

CHAPTER 6

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. Aircraft hardware is discussed in detail in the *Structural Hardware Manual*, NAVAIR 01-1A-8.

Aircraft hardware is usually identified by its specification number or trade name. Threaded fasteners and rivets are usually identified by AN (Air Force-Navy), NAS (National Aircraft Standard), and MS (Military Standard) numbers. Quick-release fasteners are usually identified by factory trade names and size designations.

LEARNING OBJECTIVES

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

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

AIRCRAFT STRUCTURAL HARDWARE

The term *aircraft structural hardware* refers to many items used in aircraft construction. These items include such hardware as rivets, fasteners, bolts, nuts, screws, washers, cables, guides, and common electrical system hardware.

RIVETS

The fact that there are thousands of rivets in an airframe is an indication of how important riveting is. A glance at any aircraft will show the thousands of rivets in the outer skin alone. Besides the riveted skin, rivets are also used for joining spar sections, for holding rib sections in place, for securing fittings to various parts of the aircraft, and for fastening bracing members and other parts together. Rivets that are satisfactory for one part of the aircraft are often unsatisfactory for another part. Therefore, it is important that you know the strength and driving properties of the various types of rivets and how to identify, drive, or install them.

Solid Rivets

Solid rivets are classified by their head shape, by the material from which they are manufactured, and by their size. Rivet head shapes and their identifying code numbers are shown in *Figure 6-1*. The prefix MS identifies hardware that conforms to written military standards. The prefix AN identifies specifications that are developed and issued under the joint authority of the Air Force and the Navy.

Rivet Identification Code

The rivet codes shown in *Figure 6-1* are sufficient to identify rivets only by head shape. To be meaningful and precisely identify a rivet, certain other information is encoded and added to the basic

code. A letter, or letters, following the head-shaped code identify the material or alloy from which the rivet was made. *Table 6-1* includes a listing of the most common of these codes. The alloy code is followed by two numbers separated by a dash. The first number is the numerator of a fraction, which specifies the shank diameter in thirty-seconds of an inch. The second number is the numerator of a fraction in sixteenths of an inch, and identifies the length of the rivet. The rivet code is shown in *Figure 6-2*.

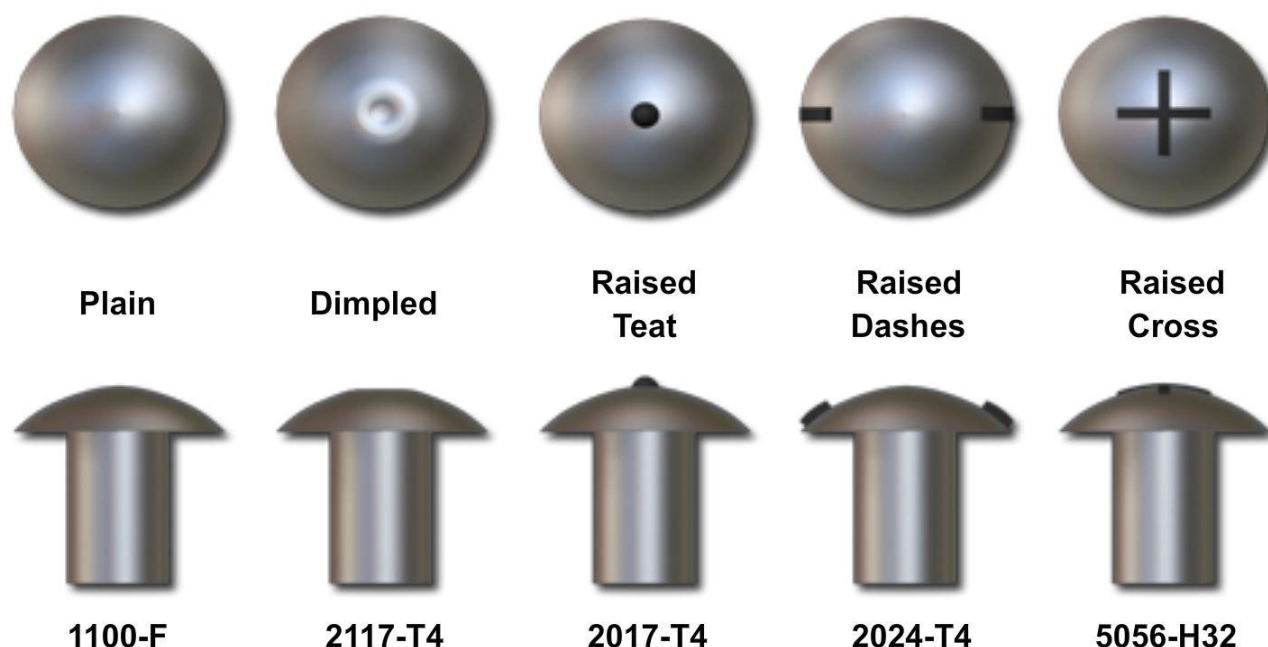


Figure 6-1 — Rivet head shapes and code numbers.

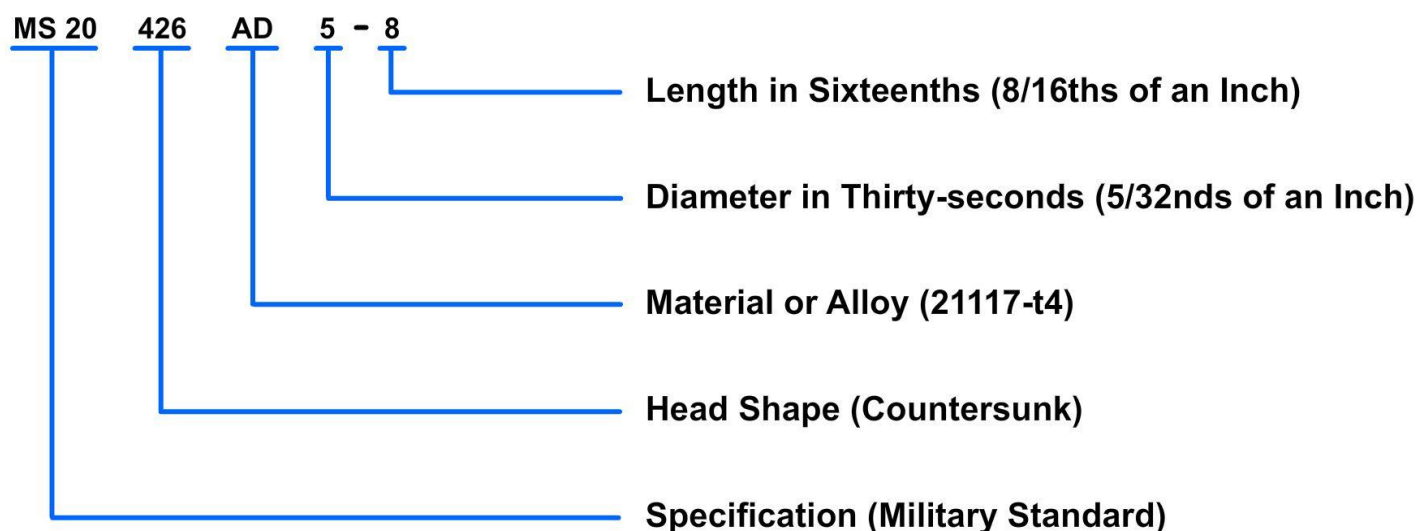


Figure 6-2 — Rivet coding example.

Rivet Composition

Most of the rivets used in aircraft construction are made of aluminum alloy. A few special-purpose rivets are made of mild steel, Monel, titanium, and copper. Those aluminum alloy rivets made of 1100, 2117, 2017, 2024, and 5056 are considered standard.

ALLOY 1100 RIVETS — Alloy 1100 rivets are supplied as fabricated (F) temper and are driven in this condition. No further treatment of the rivet is required before use, and the rivet's properties do not change with prolonged periods of storage. They are relatively soft and easy to drive. The cold work resulting from driving increases their strength slightly. The 1100-F rivets are used only for riveting nonstructural parts. These rivets are identified by their plain head, as shown in *Table 6-1*.

Table 6-1 — Rivet Material Identification

MATERIAL OR ALLOY	CODE LETTERS	HEAD MARKING ON RIVET
1100-F	A	Plain
2117-T4	AD	Indented Dimple
2017-T4	D	Raised Teat
2024-T4	DD	Raised Double Dash
5056-H32	B	Raised Cross

ALLOY 2117 RIVETS — Like the 1100-F rivets, these rivets need no further treatment before use and can be stored indefinitely. They are furnished in the solution-heat-treated (T4) temper, but change to the solution-heat-treated and cold-worked (T3) temper after driving. The 2117-T4 rivet is in general use throughout aircraft structures and is by far the most widely used rivet, especially in repair work. In most cases the 2117-T4 rivet may be substituted for 2017-T4 and 2024-T4 rivets for repair work by using a rivet with the next larger diameter. This is desirable since both the 2017-T4 and 2024-T4 rivets must be heat-treated before they are used or kept in cold storage. The 2117-T4 rivets are identified by a dimple in the head.

ALLOY 2017 AND 2024 RIVETS — Both these rivets are supplied in the T4 temper and must be heat-treated. These rivets must be driven within 20 minutes after quenching or refrigerated at or below 32 °F to delay the aging time 24 hours. If either time is exceeded, reheat treatment is required. These rivets may be reheated as many times as desired, provided the proper solution heat-treatment temperature is not exceeded. The 2024-T4 rivets are stronger than the 2017-T4 and, therefore, are harder to drive. The 2017-T4 rivet is identified by the raised teat on the head, while the 2024-T4 has two raised dashes on the head.

ALLOY 5056 RIVETS — These rivets are used primarily for joining magnesium alloy structures because of their corrosion-resistant qualities. They are supplied in the H32 temper (strain-hardened and then stabilized). These rivets are identified by a raised cross on the head. The 5056-H32 rivet may be stored indefinitely with no change in its driving characteristics.

Blind Rivets

In places accessible from only one side or where space on one side is too restricted to properly use a bucking bar, blind rivets are usually used. Blind rivets may also be used to secure nonstructural parts to the airframe.

Self-Plugging Mechanical Lock

Figure 6-3 shows a blind rivet that uses a mechanical lock between the head of the rivet and the pull stem. This lock holds the shank firmly in place from the head side.

The self-plugging rivet is made of 5056-H14 aluminum alloy and includes the conical recess and locking collar in the rivet head. The stem is made of 2024-T36 aluminum alloy. Pull grooves that fit

into the jaws of the rivet gun are provided on the stem end that protrudes above the rivet head. The blind end portion of the stem incorporates a head and a land (the raised portion of the grooved surface) with an extruding angle that expands the rivet shank.

Applied loads for self-plugging rivets are comparable to those for solid shank rivets of the same shear strength, regardless of sheet thickness. The composite shear strength of the 5056-H14 shank and the

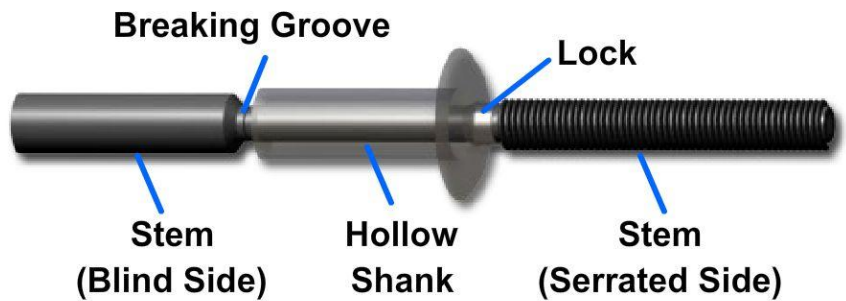
2024-T36 pin exceeds 38,000 pounds per square inch (psi). Their tensile strength is in excess of 28,000 psi. Pin retention characteristics are excellent in these rivets. The possibility of the pin working out is minimized by the lock formed in the rivet head.

Self-Plugging Friction Lock

Self-plugging friction lock rivets are available in universal and flush head styles and are manufactured from 2117 and 5056 aluminum alloy and Monel. Self-plugging friction lock rivets cannot be substituted for solid rivets, nor can they be used in critical applications, such as control surface hinge brackets, wing attachment fittings, landing gear fittings, and fluid-tight joints. Figure 6-4 shows a self-plugging friction lock rivet.

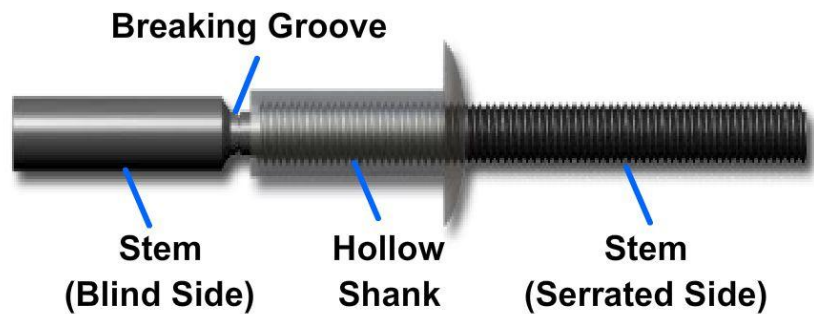
Hi-Shear Rivets®

Hi-shear® (pin) rivets are essentially threadless bolts. The pin is headed at one end and is grooved about the circumference at the other. A metal collar is swaged onto the grooved end. They are available in two head styles—the flat protruding head and the flush 100-degree countersunk head. Hi-Shear® rivets are made in a variety of materials and are used only in shear applications. Because the shear strength of the rivet is greater than either the shear or bearing strength of sheet aluminum alloys, they are used primarily to



Mechanical Lock Blind Rivet

Figure 6-3 — Self-plugging rivet (mechanical lock).



