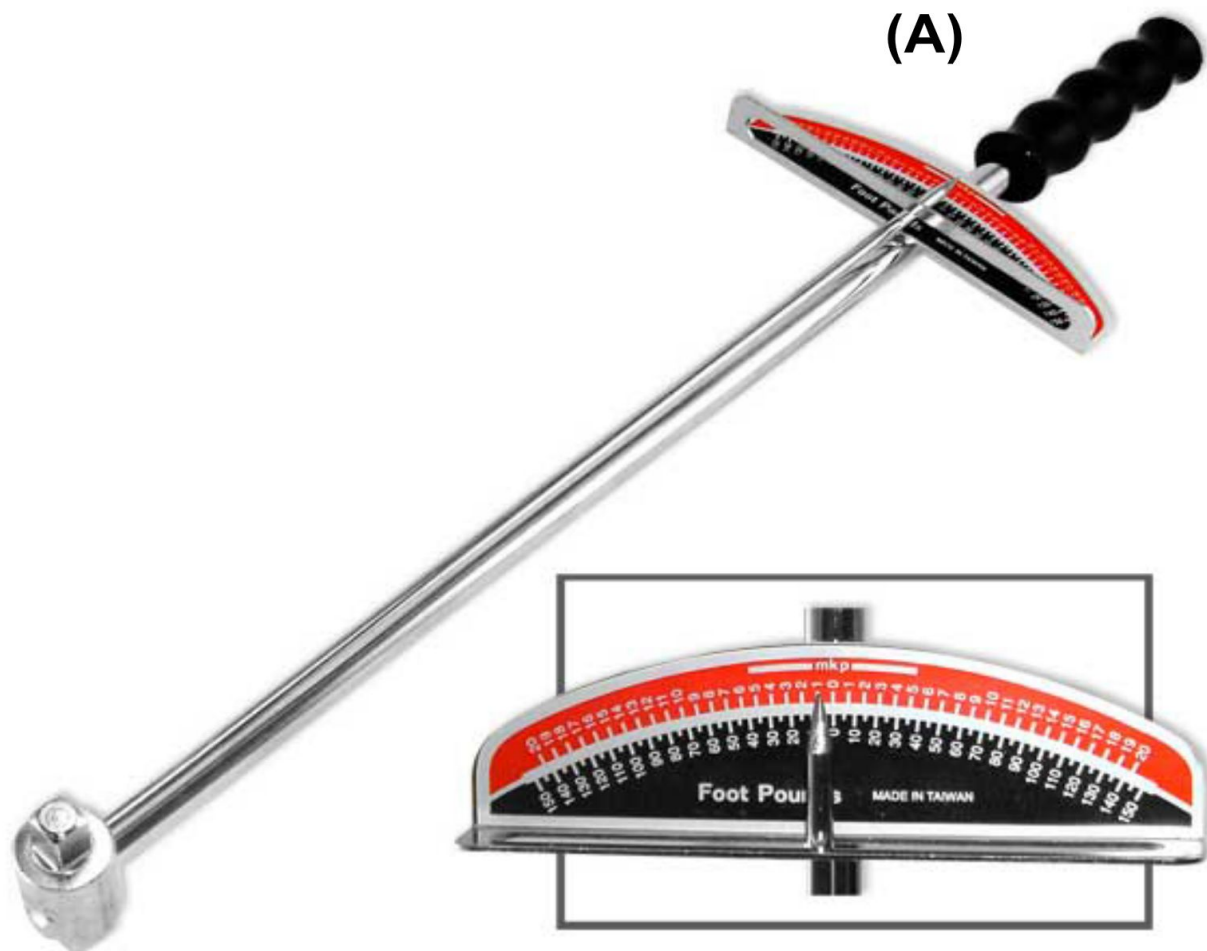


Figure 2-13 — Torque wrenches, (A) deflecting torque wrench, (B) dial torque wrench, (C) micrometer torque wrench.

To use the micrometer setting type, unlock the grip and adjust the handle to the desired setting on the micrometer scale. Relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth,

steady motion. A fast or jerky motion will result in an improperly torqued unit. When the torque applied reaches the torque value indicated on the handle setting, the handle will automatically release or “break” and move freely for a short distance. The release and free travel are easily felt, so there is no doubt about when the torqueing process is complete.

The following precautions should be observed when using torque wrenches:

- Do not use the torque wrench as a hammer.
- When using the micrometer setting type, do not move the setting handle below the lowest torque setting. Place the micrometer at its lowest setting before returning it to storage.
- Do not use the torque wrench to apply greater amounts of torque than its rated capacity.
- Do not use the torque wrench to break loose bolts that have been previously tightened.
- Never store a torque wrench in a toolbox or in an area where it may be damaged.

Torqueing can be described as the twisting stress that is applied to the fasteners to secure components together. These fasteners can be nuts, bolts, studs, clamps, and so forth. Torque values for these fasteners are expressed in inch-pounds or foot-pounds. Unless otherwise stated, all torque values should be obtained with the manufacturer’s recommended thread lubricant applied to the threads.

Torque values are listed in the appropriate section of the applicable instruction manual. In case there is no torque specified, standard torque values can be found in the *Structural Hardware Manual*, NA 01-1A-8, or in your particular aircraft general information maintenance instruction manual (MIM).

Regardless of whether torque values are specified or not, all nuts in a particular installation must be tightened the same amount. This permits each bolt in a group to carry its share of the load. It is a good practice to use a torque wrench in all applications. Using the proper torque allows the structure to develop its design strength and greatly reduces the possibility of failure due to fatigue. One word of caution—never rely on memory for torque information. Instead look up the correct torque value each time it is needed. A nut or bolt that is not torqued to the proper value may cause damage to the component or equipment.

The proper procedure is to tighten at a uniformly increasing rate until the desired torque is obtained. In some cases, where gaskets or other parts cause a slow permanent set, the torque must be held at the desired value until the material is sealed. When applying torque to a series of bolts on a flange or in an area, select a median value. If some bolts in a series are torqued to a minimum value and others to a maximum, force is concentrated on the tighter bolts and is not distributed evenly. Such unequal distribution of force may cause shearing or snapping of the bolts.

Torque wrench size must be considered when torqueing.

The torque wrenches are listed according to size and should be used within this recommended range. Use of larger wrenches with a tolerance that is too great results in inaccuracies. When an offset extension wrench is used with a torque wrench, the effective length of the torque wrench is changed. The torque wrench is calibrated so that when the extension is used, the indicated torque (the torque that appears on the dial or gauge of the torque wrench) may be different from the actual torque that is applied to the nut or bolt. The wrench must be preset to compensate for the increase when an offset extension wrench is used.

Occasionally, it is necessary to use a special extension or adapter wrench together with a standard torque wrench. To arrive at the resultant required torque limits, use the following formula:

$$S = \frac{T \times L}{(E + L)}$$

Where:

S =	reading of setting of torque wrench
T =	recommended torque on part
L =	length of torque wrench (distance between center of drive and center of hand grip)
E =	length of extension of adapter (distance between center of drive and center of broached opening measured in the same place as L)

Example

Recommended torque is 100 inch-pounds. Using a 12-inch torque wrench and a 6-inch adapter, determine reading on torque wrench.

$$S = \frac{100 \times 12}{(6 + 12)} = \frac{1200}{18} = 66.6$$

An example of the measurement of this formula is shown in *Figure 2-14*. When the extension is pointed back toward the handle of the torque wrench, subtract the effective length of the extension from the effective length of the torque wrench. If the extension is pointed at a right angle to the torque wrench, then the actual value does not change.

An engineering study revealed a widespread lack of understanding as to what happens when an adapter is used with a torque wrench.

Using solid-handle torque wrenches with extension handles can cause significant over- or under-torquing. This problem exists based on the handle length chosen for the computation and where hand force is actually applied on the handle. When the formula is applied force must be applied to the handle of the torque wrench at the point from which the measurements were taken. If this is not done, the torque obtained will be in error.

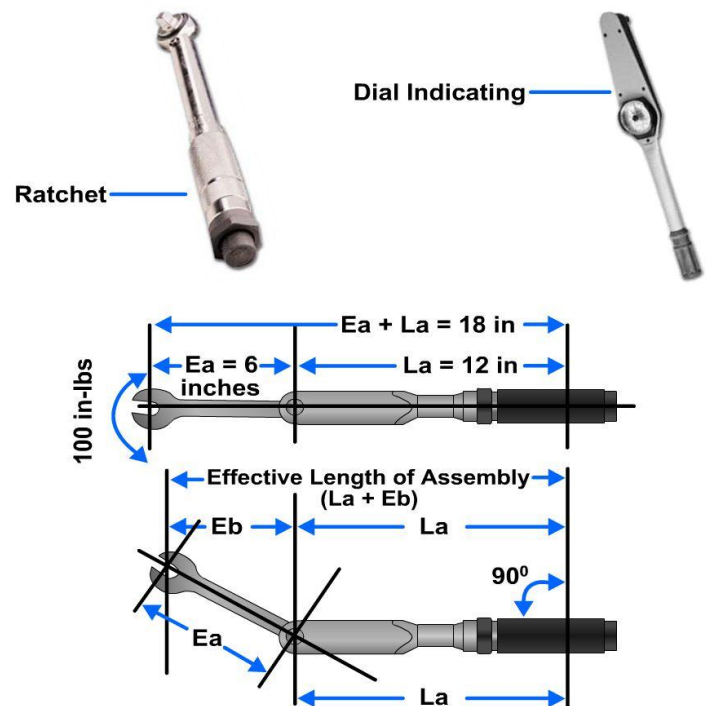


Figure 2-14 — Torque wrench with extensions.

Micrometers

It is important that a person repairing and building up engines thoroughly understand the use and care of the micrometer. Micrometers are used to set clearances and to measure damage or repair limits. *Figure 2-15* shows an outside micrometer caliper with the various parts clearly indicated. Micrometers are used to measure distances to the nearest one thousandth of an inch; the measurement is usually expressed or written as a decimal. You must know the method of writing and reading decimals.

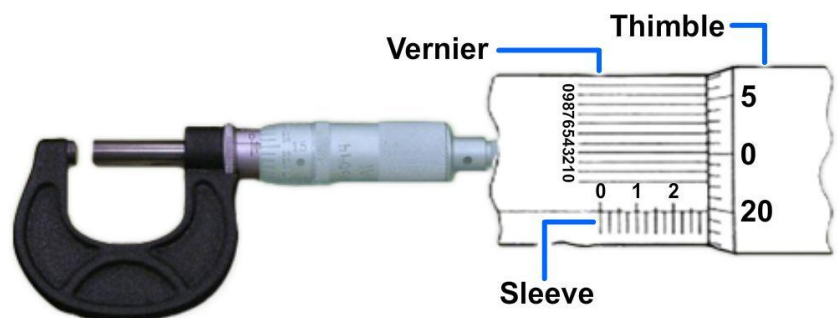


Figure 2-15 — Nomenclature of an outside micrometer caliper.

Types of Micrometers

There are three types of micrometers that are most commonly used throughout the Navy. They are