Friction Lock

Figure 6-4 — Self-plugging rivet (friction lock).

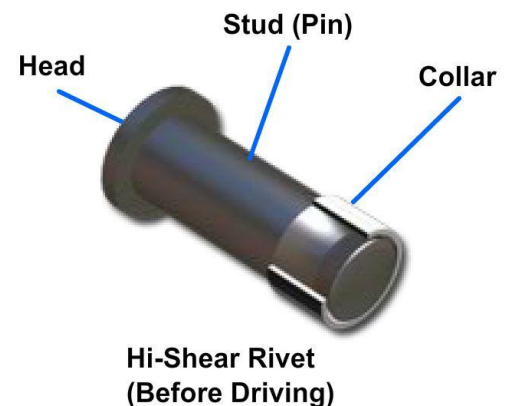
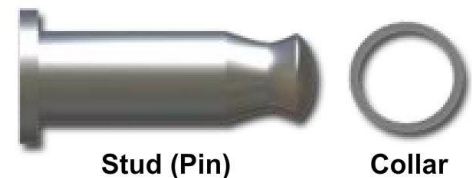


Figure 6-5 — Hi-Shear® rivet.

rivet thick-gauge sheets together. They are never used with a grip length that is less than the shank diameter. Hi-Shear[®] rivets are shown in *Figure 6-5*.

Hi-Shear[®] rivets are identified by code numbers similar to the solid rivets. The size of the rivet is measured in increments of thirty-seconds of an inch for the diameter and sixteenths of an inch for the grip length. For example, an NAS1055-5-7 rivet would be a Hi-Shear[®] rivet with a countersunk head. Its diameter would be 5/32 of an inch and its maximum grip length would be 7/16 of an inch.

The collars are identified by a basic code number and a dash number that correspond to the diameter of the rivet. An A before the dash number indicates an aluminum alloy collar. The NAS528-A5 collar would be used on a 5/32-inch-diameter rivet pin. Repair procedures involving the installation or replacement of Hi-Shear[®] rivets generally specify the collar to be used.

Rivnuts

The rivnut is a hollow rivet made of 6063 aluminum alloy, counterbored and threaded on the inside. It is manufactured in two head styles—flat and countersunk—and in two shank designs—open and closed ends. See *Figure 6-6*. Each of these rivets is available in three sizes: 6-32, 8-32, and 10-32. These numbers indicate the nominal diameter and the actual number of threads per inch of the machine screw that fits into the rivnut.

Open-end rivnuts are more widely used and are generally the recommended and preferred type. However, in sealed flotation or pressurized compartments, the closed-end rivnut must be used.



Figure 6-6 — Rivnut fastener.

FASTENERS (SPECIAL)

Fasteners on aircraft are designed for many different functions. Some are made for high-strength requirements, while others are designed for easy installation and removal.

Lock-Bolt Fasteners

Lock-bolt fasteners are designed to meet high-strength requirements. Used in many structural applications, their shear and tensile strengths equal or exceed the requirements of AN and NAS bolts.

The lock-bolt pin, shown in View A of *Figure 6-7*, consists of a pin and collar. It is available in two head styles: protruding and countersunk. Pin retention is accomplished by swaging the collar into the locking grooves on the pin.

The blind lock bolt, shown in View B of *Figure 6-7*, is similar to the self-plugging rivet shown in *Figure 6-3*. It features a positive mechanical lock for pin retention.

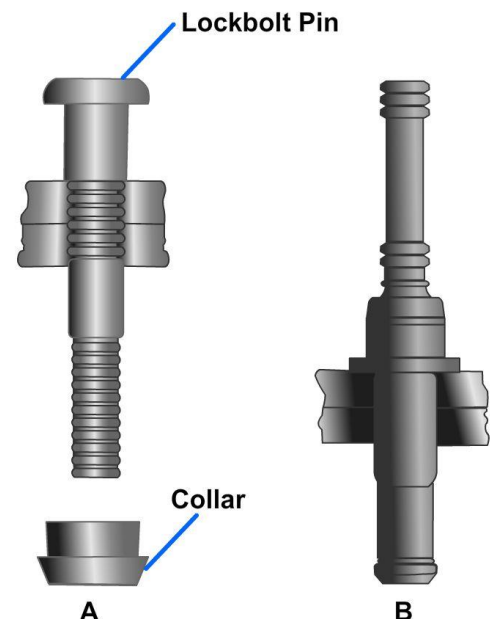


Figure 6-7 — Lock bolts.

Hi-Lok[®] Fasteners

The Hi-Lok[®] fastener, shown in *Figure 6-8*, combines the features of a rivet and a bolt and is used for high-strength, interference-free fit of primary structures. The Hi-Lok[®] fastener consists of a threaded pin and threaded locking collar. The pins are made of cadmium-plated alloy steel with protruding or 100-degree flush heads. Collars for the pins are made of anodized 2024-T6 aluminum or stainless

steel. The threaded end of the pin is recessed with a hexagon socket to allow installation from one side. The major diameter of the threaded part of the pin has been truncated (cut undersize) to accommodate a 0.004-inch maximum interference-free fit. One end of the collar is internally recessed with a 1/16-inch, built-in variation that automatically provides for variable material thickness without the use of washers and without fastener preload changes. The other end of the collar has a torque-off wrenching device that controls a predetermined residual tension of preload (10%) in the fastener.

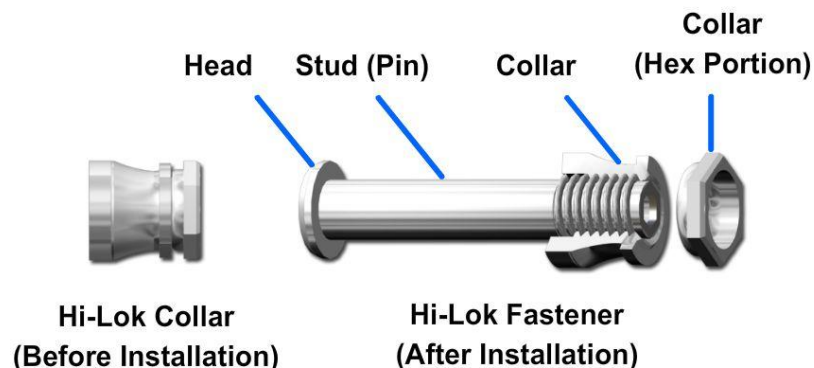


Figure 6-8 — Hi-Lok® fastener.

Jo-Bolt® Fasteners

The Jo-Bolt®, shown in *Figure 6-9*, is a high-strength, blind structural fastener that is used on difficult riveting jobs when access to one side of the work is impossible. The Jo-Bolt® consists of three factory-assembled parts: an aluminum alloy or alloy steel nut, a threaded alloy steel bolt, and a corrosion-resistant steel sleeve. The head styles available for Jo-bolts are the 100-degree flush head, the hexagon protruding head, and the 100-degree flush millable head.

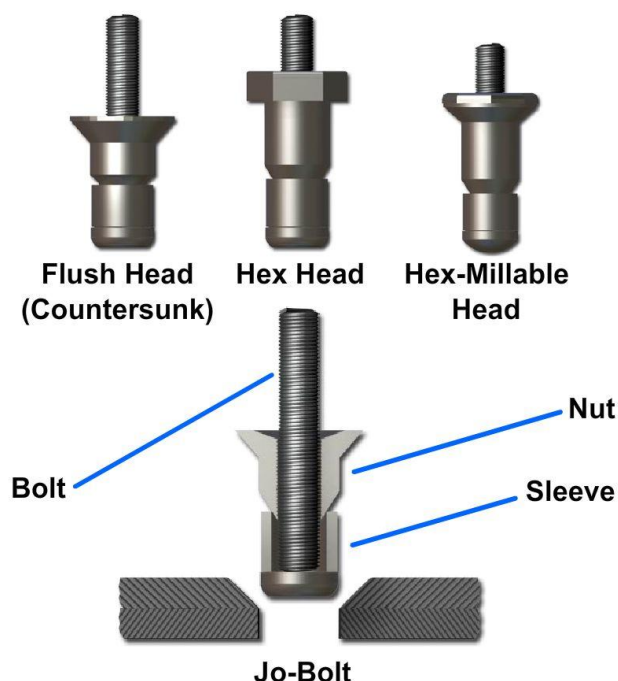


Figure 6-9 — Jo-Bolt®.

FASTENERS (THREADED)

Although thousands of rivets are used in aircraft construction, many parts require frequent dismantling or replacement. For these parts, use some form of threaded fastener. Furthermore, some joints require greater strength and rigidity than can be provided by riveting. Manufacturers solve this problem by using various types of screws, bolts, nuts, washers, and fasteners.

Bolts and screws are similar in that both have a head at one end and a screwthread at the other, but there are several differences between them. The threaded end of a bolt is always relatively blunt, while that of a screw may be either blunt or pointed. The threaded end of a bolt must be screwed into a nut, but the threaded end of the screw may fit into a nut or other female arrangement, 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 its nuts. Its head may or may not be designed to be turned. A screw is always designed to be turned by its head. Another minor but frequent 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 Standard type. This standard contains two series of threads: national coarse (NC) and national fine (NF). Most aircraft threads are of the NF series.

Threads are also produced in right-hand and left-hand types. A right-hand thread advances into engagement when turned clockwise. A left-hand thread advances into engagement when turned counterclockwise.

Threads are sized by both the diameter and the number of threads per inch. The diameter is designated by screw gauge number for sizes up to 1/4 inch, and by nominal size for those 1/4 inch and larger. Screw gauge numbers range from 0 to 12, except that numbers 7, 9, and 11 are omitted. Threads are designated by the diameter, number of threads per inch, thread series, and class in parts catalogs, on blueprints, and on repair diagrams.

For example, No. 8-32NF-3 indicates a No. 8 size thread, 32 threads per inch, national fine series, and a class 3 thread. Also, 1/4-20NC-3 indicates a 1/4-inch thread, 20 threads per inch, national coarse series, and a class 3 thread. A left-hand thread is indicated by the letters *LH* following the class of thread.

Bolts

Many types of bolts are used on aircraft. Before discussion of some of these types, it might be helpful to view a list containing information about commonly used bolt terms. Important information about the names of bolt parts and bolt dimensions that must be considered in selecting a bolt is shown in *Figure 6-10*.

The three principal parts of a bolt are the head, thread, and grip. The head is the larger diameter of the bolt and may be one of many shapes or designs. The head keeps the bolt in place in one direction, and the nut used on the threads keeps it in place in the other direction.

To choose the correct replacement, several bolt dimensions must be considered. One is the length of the bolt. Note in *Figure 6-10* that 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 chosen bolt extends through the nut at least two full threads. In the case of flat-end bolts or chamfered (rounded) end bolts, at least the full chamfer plus one full thread should extend through the nut. See *Figure 6-10*. If the bolt is too short, it may 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. Unnecessarily long bolts can affect weight and balance and reduce the aircraft payload capacity.

In addition, if a bolt is too long or too short, its grip is usually the wrong length. As shown in *Figure 6-11*, 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 and may act like a reamer when the material is vibrating. To prevent reaming, no more than two threads should extend into the bolt hole. Also, users should be certain that any threads that enter the bolt hole extend only into the thicker member that is being fastened. 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, or if the bolt grip extends only a short distance through the hole, a washer may be used.

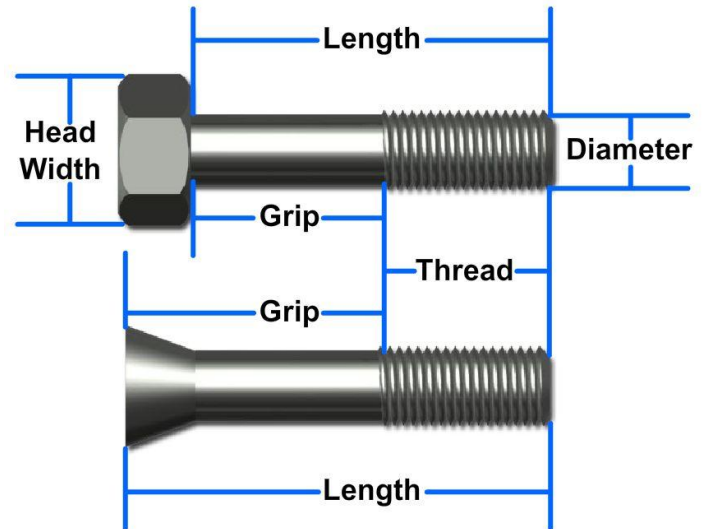


Figure 6-10 — Bolt terms and dimensions.