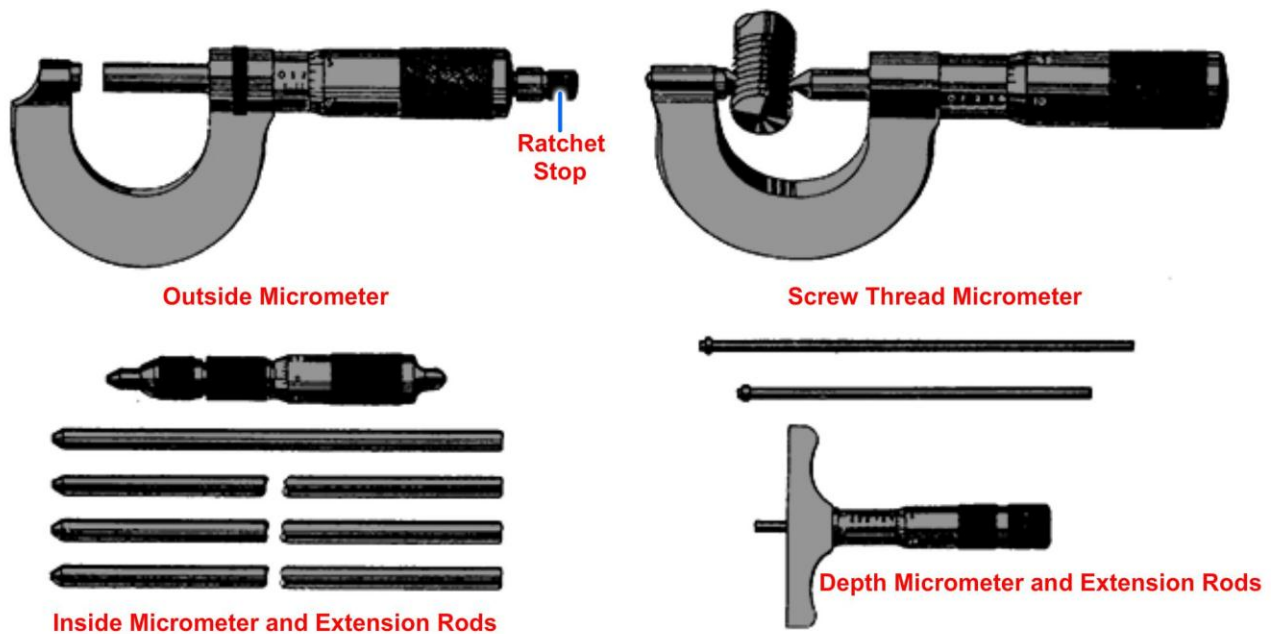


Figure 2-16 — Common types of micrometers.

the outside micrometer caliper (including the screw thread micrometer), the inside micrometer, and the depth micrometer (*Figure 2-16*). The outside micrometer is used for measuring outside dimensions, such as the diameter of a piece of round stock. Use the screw thread micrometer to determine the pitch diameter of screws. The inside micrometer is used for measuring inside dimensions. Use inside micrometers to determine the inside diameter of a tube or hole, the bore of a cylinder, or the width of a recess. Use the depth micrometer for measuring the depth of holes or recesses.

Care of Micrometers

Keep micrometers clean and lightly oiled. Make sure they are placed in a case or box when they are not in use. Anvil faces must be protected from damage and must not be cleaned with emery cloth or other abrasives.

HARDWARE

The importance of aircraft hardware is often overlooked because of the small size of most items. The safe and efficient operation of any aircraft depends upon the correct selection and use of aircraft hardware. You must make sure that items of aircraft hardware remain tightly secured in the aircraft.

Inflight mishaps continue to happen at an alarming rate. Many of these mishaps are due to improper hardware selection and installation. For example, mishaps involving aircraft fires can often be attributed to the chafing of fluid lines and wire bundles caused by improperly clamped parts.

Threaded Fasteners

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

Bolts and screws are similar in that both have a head at one end and a screw thread at the other. However, there are several differences between them. The threaded end of a bolt is always relatively blunt. A screw may be either blunt or pointed. The threaded end of a bolt must be screwed into a nut. The threaded end of the screw may fit into a nut or directly into the material being secured. A bolt has a fairly short threaded section and a comparatively long grip length (the unthreaded part). A screw may have a longer threaded section and no clearly defined grip length. A bolt assembly is generally tightened by turning a nut. The bolt head may or may not be designed to be turned. A screw is always designed to be turned by its head. Another minor difference between a screw and a bolt is that a screw is usually made of lower strength materials.

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.

Bolts

Many types of bolts are used in modern aircraft, and each type is used to fasten something in place. Before we discuss some of these types, it might be helpful to list and explain some commonly used bolt terms. You should know the names of bolt parts and be aware of the bolt dimensions that must be considered in selecting a bolt.

The three principal parts of a bolt are the *head*, *grip*, and *threads*, as shown in *Figure 2-17*. 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 bolt and may be one of many shapes or designs.

To choose the correct replacement for an unserviceable bolt, you must consider the length of the bolt. As shown in *Figure 2-16*, the bolt length is the distance from the tip of the threaded end to the head of the bolt. Correct length selection is indicated when the bolt extends through the nut at least two full threads. If the bolt is too short, it will not extend out of the bolt hole far enough for the nut to be securely fastened. If it is too long, it may extend so far that it interferes with the movement of nearby parts.

In addition, if a bolt is too long or too short, its grip will usually be the wrong length. As shown in *Figure 2-18*, the grip length should be approximately the same as the thickness of the material to be fastened. If the grip is too short, the threads of the bolt will extend into the bolt hole. The bolt may act like a reamer

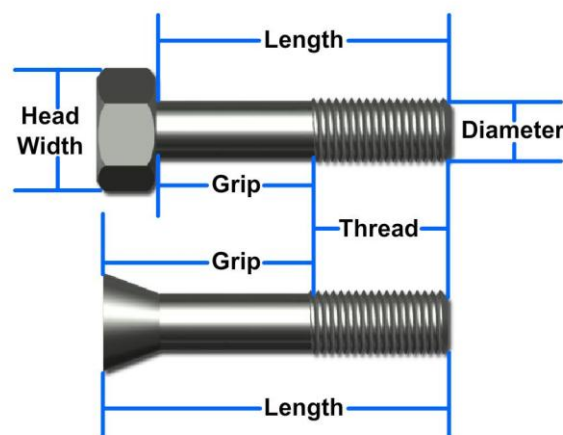


Figure 2-17 — Bolt terms and dimensions.

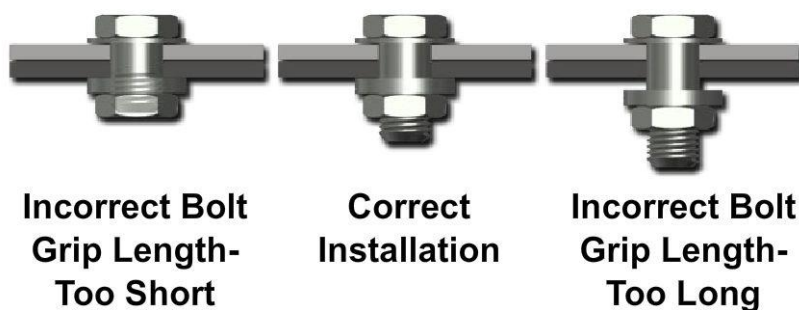


Figure 2-18 — Correct and incorrect grip lengths.

when the material is vibrating. If the grip is too long, the nut will run out of threads before it can be tightened. In this event, a bolt with a shorter grip should be used. If the bolt grip extends only a short distance through the hole, a washer may be used.