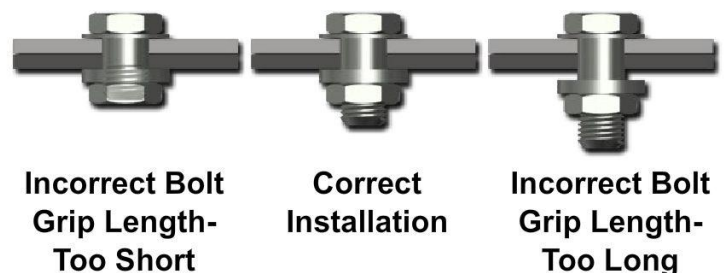


Figure 6-11 — Correct and incorrect grip lengths.

A second bolt dimension that must be considered is diameter. *Figure 6-11* shows that the diameter of the bolt is the thickness of its shaft. If this thickness is 1/4 of an inch or more, the bolt diameter is usually given in fractions of an inch (for example, 1/4, 5/16, 7/16, and 1/2). However, if the bolt is less than 1/4 of an inch thick, the diameter is usually expressed as a whole number. For instance, a bolt that is 0.190 inch in diameter is called a No. 10 bolt, while a bolt that is 0.164 inch in diameter is called a No. 8.

The results of using a bolt of the wrong diameter 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, and it is likely not as strong as the correct bolt.

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

BOLT HEADS — The most common type of head is the hex head. See *Figure 6-12*. This type of head may be thick for greater strength or relatively thin in order to fit in places having limited clearances. In addition, the head may be common or drilled to lockwire the bolt. A hex-head bolt may have a single hole drilled through it between two of the sides of the hexagon and still be classed as common. The drilled head-hex bolt has three holes drilled in the head, connecting opposite sides of the hex. Seven additional types of bolt heads are shown in *Figure 6-12*.

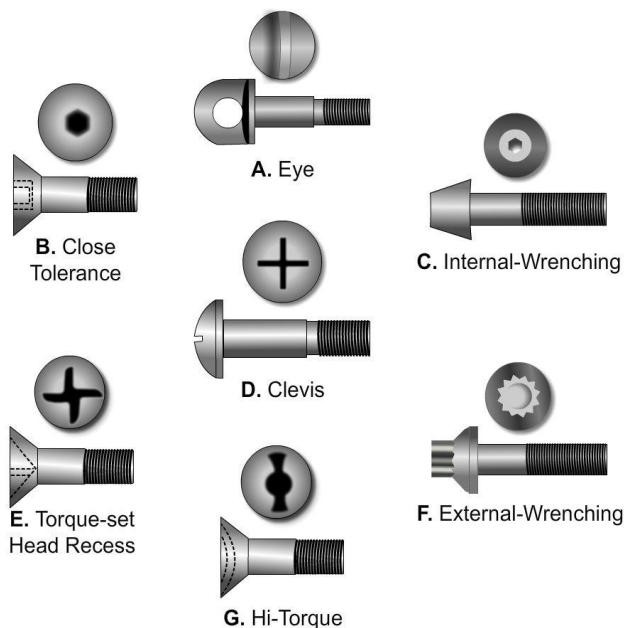


Figure 6-12 — Different types of bolts.

View A shows an eyebolt, often used in flight control systems.

View B shows a countersunk-head, close-tolerance bolt.

View C shows an internal-wrenching bolt. Both the countersunk-head bolt and the internal-wrenching bolt have hexagonal recesses (six-sided holes) in their heads. They are tightened and loosened by use of appropriately sized Allen wrenches.

View D shows a clevis bolt with its characteristic round head. This head may be slotted, as shown, to receive a common screwdriver or recessed to receive a Reed-and-Prince or a Phillips screwdriver.

View E shows a torque-set wrenching recess that has four driving wings, each one offset from the one opposite it. There is no taper in the walls of the recess. This permits higher torque to be applied with less of a tendency for the driver to slip or cam out of the slots.

View F shows an external-wrenching head that has a washer face under the head to provide an increased bearing surface. The 12-point head gives a greater wrench-gripping surface.

View G shows a hi-torque style driving slot. This single slot is narrower at the center than at the outer portions. This design, and the center dimple, provides the slot with a bow tie appearance. The recess is also undercut in a taper from the center to the outer ends, producing an inverted keystone shape. These bolts must be installed with a special hi-torque driver adapter. They must also be driven with some type of torque-limiting or torque-measuring device. Each diameter of bolt requires the proper size of driver for that particular bolt. The bolts are available in standard and reduced 100-degree flush heads. The reduced head requires a driver one size smaller than the standard head.

BOLT THREADS — Another structural feature in which bolts may differ is threads. These usually come in one of two types: coarse and fine. The two are not interchangeable. For any given size of bolt there are a different number of coarse and fine threads per inch. For instance, consider the 1/4-inch bolts. Some are called 1/4-28 bolts because they have 28 fine threads per inch. Others have only 20 coarse threads per inch and are called 1/4-20 bolts. To force one size of threads into another size, even though both are 1/4 of an inch, can strip the finer threads of softer metal. The same result is true concerning the other sizes of bolts; therefore, it is important to be certain that selected bolts have the correct type of threads.

BOLT MATERIALS — The type of metal used in an aircraft bolt helps to determine its strength and its resistance to corrosion. Therefore, it is important that material is considered in the selection of replacement bolts. Like solid shank rivets, bolts have distinctive head markings that help to identify the material from which they are manufactured. *Figure 6-13* shows the tops of several hex-head bolts—each marked to indicate the type of bolt material.

BOLT IDENTIFICATION — Unless current directives specify otherwise, every unserviceable bolt should be replaced with a bolt of the same type. Of course, substitute and interchangeable items are sometimes available, but the ideal fix is a bolt-for-bolt replacement. The part number of a needed bolt may be obtained by referring to the illustrated parts breakdown (IPB) for the aircraft concerned. Exactly what this part number means depends upon whether the bolt is AN, NAS, or MS.

AN Part Number — There are several classes of AN bolts, and in some instances their part numbers reveal slightly different types of information. However, most AN numbers contain the same type of information.

Figure 6-14 shows a breakdown of a typical AN bolt part number. Like the AN rivets discussed earlier, it starts with the letters AN. Next, a number follows the letters. This number usually consists of two digits. The first digit (or absence of it) shows the class of the bolt. For instance, in *Figure 6-14*, the series number has only one digit, and the absence of one digit shows that this part number represents a general-purpose hex-head bolt. However, the part numbers for some bolts of this class have two digits. In fact, general-purpose hex-head bolts include all part numbers from AN3 to AN20. Other series numbers and the classes of bolts they represent are as follows:

- AN21 through AN36—clevis bolts
- AN42 through AN49—eyebolts

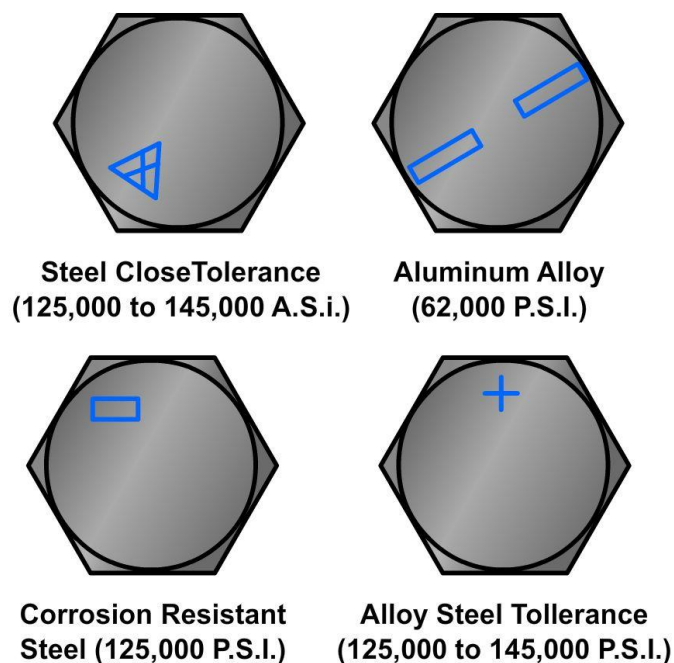


Figure 6-13 — Bolt head markings.

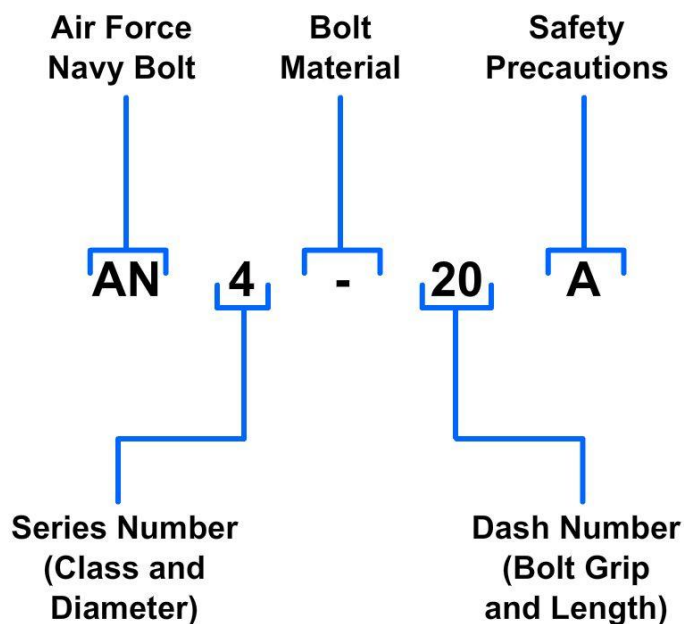


Figure 6-14 — AN bolt part number breakdown.

The series number shows another type of information other than bolt class. With a few exceptions, it indicates bolt diameter in sixteenths of an inch. For instance, in *Figure 6-14*, the last digit of the series number is 4; therefore, this bolt is 4/16 of an inch (1/4 of an inch) in diameter. In the case of a series number ending in 0—for instance, AN30—the 0 stands for 10, and the bolt has a diameter of 10/16 of an inch (5/8 of an inch).

Refer to *Figure 6-14* again and observe that a dash follows the series number. When used in the part numbers for general-purpose AN bolts, clevis bolts, and eyebolts, this dash indicates that the bolt is made of carbon steel. With these types of bolts, the letter *C*, used in place of the dash, means corrosion-resistant steel. The letter *D* means 2017 aluminum alloy. The letters *DD* stand for 2024 aluminum alloy. For some bolts of this type, a letter *H* is used with these letters or with the dash. If it is used, the letter *H* shows that the bolt has been drilled for safetying.

Next, observe the number 20 that follows the dash. This is called the dash number. It represents the bolt's grip (as taken from special tables). In this instance the number 20 stands for a bolt that is 2 1/32 inches long.

The last character in the AN number shown in *Figure 6-14* is the letter *A*. This signifies that the bolt is not drilled for cotter pin safetying. If no letter were used after the dash number, the bolt shank would be drilled for safetying.

MS Part Number — MS is another series of bolts used in aircraft construction. In the part number shown in *Figure 6-15*, the MS indicates that the bolt is a Military Standard bolt. The series number (20004) indicates the bolt class and diameter in sixteenths of an inch (internal-wrenching, 1/4-inch diameter). The letter *H* before the dash number indicates that the bolt has a drilled head for safetying. The dash number (9) indicates the bolt grip in sixteenths of an inch.



Figure 6-15 — MS bolt part number breakdown.

NAS Part Number — Another series of bolts used in aircraft construction is the NAS. See *Figure 6-16*. In considering the NAS144-25 bolt (special internal-wrenching type), the bolt identification code starts with the letters *NAS*. Next, the series has a three-digit number, 144. The first two digits (14) show the class of the bolt. The next number (4) indicates the bolt diameter in sixteenths of an inch. The dash number (25) indicates bolt grip in sixteenths of an inch.

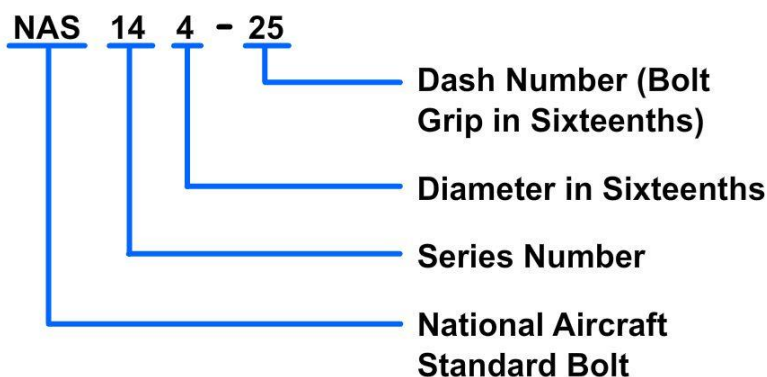


Figure 6-16 — NAS bolt part number breakdown.

Nuts

Aircraft nuts differ in design and material, just as bolts do, because they are designed to do a specific job with the bolt. For instance, some of the nuts are made of cadmium-plated carbon steel, stainless steel, brass, or aluminum alloy. The type of metal used is not identified by markings on the nuts themselves. Instead, the material must be recognized from the luster of the metal.

Nuts also differ greatly in size and shape. In spite of these many and varied differences, they all fall under one of two general groups: self-locking and nonself-locking. Nuts are further divided into types

such as plain nuts, castle nuts, check nuts, plate nuts, channel nuts, barrel nuts, internal-wrenching nuts, external-wrenching nuts, shear nuts, sheet spring nuts, wing nuts, and Klincher locknuts.

NONSELF-LOCKING NUTS — Nonself-locking nuts require the use of a separate locking device for security of installation. There are several types of these locking devices mentioned in the following paragraphs in connection with the nuts on which they are used. Since no single locking device can be used with all types of nonself-locking nuts, one must be selected that is suitable for the type of nut being used.

SELF-LOCKING NUTS — Self-locking nuts provide tight connections that will not loosen under vibrations. Self-locking nuts approved for use on aircraft meet critical strength, corrosion-resistance, and temperature specifications. The two major types of self-locking nuts are prevailing torque and free spinning. The two general types of prevailing torque nuts are the all-metal nuts and the nonmetallic insert nuts. New self-locking nuts must be used each time components are installed in critical areas throughout the entire aircraft, including all flight, engine, and fuel control linkage and attachments. The flexloc nut is an example of the all-metal type. The elastic stop nut is an example of the nonmetallic insert type. All-metal self-locking nuts are constructed with the threads in the load-carrying portion of the nut out of phase with the threads in the locking portion, or with a saw cut top portion with a pinched-in thread. The locking action of these types depends upon the resiliency of the metal when the locking section and load-carrying section are forced into alignment when engaged by the bolt or screw threads.

PLAIN HEX NUTS — These nuts are available in self-locking or nonself-locking styles. When the nonself-locking nuts are used, they should be locked with an auxiliary locking device such as a check nut or lock washer. See *Figure 6-17*.

CASTLE NUTS — These nuts are used with drilled shank bolts, hex-head bolts, clevis bolts, eyebolts, and drilled-head studs. These nuts are designed to be secured with cotter pins or safety wire.

CASTELLATED NUTS — Like the castle nuts, these nuts are castellated for safetying. They are not as strong or cut as deep as the castle nuts.

CHECK NUTS — These nuts are used in locking devices for nonself-locking plain hex nuts, setscrews, and threaded rod ends.

PLATE NUTS — These nuts are used for blind mounting in inaccessible locations and for easier maintenance. They are available in a wide range of sizes and shapes. One-lug, two-lug, and right-angle shapes are available to accommodate the specific physical requirements of nut locations. Floating nuts provide a controlled amount of nut movement to compensate for subassembly misalignment. They can be either self-locking or nonself-locking. See *Figure 6-18*.



Figure 6-17—Nuts.

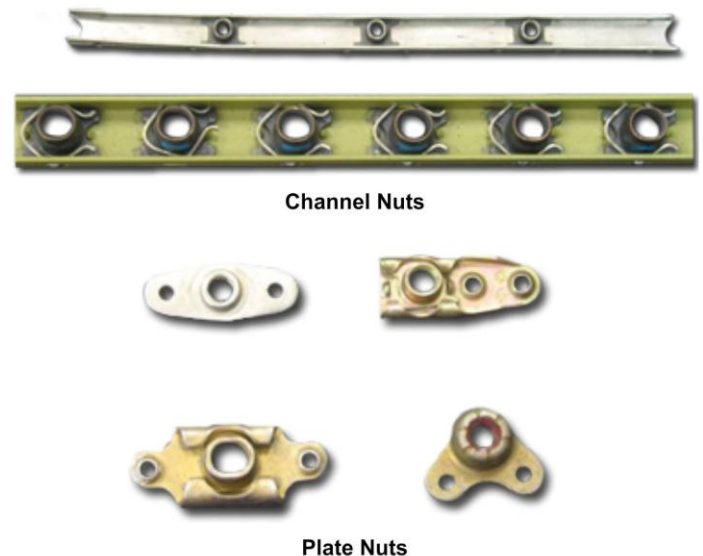


Figure 6-18—Self-locking plate nuts.

CHANNEL NUTS — These nuts are used in applications requiring anchored nuts equally spaced around openings such as access and inspection doors and removable leading edges. Straight or curved channel nut strips offer a wide range of nut spacing and provide a multinut unit that has all the advantages of floating nuts. They are usually self-locking.

BARREL NUTS — These nuts are installed in drilled holes. The round portion of the nut fits in the drilled hole and provides a self-wrenching effect. They are usually self-locking.

INTERNAL-WRENCHING NUTS — These nuts are generally used where a nut with a high tensile strength is required or where space is limited and the use of external-wrenching nuts would not permit the use of conventional wrenches for installation and removal. This is usually where the bearing surface is counterbored. These nuts have a nonmetallic insert that provides the locking action.

POINT WRENCHING NUTS — These nuts are generally used where a nut with a high tensile strength is required. These nuts are installed with a small socket wrench. They are usually self-locking.

SHEAR NUTS — These nuts are designed for use with devices such as drilled clevis bolts and threaded taper pins that are normally subjected to shearing stress only. They are usually self-locking.

SHEET SPRING NUTS — These nuts are used with standard and sheet metal self-tapping screws to support line clamps, conduit clamps, electrical equipment, and access doors. The most common types are the float, the two-lug anchor, and the one-lug anchor. The nuts have an arched spring lock that prevents the screw from working loose. They should be used only where originally used in the fabrication of the aircraft. See *Figure 6-19*.

WING NUTS — These nuts are used where the desired tightness is obtained by the use of your fingers and where the assembly is frequently removed.

KLINCHER LOCKNUTS — Klincher locknuts are used to ensure a permanent and vibration-proof, bolted connection that holds solidly and resists thread wear. It will withstand extremely high or low temperatures and exposure to lubricants, weather, and compounds without impairing the effectiveness of the locking element. The nut is installed with the end that looks like a double washer toward the metal being fastened. Notice in *Figure 6-20* that the end that looks like a double hexagon is away from the metal being fastened.

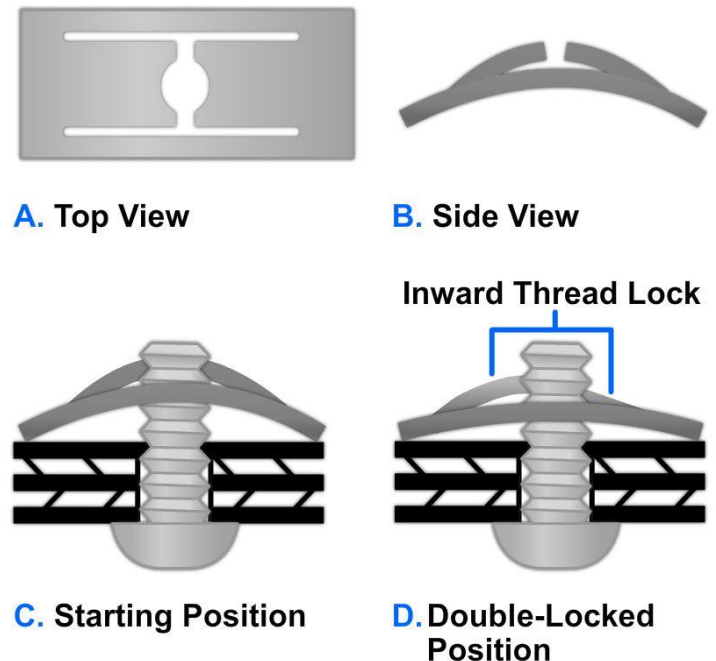


Figure 6-19 — Sheet spring nut.

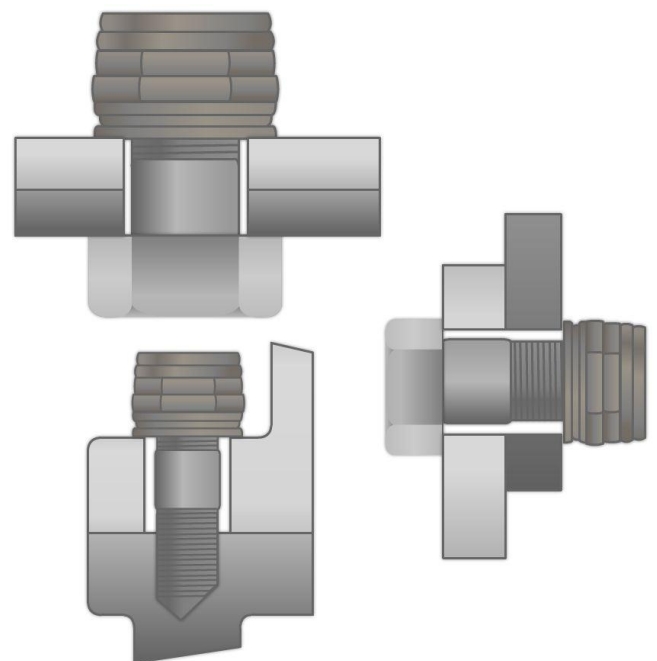


Figure 6-20 — Typical installations of the Klincher locknut.

Screws

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

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. See *Figure 6-21*.

MACHINE SCREWS — The commonly used machine screws are the flush-head, round-head, fillister-head, socket-head, pan-head, and truss-head types.

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 and sheet metal self-tapping screws.

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.

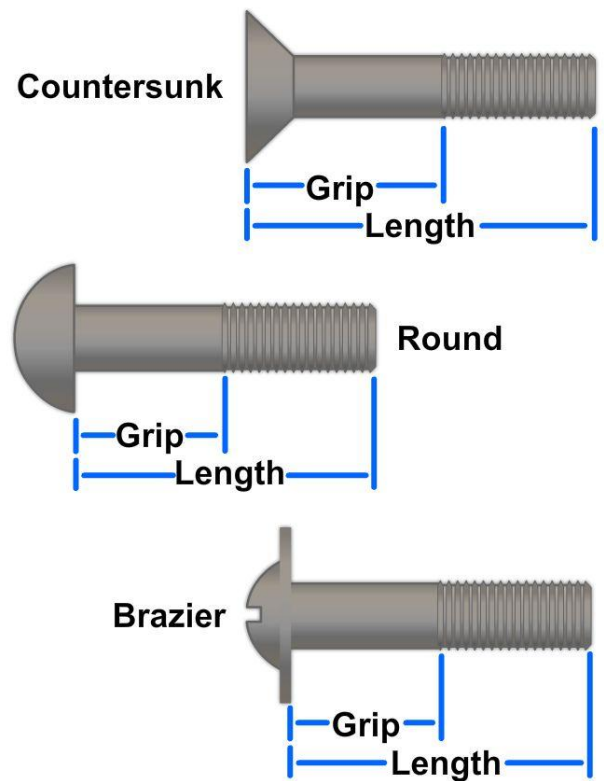


Figure 6-21 — Structural screws.



CAUTION

Self-tapping screws should never be used to replace standard screws, nuts, or rivets in the original structure. Over a time, vibration and stress will loosen this type of fastener, causing it to lose its holding ability.

Washers

Washers such as ball socket and seat washers, taper pin washers, and washers for internal-wrenching nuts and bolts have been designed for special applications. See *Figure 6-22*.

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.



Figure 6-22 — Various types of special washers.

Turnlock Fasteners

Turnlock 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. See *Figure 6-23*. 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.

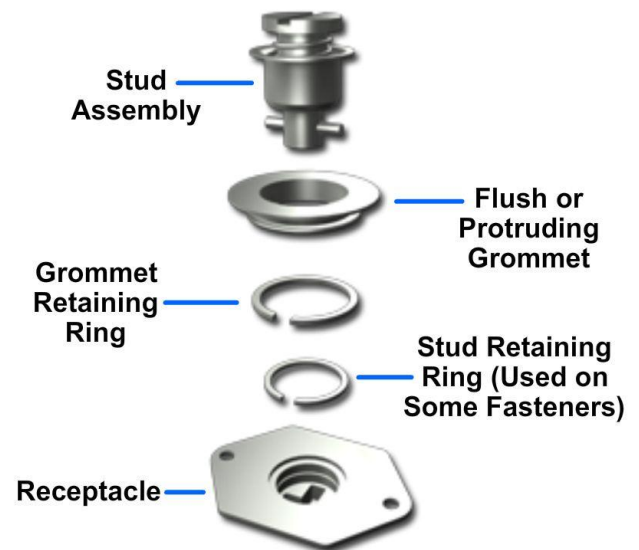


Figure 6-23 — Camloc 4002 series fastener.

The Camloc high-stress panel fastener, shown in *Figure 6-24*, is a high-strength, quick-release rotary fastener and may be used on flat or curved inside or outside panels. The fastener may have either a flush or a protruding stud. The studs are held in the panel with flat or cone-shaped washers—the latter being used with flush fasteners in dimpled holes. This fastener may be distinguished from screws by the deep No. 2 Phillips recess in the stud head and by the bushing in which the stud is installed.

A threaded insert in the receptacle provides an adjustable locking device. As the stud is inserted and turned counterclockwise one-half turn or more, it screws out the insert to permit the stud key to engage the insert cam when turned clockwise. Rotating the stud clockwise one-fourth turn engages the insert. Continued rotation screws the insert in and tightens the fastener. Turning the stud one-fourth turn counterclockwise will release the stud, but will not screw the insert out far enough to permit re-engagement. The stud should be turned at least one-half turn counterclockwise to reset the insert.

DZUS FASTENERS — Dzus fasteners are available in two types. A light-duty type is used on box covers, access hole covers, and lightweight fairings. The heavy-duty type is used on cowlings and heavy fairings. The main difference between the two Dzus fasteners is a grommet, which is used only on the heavy-duty fasteners. Otherwise, their construction features are about the same.