A second bolt dimension that must be considered is diameter. As shown in *Figure 2-17*, the diameter of the bolt is the thickness of its shaft.

The results of using a wrong diameter bolt should be obvious. If the bolt is too big, it cannot enter the bolt hole. If the diameter is too small, the bolt has too much play in the bolt hole.

The third and fourth bolt dimensions that should be considered when you choose a bolt replacement are head thickness and width. If the head is too thin or too narrow, it might not be strong enough to bear the load imposed on it. If the head is too thick or too wide, it might extend so far that it interferes with the movement of adjacent parts.

Air Force/Navy (AN) bolts come in three head styles—hex head, clevis, and eyebolt. National Aeronautic Standards (NAS) bolts are available in countersunk, internal wrenching, and hex head styles. Military Standards (MS) bolts come in internal wrenching and hex head styles. Head markings indicate the material of which standard bolts are made. Head markings may indicate if the bolt is classified as a close-tolerance bolt. See *Figure 2-19*. Additional information, such as bolt diameter, bolt length, and grip length, may be obtained from the bolt part number. Refer to the *Structural Hardware Manual*, NAVAIR 01-1A-8, for complete identification of threaded fasteners.

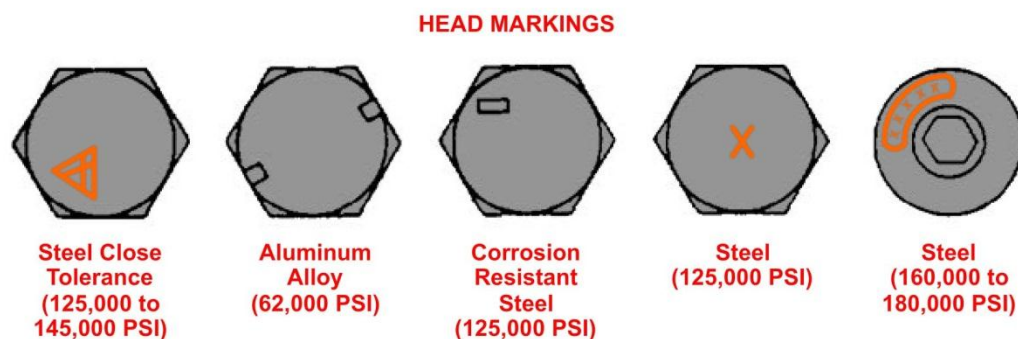


Figure 2-19 — Bolt head markings.

Nuts

Aircraft nuts may be divided into two general groups: non-self-locking and self-locking nuts. Non-self-locking nuts are those that must be safetied by external locking devices, such as cotter pins, safety wire, or locknuts. The locking feature is an integral part of a self-locking nut.

Non-Self-Locking Nuts

The most common of the non-self-locking nuts are the castle nut, the plain hex nut, the castellated shear nut, and the wing nut. *Figure 2-20* shows these non-self-locking nuts.

Castle nuts are used with drilled-shank AN hex head bolts, clevis bolts, or studs. They are designed to accept a cotter pin or lock wire for safetying.

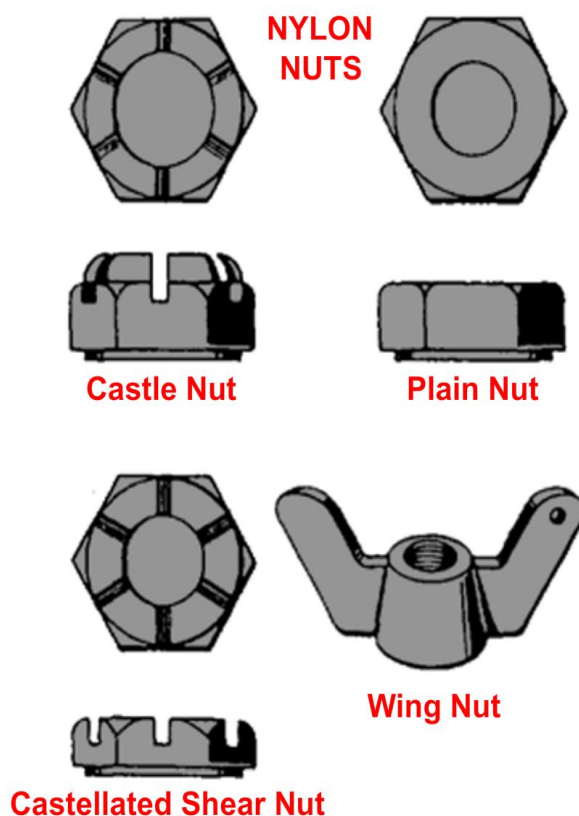


Figure 2-20 — Non-self-locking nuts.

Shear nuts are used on such parts as drilled clevis bolts and threaded taper pins. They are normally subjected to shearing stress only. They must not be used in installations where tension stresses are encountered.

Plain hex nuts have limited use on aircraft structures. They require an auxiliary locking device, such as a check nut or a lock washer.

Use wing nuts where the desired tightness can be obtained by the fingers and where the assembly is frequently removed. Wing nuts are commonly used on battery connections.

Self-Locking Nuts

Self-locking nuts provide tight connections that will not loosen under vibrations. Self-locking nuts approved for use on aircraft must meet critical specifications. These specifications pertain to strength, corrosion resistance, and heat-resistant temperatures. Use new self-locking nuts each time components are installed in critical areas throughout the entire aircraft. Self-locking nuts are found on all flight, engine, and fuel control linkage and attachments. There are two general types of self-locking nuts. They are the all-metal nuts and the metal nuts with a nonmetallic insert to provide the locking action.

NOTE

If any doubt exists about the condition of a nut, use a new one!

The elastic stop nut is constructed with a nonmetallic (nylon) insert, which is designed to lock the nut in place. The insert is unthreaded and has a smaller diameter than the inside diameter of the nut. Its use is limited to engine cold sections, since high heat could melt the nonmetallic insert.

Self-locking nuts are generally suitable for reuse in noncritical applications provided the threads have not been damaged. If the locking material has not been damaged or permanently distorted, it can be reused.

Installation of Nuts and Bolts

It is of extreme importance to use like bolts in replacement. In every case, refer to the applicable maintenance instruction manual and illustrated parts breakdown. Be certain that each bolt is of the correct material, size, and grip length. Examine the markings on the head to determine whether a bolt is steel or aluminum alloy. This knowledge is especially important if you are to use the bolt in the engine hot section.

Use washers under the heads of both bolts and nuts unless their omission is specified. A washer guards against mechanical damage to the material being bolted. A washer also prevents corrosion of the structural members. An aluminum alloy washer used under the head and nut of a steel bolt securing aluminum alloy or magnesium alloy members will corrode the washer rather than the members. Steel washers should be used when steel members are joined with steel bolts.

Whenever possible, the bolt should be placed with the head on top or in the forward position. This positioning helps prevent the bolt from slipping out if the nut is accidentally lost.

Washers

Washers used in aircraft structures may be grouped into three general classes: plain washers, lock washers, and special washers. *Figure 2-21* shows some of the most commonly used types.

Plain Washers

Plain washers are widely used under AN hex nuts to provide a smooth mating surface. They act as a shim in obtaining the correct relationship between the threads of a bolt and the nut. They also aid in adjusting the position of castellated nuts with respect to drilled cotter pin holes in bolts. Plain washers are also used under lock washers to prevent damage to surfaces of soft material.

Lock Washers

Lock washers are used whenever the self-locking or castellated-type nut is not used. Sufficient friction is provided by the spring action of the washer to prevent loosening of the nut because of vibration. Lock washers must not be used as part of a fastener for primary or secondary structures.

The star lock or shake proof washer is a round washer made of hardened and tempered carbon steel, stainless steel, or Monel. This washer can have either internal or external teeth. Each tooth is twisted, one edge up and one edge down. The top edge bites into the nut or bolt, and the bottom edge bites into the working surface. It depends on spring action for its locking feature. This washer can be used only once because the teeth become compressed after being used.

Tab lock washers are round washers designed with tabs or lips that are bent across the sides of a hex nut or bolt to lock the nut in place. There are various methods of securing the tab lock washer to prevent it from turning. An external tab bent downward 90 degrees into a small hole in the face of the unit, an external tab that fits a keyed bolt, or two or more tab lock washers connected by a bar are some of the present methods used. Tab lock washers can withstand higher heat than other methods of safetying. The washer can be used safely under high vibration conditions. Use tab lock washers only once because the tab tends to crystallize when bent a second time.

Special Washers

Special washers, such as ball-seat and socket washers and taper pin washers, are designed for special applications. For example, the ball-seat and socket washer is used where the bolt may be installed at an angle to the surface. The washer is also used where perfect alignment with the surface is required, such as engine mount bolts.

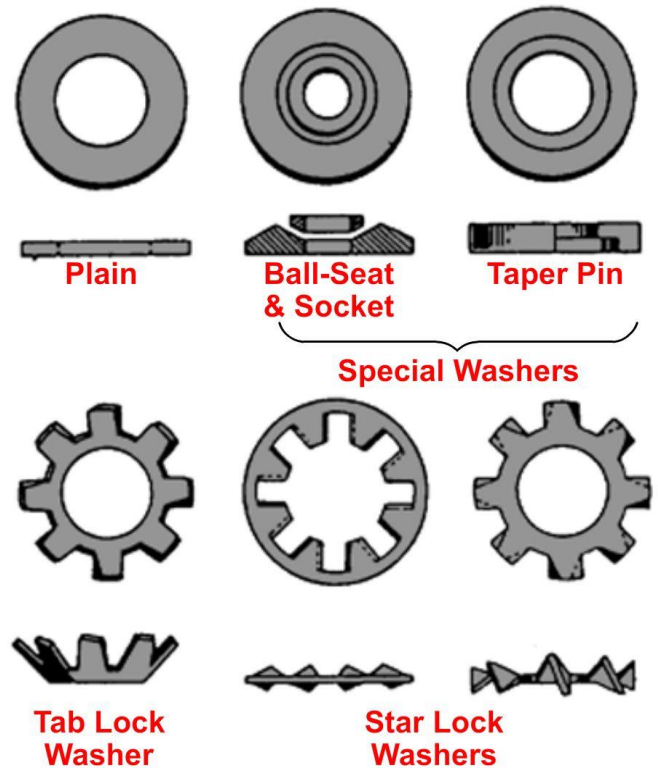


Figure 2-21 — Various types of washers.

Clamps

Clamps used on aircraft engines prevent lines from chafing on parts or against other lines. They can also connect two lines or pieces of material. *Figure 2-22* shows examples of the Adell clamp to maintain line clearance and prevent chafing. The Adell clamp shown in *Figure 2-22* comes in two different types. One is made of a rubber or Teflon[®] cushion for low-range temperatures. The second type has an asbestos cushion for high temperatures.

When installing clamps, be sure to use the proper size and material. Although clamps may be reused, make sure reused clamps are in good condition. Inspect support clamps for deterioration of the cushion material to prevent the metal part of the clamps from cutting or chafing the supported line. Carefully inspect clamps for proper installation. *Figures 2-23 and 2-24* show two examples of correct and incorrect installations, *Figure 2-25* shows how improperly installed or wrong size clamps hide the damage they cause.

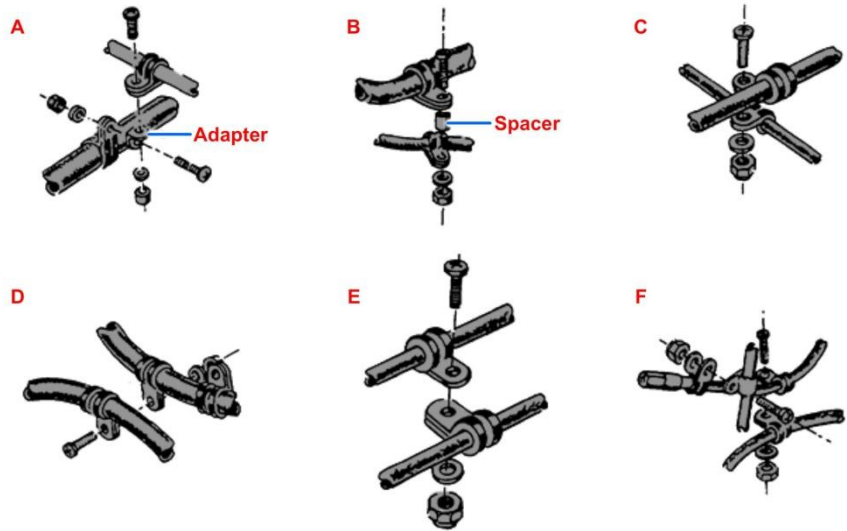


Figure 2-22 — Securing lines using support clamps.