Figure 6-25 shows the parts of a light-duty Dzus fastener. Notice that they include a spring and a stud. The spring is made of cadmium-plated steel music wire and is usually riveted to an aircraft structural member. The stud comes in a number of designs (as shown in *Views A, B, and C*) and mounts in a dimpled hole in the cover assembly.

When the panel is being positioned on an aircraft, the spring riveted to the structural member enters the hollow center of the stud. Then, when the stud is turned about one-fourth turn, the curved jaws of the stud slip over the spring and compress it. The resulting tension locks the stud in place and secures the panel.

Miscellaneous Fasteners

Some fasteners cannot be classified as rivets, turnlocks, or threaded fasteners. Included in this category are connectors, couplings, clamps, taper and flat-head pins, snap rings, studs, and heli-coil inserts.

FLEXIBLE CONNECTORS AND COUPLINGS — A variety of clamping devices are used to connect ducting sections to each other or to various components. Whenever lines, components, or ducting are disconnected or removed for any reason, suitable plugs, caps, or coverings should be installed on the openings to prevent the entry of foreign materials. Various parts should also be tagged to ensure correct reinstallation. Care should be exercised during handling and installation to ensure that flanges are not scratched, distorted, or deformed. Flange surfaces should be free of dirt, grease, and corrosion. The protective flange caps should be left on the ends of the ducting until the installation progresses to the point that removal is necessary.

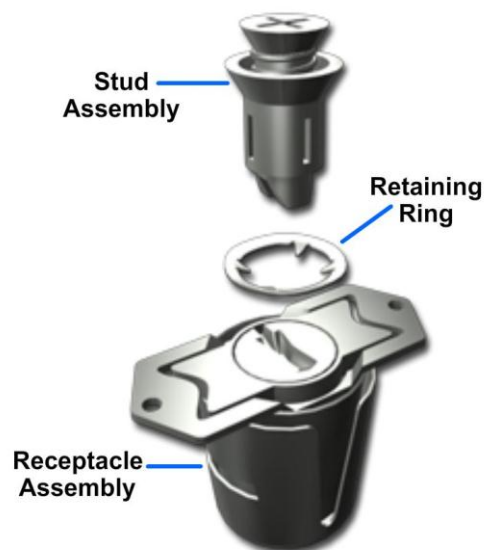


Figure 6-24 — Camloc high-stress panel fastener.

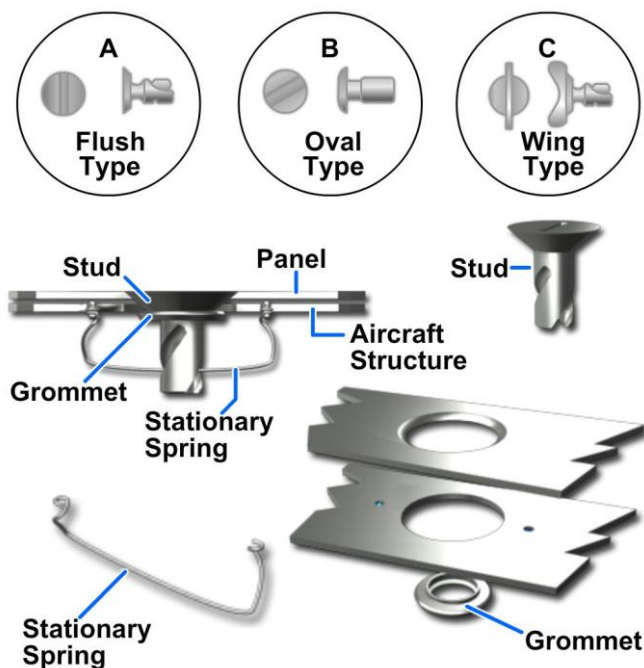


Figure 6-25 — Dzus fastener.

In most cases it is mandatory to discard and replace seals and gaskets. It is important to ensure that seals and gaskets are properly seated and that mating and alignment of flanges are fitted. This will prevent the excessive torque required to close the joint, which imposes structural loads on the clamping devices. Adjacent support clamps and brackets should remain loose until installation of the coupling has been completed.

Some of the most commonly used plain-band couplings are shown in *Figure 6-26*. When a hose is installed between two duct sections, the gap between the duct ends should be a minimum of 1/8 of an inch and a maximum of 3/4 of an inch. When the clamps are installed on the connection, the clamps should be 1/4 of an inch from the end of the connector. Misalignment between the ducting ends should not exceed 1/8 of an inch.

Marman clamps are commonly used in ducting systems and should be tightened to the torque value indicated on the coupling. Tighten all couplings in the manner and to the torque value specified on the clamp or in the applicable maintenance instruction manual (MIM).

When flexible couplings are installed—such as the one shown in *Figure 6-27*—the following steps are recommended to assure proper security:

1. Fold back half of the sleeve seal and slip it onto the sleeve.
2. Slide the sleeve (with the sleeve seal partially installed) onto the line.
3. Position the split sleeves over the line beads.
4. Slide the sleeve over the split sleeves and fold over the sleeve seal so it covers the entire sleeve.
5. Install the coupling over the sleeve seal and torque to correct value.

RIGID COUPLINGS — The rigid line coupling shown in *Figure 6-28* is referred to as a V-band coupling. When installed in restricted areas, some of the stiffness of the coupling can be overcome by tightening the coupling over a spare set of flanges and a gasket to the recommended torque value of the joint. Before the coupling is removed, it should be tapped a few times with a plastic mallet.

When rigid couplings are installed, the steps below should be followed:

1. Slip the V-band coupling over the flanged tube.

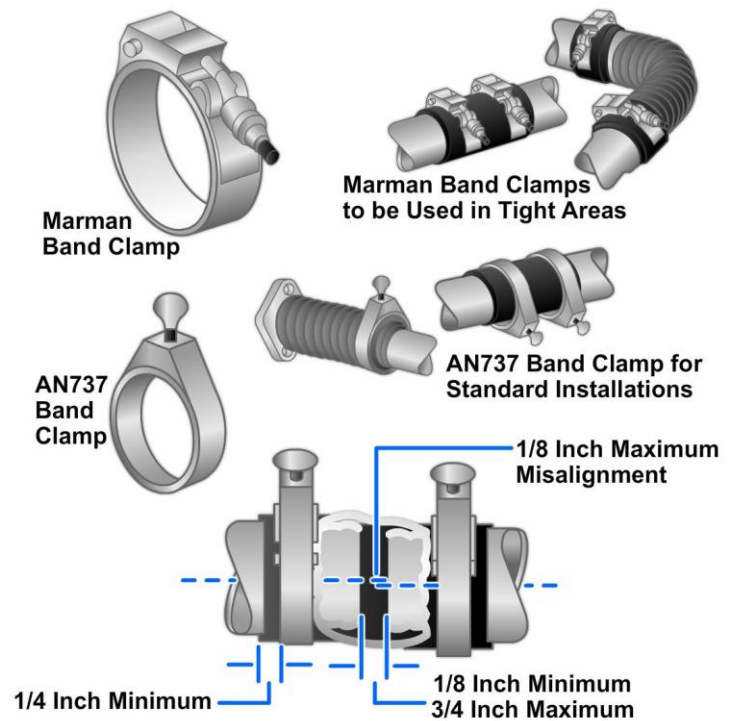


Figure 6-26 — Flexible line connectors.

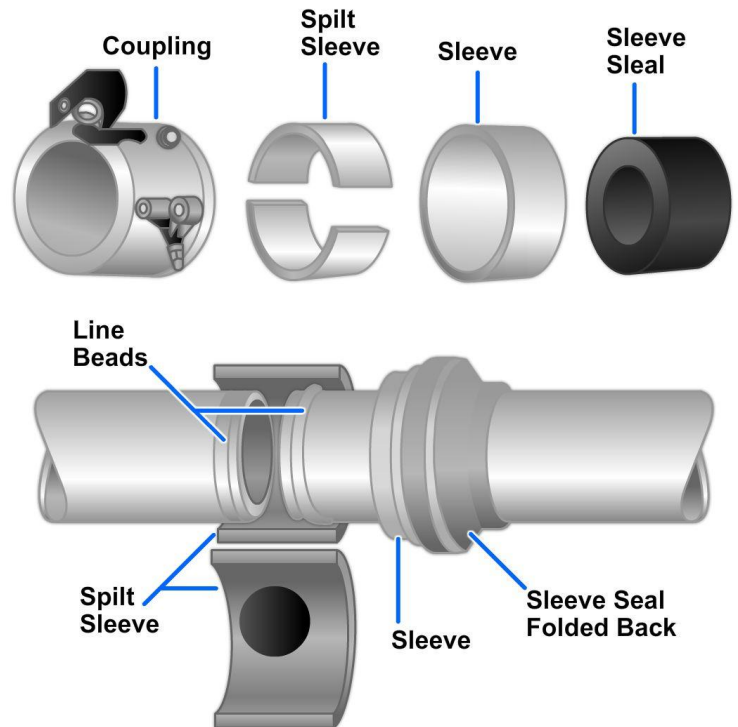


Figure 6-27 — Flexible line coupling.

2. Place a gasket into one flange. One quick rotary motion assures positive seating of the gasket.
3. Hold the gasket in place with one hand while the mating flanged tube is assembled into the gasket with a series of vertical and horizontal motions to assure the seating of the mating flange to the gasket.

NOTE

View B of Figure 6-28 shows the proper fitting and connecting of a rigid coupling using a metal gasket between the ducting flanges.

4. While holding the joint firmly with one hand, install the V-band coupling over the two flanges.
5. Press the coupling tightly around the flanges with one hand while engaging the latch.
6. Tighten the coupling firmly with a ratchet wrench. Tap the outer periphery of the coupling with a plastic mallet to assure proper alignment of the flanges in the coupling. This will seat the sealing edges of the flanges in the gasket. Tighten again, making sure the recommended torque is not exceeded.
7. Check the torque of the coupling with a torque wrench and tighten until the specified torque is obtained.
8. Safety wire the V-band coupling, as shown in *Figure 6-29*, as an extra measure of security in the event of T-bolt failure. The safety wire will be installed through the band loops that retain the T-bolt and the trunnion or quick coupler. A minimum of two turns of the wire is required. Most V-band connectors will use a T-bolt with some type of self-locking nut.

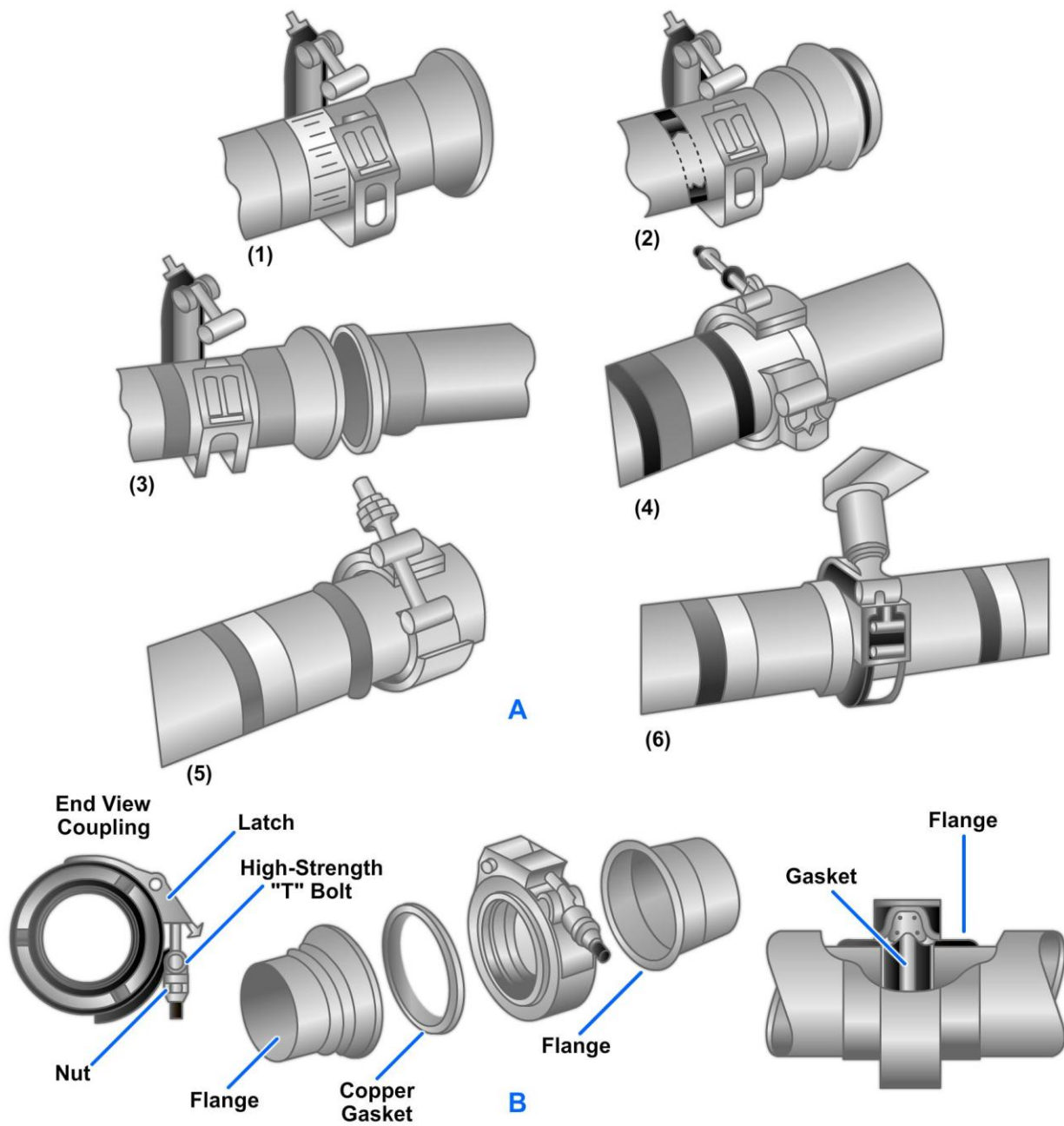


Figure 6-28 — Installation of rigid line couplings.