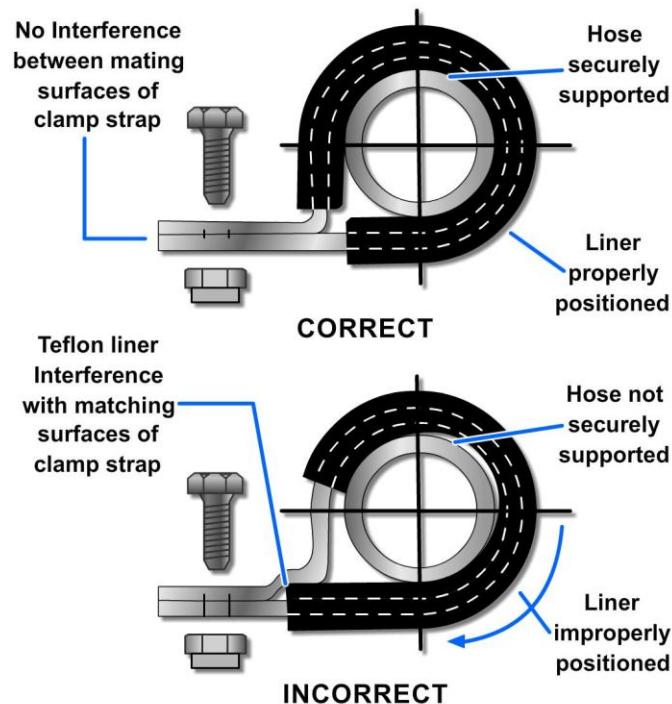
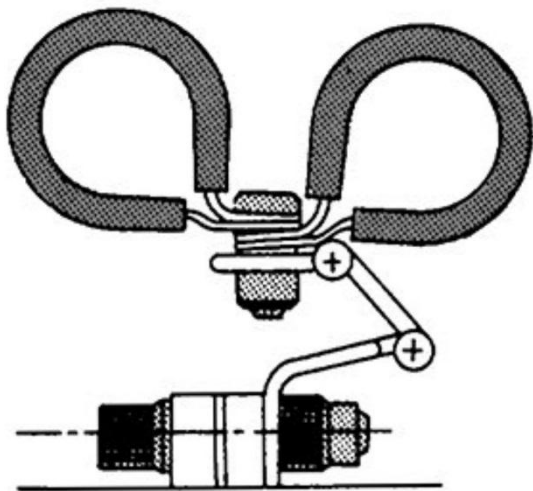
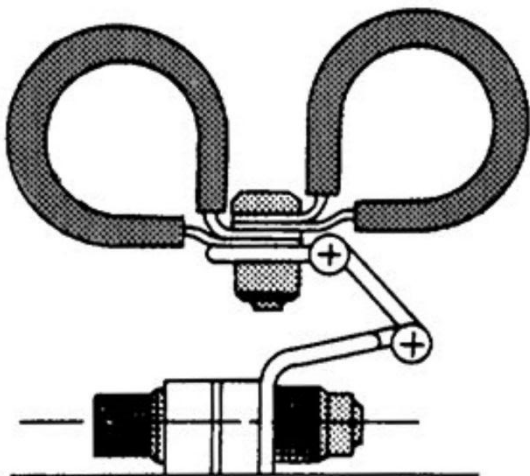


Figure 2-23 — Examples of (A) incorrect and (B) correct installation of hinged clamp.

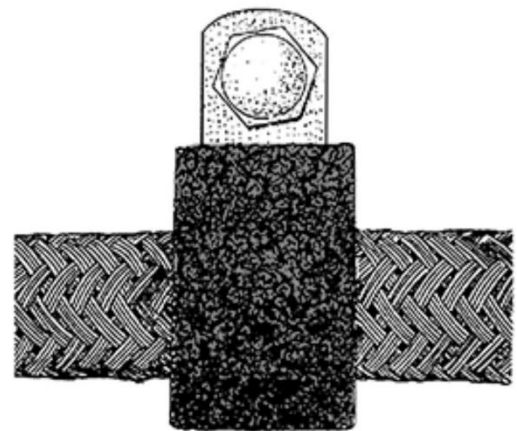


(A) Incorrect

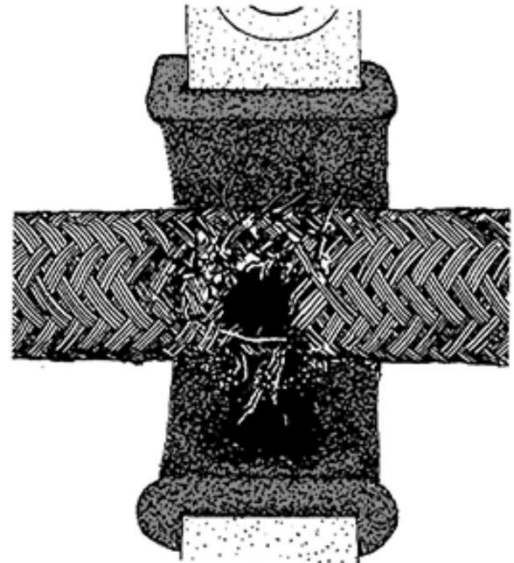


(B) Correct

Figure 2-24 — Examples of (A) incorrect and (B) correct installation of Adell clamp.



This clamp installation looks good, doesn't it?



But it's not. This a good exmple of Line-to-Clamp Chafing. It's particularly bad because it's hidden.

Figure 2-25 — Hidden damage from improperly installed clamp.

SAFETY METHODS

Safetying is a process of securing all aircraft bolts, nuts, cap screws, studs, and other fasteners. Safetying prevents the fasteners from working loose due to vibration. Loose bolts, nuts, or screws can ruin engines or cause parts of the aircraft to drop off. To carry out an inspection on an aircraft, you must be familiar with the various methods of safetying. Careless safetying is a sure road to disaster. Always use the proper method for safetying. You should always inspect for proper safetying throughout the area in which you are working.



CAUTION
Beware—cut ends could seriously hurt personnel. Account for all cut pieces as they could become a FOD hazard if not properly accounted for.

There are various methods of safetying aircraft parts. The most widely used methods are safety wire, cotter pins, lock washers, snap rings, and special nuts. Some of these nuts and washers have been described previously in this chapter. You should know how to use safety wire and cotter pins

Safety Wiring

Safety wiring is the most positive and satisfactory method of safetying. It is a method of wiring together two or more units. Any tendency of one unit to loosen is counteracted by the tightening of the wire.

Nuts, bolts, and screws are safety wired by the single-wire double-twist method. This method is the most common method of safety wiring. A single wire may be used on small screws in close spaces, in closed electrical systems, and in places difficult to reach.

Figure 2-26 shows various methods commonly used in safety wiring nuts, bolts, and screws. Examples 1, 2, and 5 of Figure 2-26 show proper methods of safety wiring bolts, screws, square-head plugs, and similar parts when wired in pairs. Examples 6 and 7 show a single-threaded component wired to a housing or lug. Example 3 shows several components wired in series. Example 4 shows the proper method of wiring castellated nuts and studs. Note that there is no loop around the nut. Example 8 shows several components in a closely spaced, closed geometrical pattern using the single-wire method. Figure 2-27 shows safety wire techniques for T-bolt clamps.

When drilled-head bolts, screws, or other parts are grouped together, they are more conveniently safety wired to each other in a series rather than individually. The number of nuts, bolts, or screws that may be safety wired together depends on the application. For instance, when you are safety wiring widely spaced bolts by the double-twist method, a group of three should be the maximum number in a series.

When you are safety wiring closely spaced bolts, the number that can be safety wired by a 24-inch length of wire is the maximum allowed in a series. The wire is arranged in such a manner that if the bolt or screw begins to loosen, the force applied to the wire is in the tightening direction.

When you use the safety wire method of safetying, follow these general rules:

- Torque all parts to the recommended values and align holes before you attempt to proceed with the safetying operation.
- Never over-torque or loosen a torqued nut to align safety wire holes. The safety wire must be new upon each application.

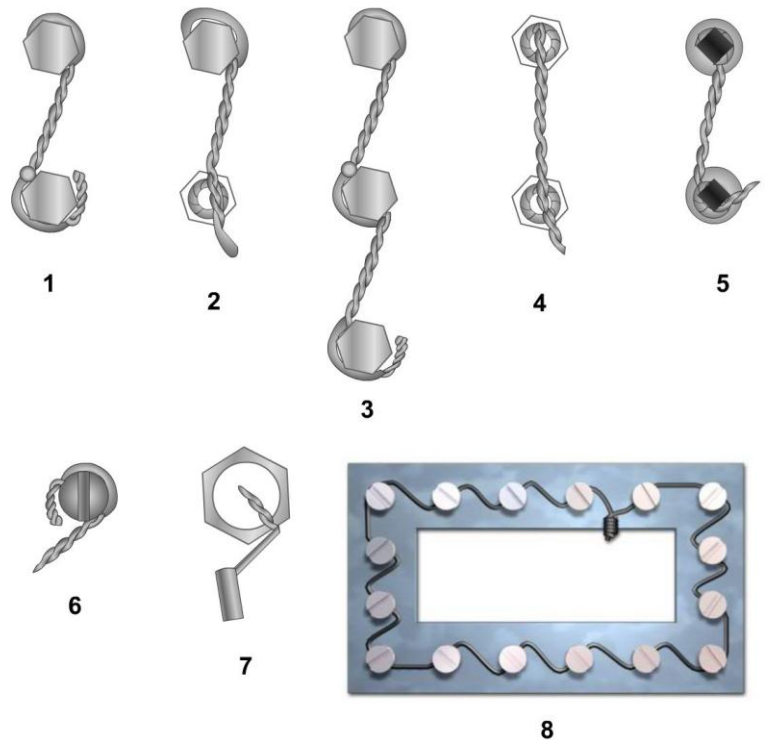


Figure 2-26 — Safety wiring methods.

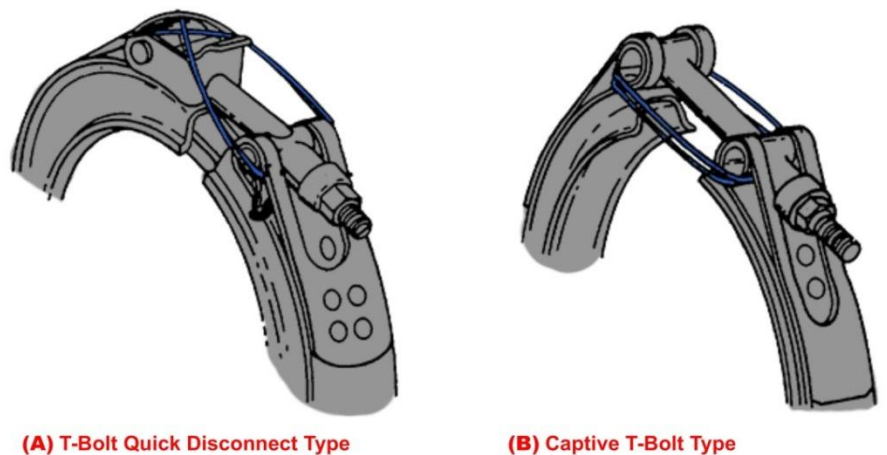


Figure 2-27 — V-band coupling safety wiring techniques.

- When you secure castellated nuts with safety wire, tighten the nut to the low side of the selected torque range unless otherwise specified. If necessary, continue tightening until a slot aligns with the hole.
- All safety wires must be tight after installation but not under such tension that normal handling or vibration will break the wire.
- Apply the wire so that all pull exerted by the wire tends to tighten the nut.
- Twists should be tight and even, and the wire between the nuts should be as taut as possible without being over-twisted.
- A pigtail of 1/4 to 1/2 inch (three to six twists) should be made at the end of the wiring. This pigtail must be bent back or under to prevent it from becoming a snag.