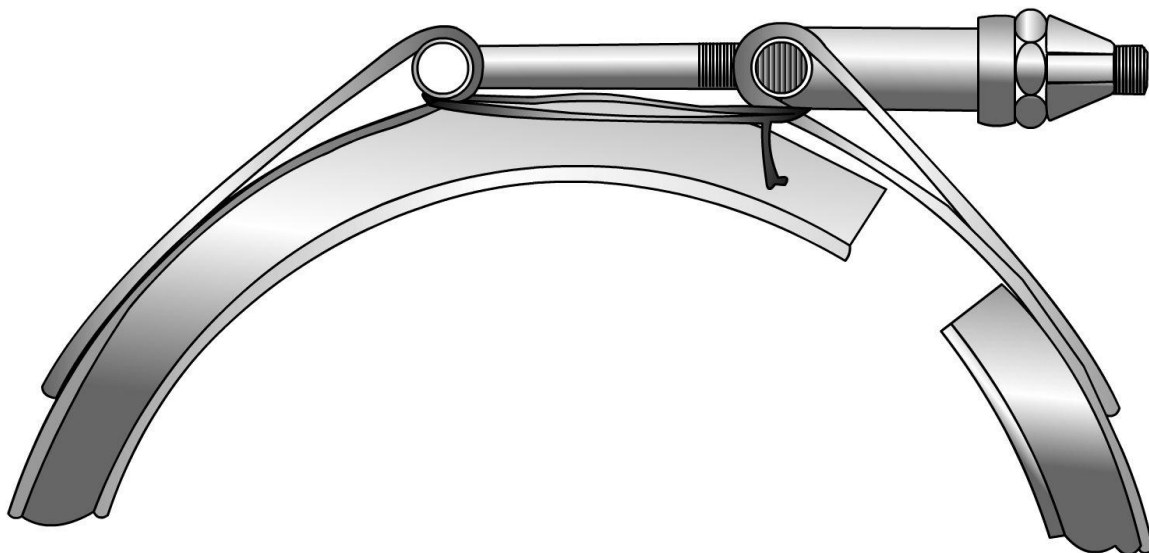


Figure 6-29 — Safelying a V-band coupling.

TAPER PINS — Taper pins are used in joints that carry shear loads and where the absence of clearance is essential. See *Figure 6-30*. The threaded taper pin is used with a taper pin washer and a shear nut if the taper pin is drilled, or with a self-locking nut if undrilled. When a shear nut is used with the threaded taper pin and washer, the nut is secured with a cotter pin.

FLAT-HEAD PINS — The flat-head pin is used with tie rod terminals or secondary controls that do not operate continuously. The flat-head pin should be secured with a cotter pin. The pin is normally installed with the head up. See *Figure 6-30*. This precaution is taken to maintain the flat-head pin in the installed position in case of cotter pin failure.

SNAP RINGS — A snap ring is a ring of metal, either round or flat in cross section, that is tempered to have springlike action. This springlike action will hold the snap ring firmly seated in a groove. The external types are designed to fit in a groove around the outside of

a shaft or cylinder. The internal types fit in a groove inside a cylinder. Special pliers are designed to install each type of snap ring.

Snap rings can be reused as long as they retain their shape and springlike action. External snap rings may be safety wired, but internal types are never safetied.

STUDS — There are four types of studs used in aircraft structural applications. They are the coarse thread, fine thread, stepped, and locking studs. Studs may be drilled or undrilled on the nut end. Coarse (NAS183) and fine (NAS184) thread studs are manufactured from alloy steel and are heat-treated. They have identical threads on both ends. The stepped stud has a different thread on each end of the stud. The locking stud may be substituted for undersize or oversize studs. The locking on this stud prevents it from backing out due to vibration, stress, or temperature variations. Refer to the *Structural Hardware Manual*, NAVAIR 01-1A-8, for more detailed information on studs.

HELI-COIL INSERTS — Heli-coil thread inserts are primarily designed to be used in materials that are not suitable for threading because of their softness. The inserts are made of a diamond cross-sectioned stainless steel wire that is helically coiled and, in its finished form, is similar to a small, fully compressed spring. There are two types of heli-coil inserts. See *Figure 6-31*. One is the plain insert,

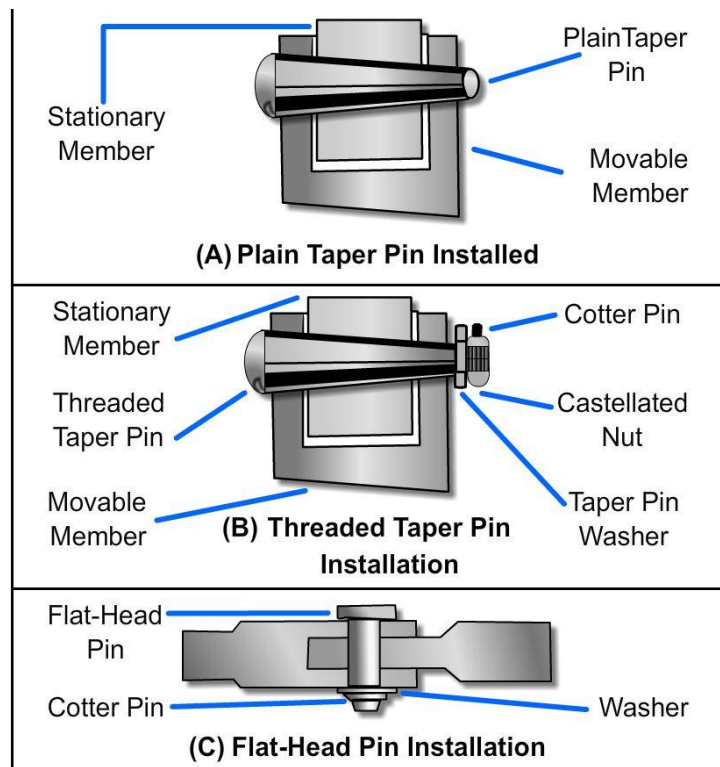


Figure 6-30 — Types of aircraft pins.

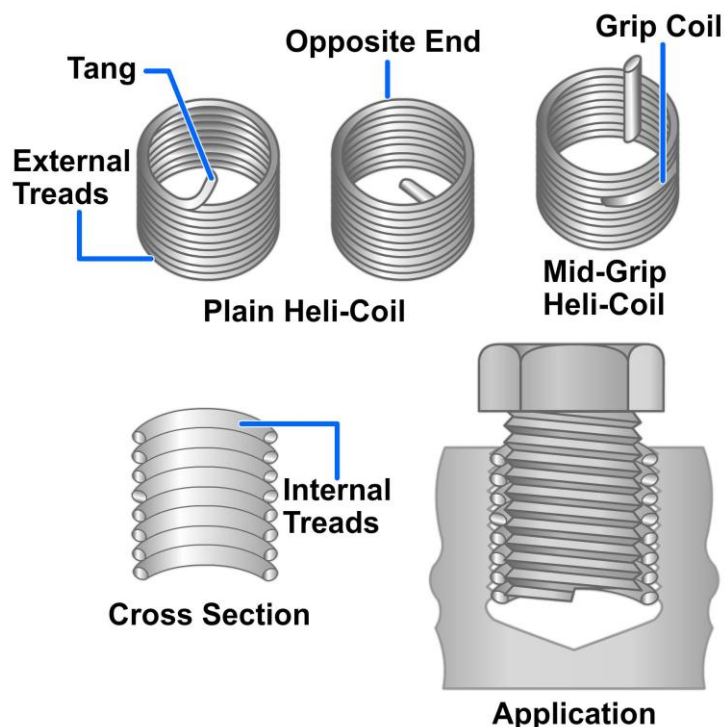


Figure 6-31 — Heli-coil insert.

made with a tang that forms a portion of the bottom coil offset and is used to drive the insert. This tang is left on the insert after installation, except when its removal is necessary to provide clearance for the end of the bolt. The tang is notched to break off from the body of the insert, thereby providing full penetration for the fastener.

The second type of insert used is the self-locking, mid-grip insert, which has a specially formed grip coil midway on the insert. This produces a gripping effect on the engaging screw. For quick identification, the self-locking, mid-grip inserts are dyed red.

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*. The lay of the cable is an important factor in its strength. If the strands are twisted in a direction opposite to the twist of the strands around the center strand or core, the cable will not stretch (or set) as much as one in which they are all twisted in the same direction. This direction of twist (in opposite direction) is most commonly adopted, and it is called a *regular* or an *ordinary lay*. Cables may have a right regular lay or a left regular lay. If the strands are twisted in the direction of twist around the center strand or core, the lay is called a *lang lay*. There is a right and left lang lay. The only other twist arrangement—twisting the strands alternately right and left, and then twisting them all either to the right or to the left about the core—is called a *reverse lay*. Most aircraft cables have a right regular lay.

When aircraft cables are manufactured, each strand is first formed to the spiral or helical shape to fit the position it is to occupy in the finished cable. The process of such forming is called preforming, and cables made by such a process are said to be *preformed*. The process of preforming is adopted to ensure flexibility in the finished cable and to relieve bending and twisting stresses in the strands as they are woven into the cable. It also keeps the strands from spreading when the cable is cut. All aircraft cables are internally lubricated during construction.

Aircraft control cables are fabricated either from flexible, preformed carbon steel wire or from flexible, preformed, corrosion-resistant steel wire. The small corrosion-resistant steel cables are made of steel containing not less than 17 percent chromium and 8 percent nickel, while the larger ones (those of the 5/16-, 3/8-, and 7/16-inch diameters) are made of steel that, in addition to the amounts of chromium and nickel just mentioned, also contains not less than 1.75 percent molybdenum.

Cables may be designated 7 × 7, 7 × 19, or 6 × 19 according to their construction. A 7 × 7 cable consists of six strands of seven wires each, laid around a center strand of seven wires. A 7 × 19 cable consists of six strands of 19 wires, laid around a 19-wire central strand. A 6 × 19 IWRC cable consists of six strands of 19 wires each, laid around an independent wire rope center.

The size of cable is given in terms of diameter measurement. A 1/8-inch cable or a 5/16-inch cable means that the cable measures 1/8 inch or 5/16 inch in diameter, as shown in *Figure 6-32*. Note that the cable diameter is that of the smallest circle that would enclose the entire cross section of the cable. Aircraft control cables vary in diameters, ranging from 1/16 of an inch to 3/8 of an inch.

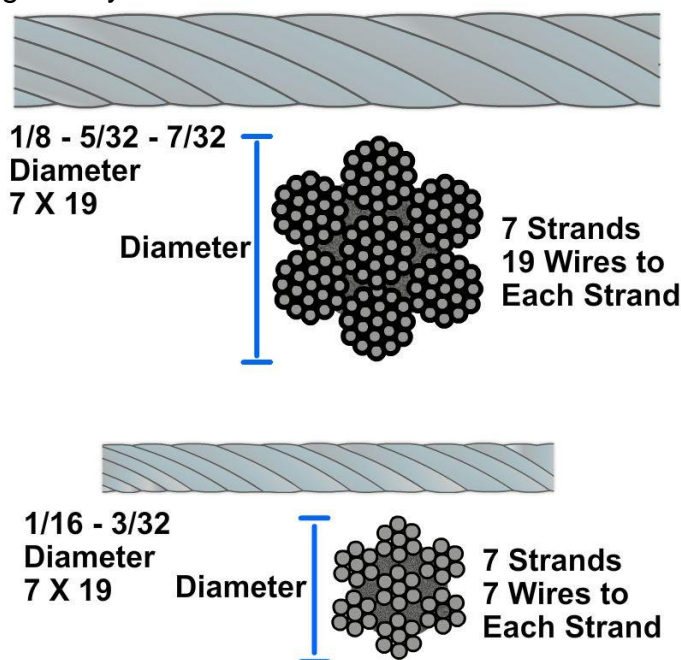


Figure 6-32 — Cable cross section.

Fittings

Cable ends may be equipped with several different types of fittings such as terminals, thimbles, bushings, and shackles. Terminal fittings are generally of the swaged type. Terminal fittings are available with threaded ends, fork ends, eye ends, and single-shank and double-shank ball ends.