Safety wire comes in different sizes and material. Use the size and material appropriate for the job. When using the single-wire method, you should use the largest size wire that the hole will accommodate. Different types of safety wire include Monel for normal use, Inconel for high temperatures (800 to 1,500 degrees Fahrenheit), and Alclad for nonmagnetic applications.

Cotter Pins

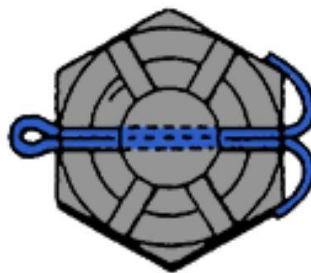
Use cotter pins to secure bolts, screws, nuts, and pins. Some cotter pins are made of low carbon steel, while others consist of stainless steel and thus are more resistant to corrosion. Use stainless steel cotter pins in locations where nonmagnetic material is required. Regardless of shape or material, use all cotter pins for the same general purpose—safetying.

NOTE

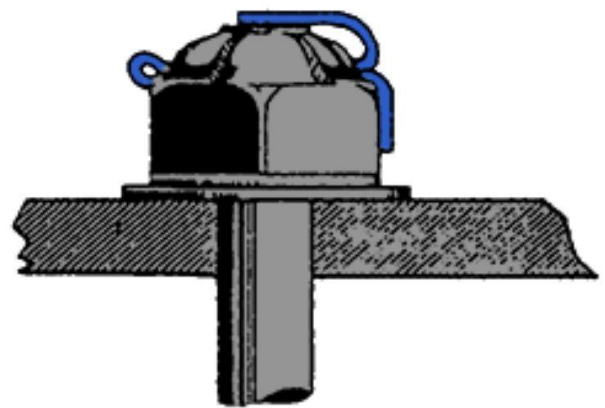
Whenever uneven-prong cotter pins are used, the length measurement is to the end of the shorter prong.

To install a cotter pin (*Figure 2-28*), use castellated nuts with bolts that have been drilled for cotter pins. Use stainless steel cotter pins. The cotter pin should fit neatly into the hole, with very little side-play. The following general rules apply to cotter pin safetying:

- Do not bend the prong over the bolt end beyond the bolt diameter. (Cut it off if necessary.)
- Do not bend the prong down against the surface of the washer. (Again, cut it off if necessary.)
- Do not extend the prongs outward from the sides of the nut if you use the optional wraparound method.
- Bend all prongs over a reasonable radius. Sharp-angled bends invite breakage. Tap the prongs lightly with a mallet to bend them.



Optional



Preferred

Figure 2-28 — Cotter pin installation.

END OF CHAPTER 2

TOOLS AND HARDWARE

Review Questions

- 2-1. What is the main purpose of the Tool Control Program?
- A. Ensure that proper tools are available for maintenance
 - B. Reduce tool loss and thus costs
 - C. Ensure the command always has a cool set of tools
 - D. Reduce Foreign Object Damage related mishaps
- 2-2. Which of the following information is part of every Tool Control Plan?
- A. An allowance list for tool containers
 - B. A standard tool list and layout diagram for each container
 - C. Procurement information for tool containers
 - D. Daily workload report
- 2-3. What minimum marking(s) should be etched on each tool?
- A. Tool container number only
 - B. Tool container number and work center only
 - C. Organization code and work center only
 - D. Tool container number, work center, and organization code
- 2-4. How are sockets classified?
- A. Drive size and the size of the opening at the wrench end
 - B. Drive size and depth
 - C. Depth and the size of the opening at the nut or bolt end
 - D. The length of the ratchet
- 2-5. Which of the following techniques is the correct procedure to follow when you use hammers?
- A. Grip the hammer near the end with your fingers underneath and your thumb along the side of the handle
 - B. Lubricate the face of the hammerhead with oil before using it
 - C. Use a hard hammer to strike hardened steel
 - D. Use a soft hammer to strike hardened steel
- 2-6. Which of the following socket wrench handles has a reversible feature?
- A. Sliding T-bar
 - B. Speed handle
 - C. Ratchet
 - D. Hinged bar

- 2-7. What type of hammer has a soft face?
- A. Ball peen
 - B. Claw
 - C. Mallet
 - D. Sledge
- 2-8. What is the advantage of the box-end wrench?
- A. Extra strength
 - B. Safety under stress
 - C. 25 degree clearance over nearby parts
 - D. Comfortable gripping action
- 2-9. The box-end wrench is usually constructed with how many points?
- A. 16
 - B. 12
 - C. 8
 - D. 6
- 2-10. What are the two basic types of screwdriver blades?
- A. Phillips and Reed and Prince
 - B. Common and Cross-point
 - C. Cross-point and Phillips
 - D. Reed and Prince and cross-point
- 2-11. Which of the following tool is a commonly used socket wrench accessory that is included in a standard socket set?
- A. Screwdriver
 - B. Hammer
 - C. Flashlight
 - D. Adapter
- 2-12. What is the advantage of the open end combination wrench?
- A. Speed
 - B. Slow work
 - C. Poor clearance over nearby parts
 - D. Poorly adapted for snugging up work
- 2-13. How is the size of diagonal cutters determined?
- A. The overall length of the cutting edge
 - B. The overall length of the pliers
 - C. The overall length of the handles
 - D. The overall length of the tip offset

2-14. What is considered a special tool?

- A. It's an instrument type of tool that requires calibration
- B. It's a high used item
- C. It's a easily stored item
- D. It's a tool that requires no calibration

2-15. Which micrometer is most commonly used in the Navy?

- A. Barbell micrometer
- B. Dual micrometer
- C. Outside micrometer
- D. Series micrometer

2-16. What are the two series types of threads used on aircraft?

- A. National long (NL) and national ready (NR)
- B. National wide (NW) and national straight(NS)
- C. National executive (NE) and national hard (NH)
- D. National coarse (NC) and national fine(NF)

2-17. What is the maximum number of bolts/screws that can be safety wired together in a series?

- A. 2
- B. 3
- C. 4
- D. 5

2-18. What is the purpose of cotter pins?

- A. Adapting
- B. Prying
- C. Safetying
- D. Torqueing

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