Threaded-end, fork-end, and eye-end terminals are used to connect the cable to turnbuckles, bell cranks, and other linkage in the system. The ball terminals are used for attaching cable to quadrants and special connections where space is limited. The single-shank ball end is usually used on the ends of cables, and the double-shank ball end may be used either at the ends or in the center of a cable run. *Figure 6-33* shows the various types of terminal fittings.

Thimble, bushing, and shackle fittings may be used in place of some types of terminal fittings when facilities and supplies are limited and immediate replacement of the cable is necessary. *Figure 6-34* shows these fittings.

Turnbuckles

A turnbuckle is a mechanical screw device that consists of two threaded terminals and a threaded barrel. *Figure 6-35* shows a typical turnbuckle assembly. Turnbuckles are fitted in the cable assembly to make minor adjustments in cable length and to adjust 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 threads internally. The end of the barrel, with left-hand threads inside, can usually be identified by either a groove or knurl around the end of the barrel. Barrels and terminals are available in both long and short lengths.

When you install a turnbuckle in a control system, it is necessary to screw both of the terminals an equal number of turns into the turnbuckle barrel. It is also essential that all turnbuckle terminals be screwed into the barrel, at least, until not more than three threads are

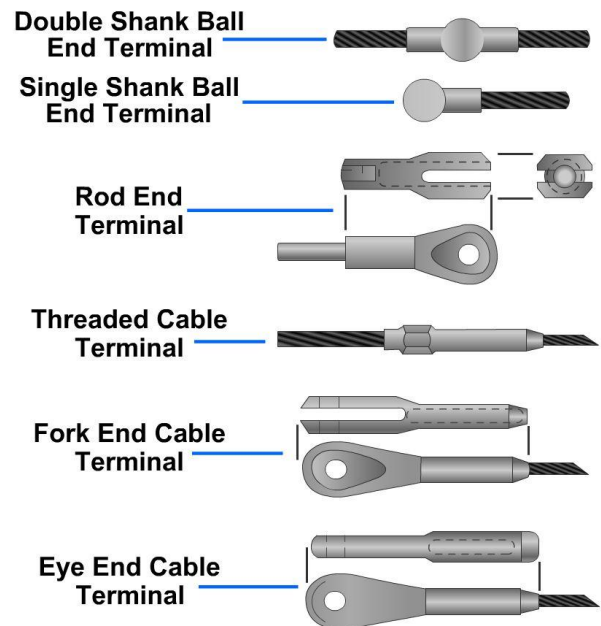


Figure 6-33 — Types of cable terminal fittings.

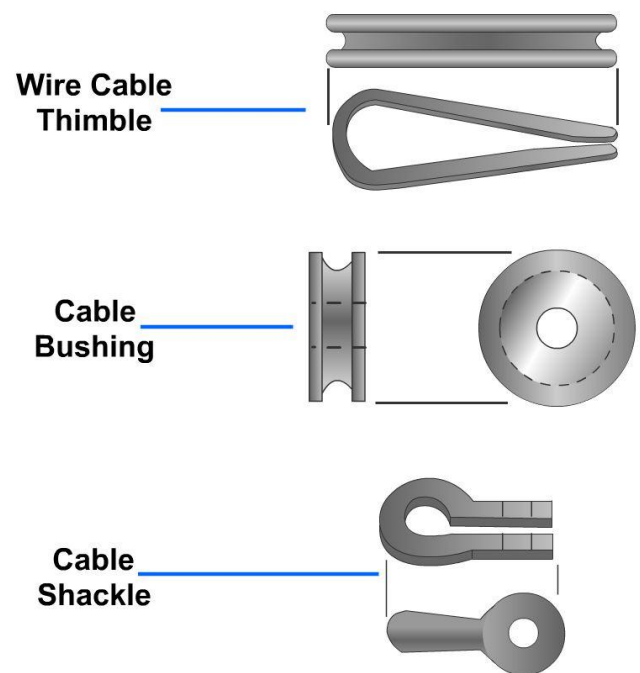


Figure 6-34 — Thimble, bushing, and shackle fittings.

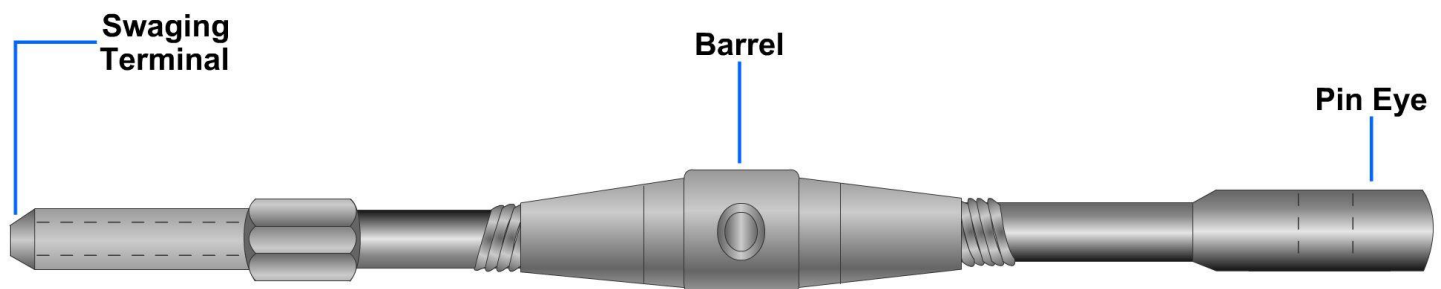


Figure 6-35 — Typical turnbuckle assembly.

exposed. On initial installation, the turnbuckle terminals should not be screwed inside the turnbuckle barrel more than four threads. *Figure 6-36* shows turnbuckle thread tolerances.

After a turnbuckle is properly adjusted, it must be safetied. There are several methods of safetying turnbuckles. However, only two methods have been adopted as standard procedures by the services: the clip-locking (preferred) method and the wire-wrapping method.

Adjustable Connector Links

An adjustable connector link consists of two or three metal strips with holes arranged that they may be matched and secured with a clevis bolt to adjust the length of the connector. They are installed in cable assemblies to make major adjustments in cable length and to compensate for cable stretch. Adjustable connector links are usually used in very long cable assemblies.

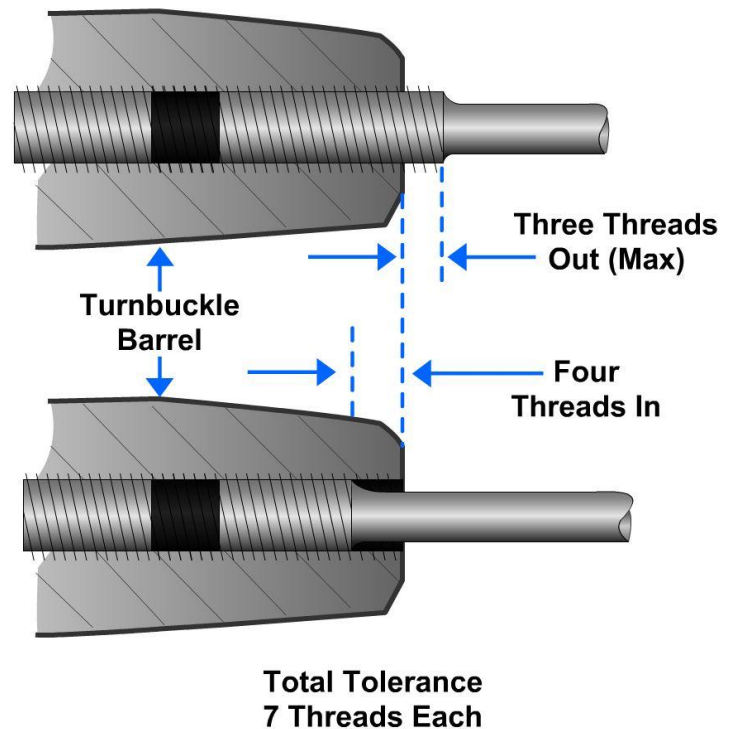


Figure 6-36 — Turnbuckle thread tolerances.

GUIDES

Fairleads (rubstrips), grommets, pressure seals, and pulleys are all types of cable guides. They are used to protect control cables by preventing the cables from rubbing against nearby metal parts. They are also used as supports to reduce cable vibration in long stretches (runs) of cable. *Figure 6-37* shows some typical cable guides.

Fairleads

Fairleads may be made of a solid piece of material to completely encircle cables when they pass through holes in bulkheads or other metal parts. Fairleads may be used to

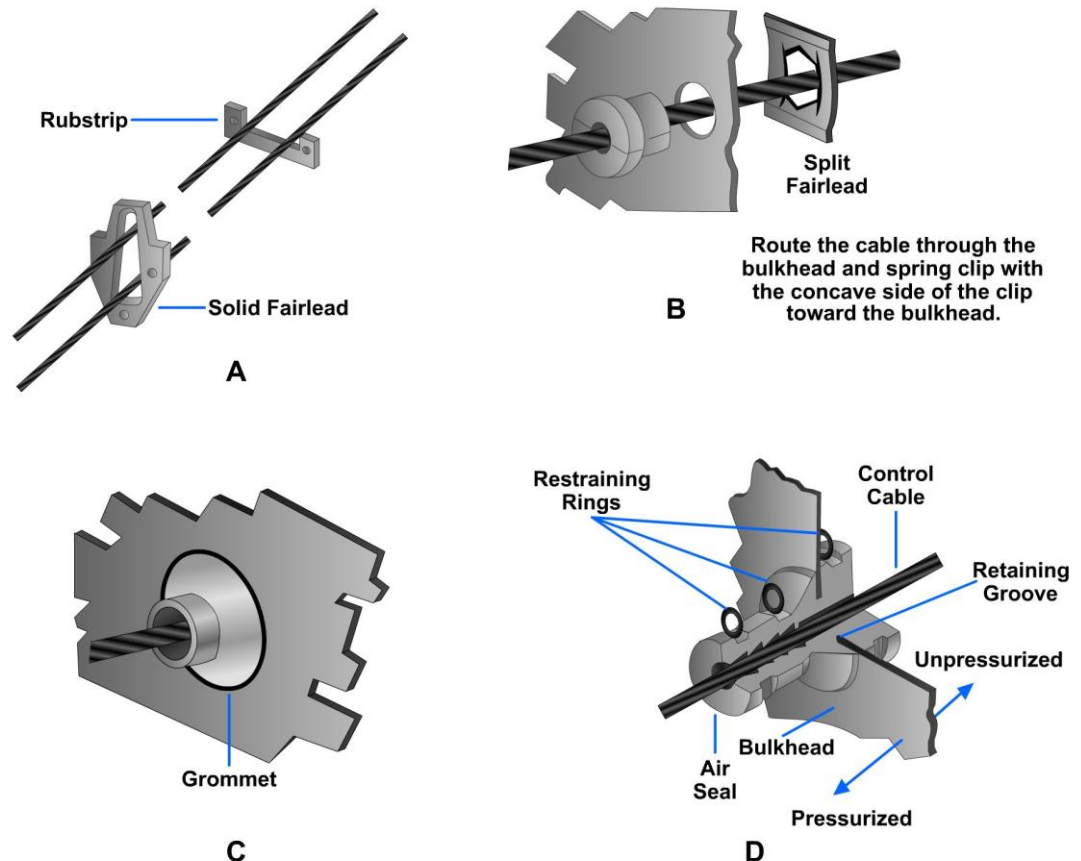


Figure 6-37 — Typical cable guides.

reduce cable whipping and vibration in long runs of cable. Split fairleads are made for easy installation around single cables to protect them from rubbing on the edges of holes.

Grommets

Grommets are made of rubber, and they are used on small openings where single cables pass through the walls of unpressurized compartments.

Pressure Seals

Pressure seals are used on cables or rods that must move through pressurized bulkheads. They fit tightly enough to prevent air pressure loss, but not so tightly as to hinder movement of the unit.

Pulleys

Pulleys (or sheaves) are grooved wheels used to change cable direction and to allow the cable to move with a minimum of friction. Most pulleys used on aircraft are made from layers of cloth impregnated with phenolic resin and fused together under high temperatures and pressures. Aircraft pulleys are extremely strong and durable and cause minimum wear on the cable passing over them. Pulleys are provided with grease-sealed bearings and usually do not require further lubrication. However, pulley bearings may be pressed out, cleaned, and relubricated with special equipment. This is usually done by depot-level maintenance activities.

Pulley brackets made of sheet or cast aluminum are required with each pulley installed in the aircraft.

See *Figure 6-38*. Besides holding the pulley in the correct position and at the correct angle, the brackets prevent the cable from slipping out of the groove on the pulley wheel.

SECTORS AND QUADRANTS

These units are generally constructed in the form of an arc or in a complete circular form. They are grooved around the outer circumference to receive the cable, as shown in *Figure 6-38*. The terms *sector* and *quadrant* are used interchangeably. Sectors and quadrants are similar to bell cranks and walking beams, which are used for the same purpose in rigid control systems.

AIRCRAFT ELECTRICAL HARDWARE

An important part of aircraft electrical maintenance is determining the correct type of electrical hardware for a given job. These maintenance functions normally require a joint effort on the part of the AM and the Aviation Electrician/Aviation Electronics Technician (AE/AT) personnel. It is important to become familiar with wire and cable, connectors, terminals, and bonding and bonding devices.

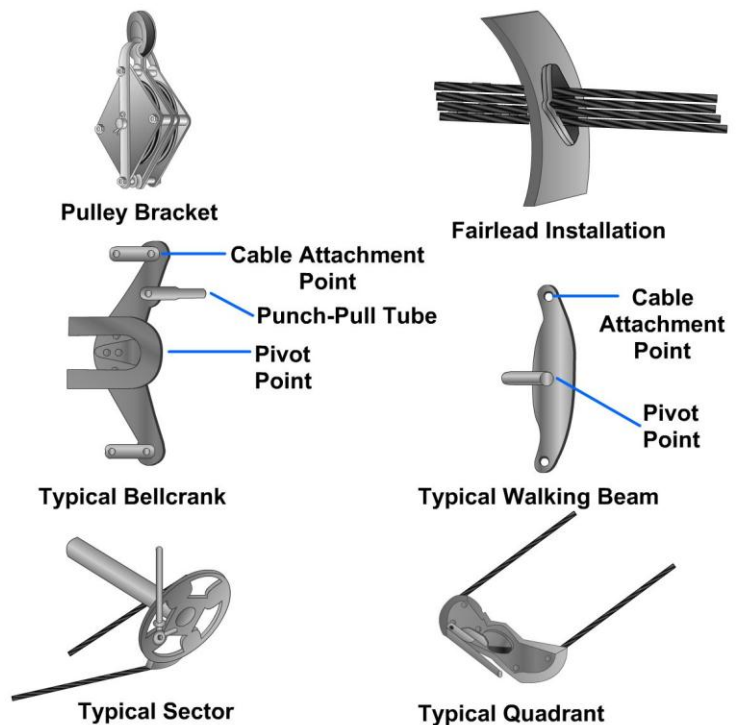


Figure 6-38 — Control system components.

WIRE AND CABLE

For purposes of electrical installations, a *wire* is defined as a stranded conductor covered with an insulating material. The term *cable*, as used in aircraft electrical installations, includes the following:

- Two or more insulated conductors contained in the same jacket (multiconductor cable)
- Two or more insulated conductors twisted together (twisted pair)
- One or more insulated conductors covered with a metallic braided shield (shielded cable)
- A single insulated conductor with a metallic braided outer conductor (RF cable)

For wire replacement work, the aircraft MIM should be consulted first. The manual should list the wire used in a given aircraft.

CONNECTORS

Connectors are devices attached to the ends of cables and sets of wires to make them easier to connect and disconnect. Each connector consists of a plug assembly and a receptacle assembly. The two assemblies are coupled by means of a coupling nut. Each consists of an aluminum shell containing an insulating insert that holds the current-carrying contacts. The plug is usually attached to the cable end and is the part of the connector on which the coupling nut is mounted. The receptacle is the half of the connector to which the plug is connected. It is usually mounted on a part of the equipment. One type of connector assembly commonly used in aircraft electrical systems is shown in *Figure 6-39*.

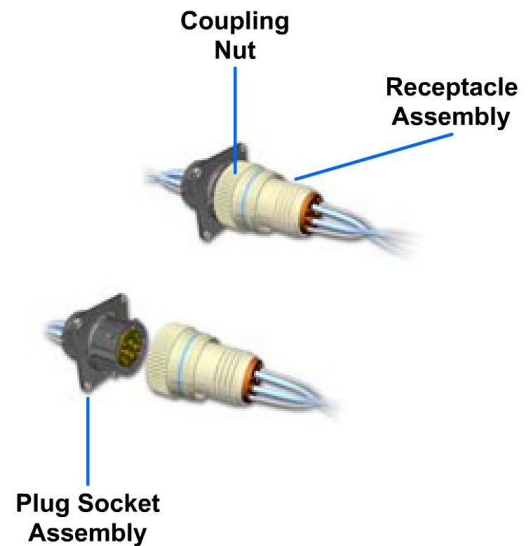


Figure 6-39 — Connector assembly.

TERMINALS

Since most aircraft wires are stranded, it is necessary to use terminal lugs to hold the strands together. This allows a means of fastening the wires to terminal studs. The terminals used in electrical wiring are either of the soldered or crimped type. Terminals used in repair work must be of the size and type specified in the applicable MIM. The solderless crimped-type terminals are generally recommended for use on naval aircraft. Soldered-type terminals are usually used in emergencies only.

The basic types of solderless terminals are shown in *Figure 6-40*. They are the straight, right angle, flag, and splice types. There are variations of these types.

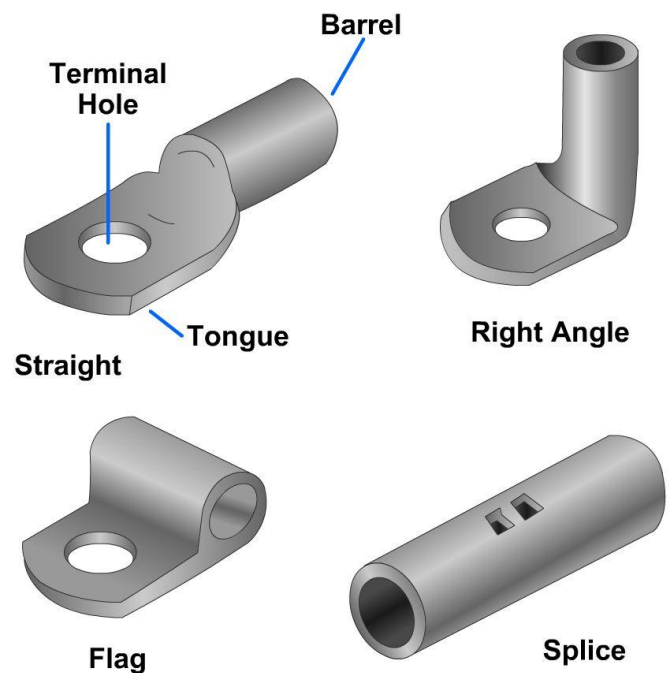


Figure 6-40 — Basic types of solderless terminals.

BONDING

An aircraft can become highly charged with static electricity while in flight. If the aircraft is improperly bonded, not all metal parts have the same amount of static charge. A difference of potential exists between the various metal surfaces. If the resistance between insulated metal surfaces is great enough, charges can accumulate. The potential difference could become high enough to cause a spark. This constitutes a fire hazard and also causes radio interference. If lightning strikes an aircraft, a good conducting path for heavy current is necessary to minimize severe arcing and sparks.

When all metal parts of an aircraft are connected to complete an electrical unit, the result is called *bonding*. Bonding connections are made of screws, nuts, washers, clamps, and bonding jumpers.

Figure 6-41 shows a typical bonding link installation.

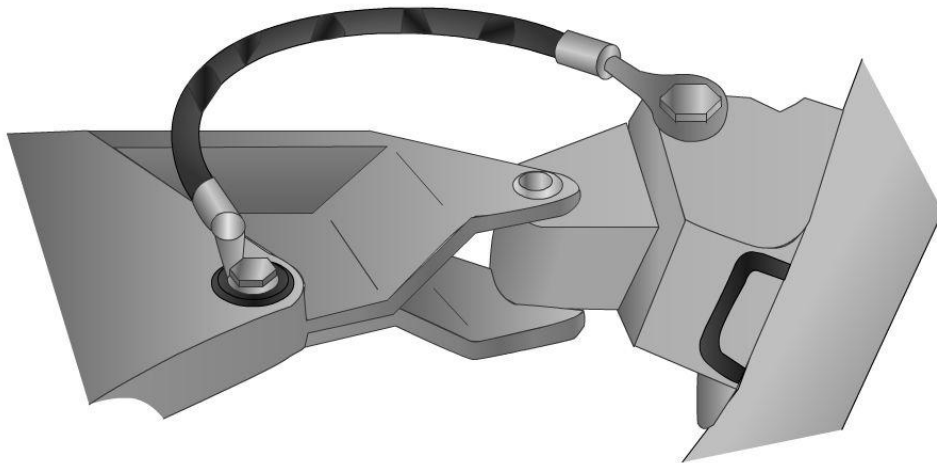


Figure 6-41 — Typical bonding link installation.

Bonding also provides the necessary low-resistance return path for single-wire electrical systems. This low-resistance path provides a means of bringing the entire aircraft to the earth's potential when it is grounded.

When an inspection is performed, both bonding connections and safetying devices must be inspected with great care.

STATIC DISCHARGERS

Static dischargers are commonly known as *static wicks* or *static discharge wicks*. They are used on aircraft to allow the continuous satisfactory operation of onboard navigation and radio communication systems. During adverse charging conditions, they limit the potential static buildup on the aircraft and control interference generated by static charge. Static dischargers are not lightning arrestors and do not reduce or increase the likelihood of an aircraft being struck by lightning. Static dischargers are subject to damage or significant changes in resistance characteristics as a result of lightning strike to the aircraft, and they should be inspected after a lightning strike to ensure proper static discharge operation.

Static dischargers are fabricated with a wick of wire or a conductive element on one end, which provides a high-resistance discharge path between the aircraft and the air. See Figure 6-42. They are attached on some aircraft to the

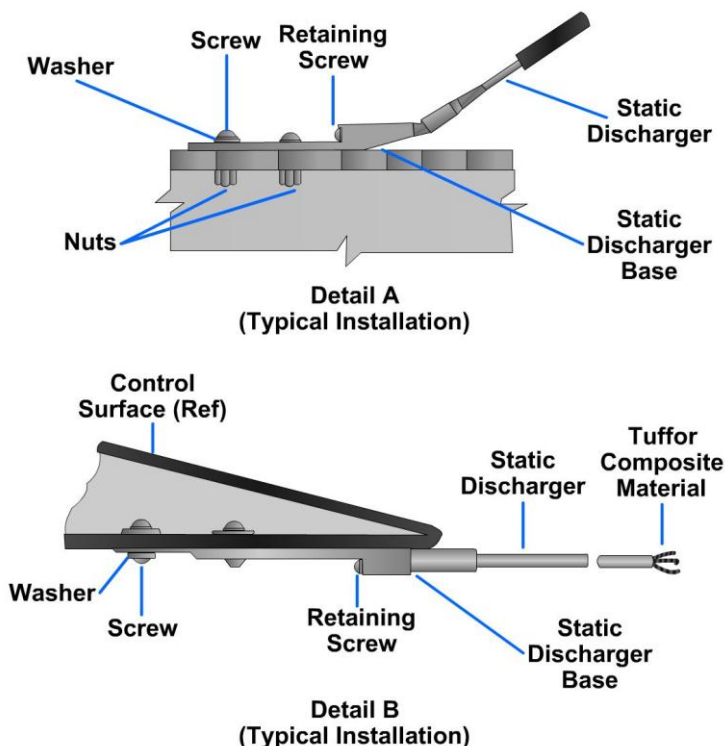


Figure 6-42 — Typical static dischargers.

ailerons, elevators, rudder, wing, horizontal and vertical stabilizer tips, etc. Refer to your aircraft's MIM for maintenance procedures.

TORQUING OF FASTENERS

Fastener fatigue failure accounts for the majority of all fastener problems. Fatigue breaks are caused by insufficient tightening and the lack of proper preload or clamping force. This results in movement between the parts of the assembly and the bending back and forth or cyclic stressing of the fastener. Eventually, cracks will progress to the point that the fastener can no longer support its designed load. At this point the fastener fails with varying consequences.

TYPES OF TORQUE WRENCHES

The two most commonly used torque wrenches are the dial indicating type and the setting or click type.

Dial Indicating Type

This torque wrench measures change in applied torque through a deflecting member. A dial or digital readout is located below the handle to permit convenient and accurate reading. Indicating torque wrenches operate in clockwise and counterclockwise directions.

Setting or Click Type

This type of wrench compares the applied load to a self-contained standard. Reset is automatic upon release of applied load.

TORQUING PROCEDURES

For the nut to properly load the bolt and prevent premature failure, a designated amount of torque must be applied. Proper torque reduces the possibility of the fastener loosening while in service. The correct torque to apply when you are tightening an assembly is based on many variables. The fastener is subjected to two stresses when it is tightened. These stresses are tension and torsion. Tension is the desired stress, while torsion is the undesirable stress caused by friction. A large percentage of applied torque is used to overcome this friction, so that only tension remains after tightening. Proper tension reduces the possibility of fluid leaks.

The recommended torque values provided in *Table 6-2* have been established for average dry, cadmium-plated nuts for both the fine and coarse thread series. Thread surface variations such as paint, lubrication, hardening, plating, and thread distortion may alter these values considerably. The torque values must be followed unless the MIM or structural repair manual for the specific aircraft requires a specific torque for a given nut. Torque values vary slightly among manufacturers. When the torque values are included in a technical manual, these values take precedence over the standard torque values provided in the *Structural Hardware Technical Manual*, NAVAIR 01-1A-8.

Separate torque tables and torquing considerations are provided in NAVAIR 01-1A-8 for the large variety of nuts, bolts, and screws used in aircraft construction. This manual should be used when specific torque values are not provided as a part of the removal/replacement instructions.

To obtain values in foot-pounds, inch-pound values should be divided by 12. Nuts or bolts should not be lubricated except for corrosion-resistant steel parts or where specifically instructed to do so. If possible, it should always be tightened by rotating the nut first. When space considerations make it necessary to tighten the fastener by rotating the bolt head, the high side of the indicated torque range should be approached without exceeding the maximum allowable torque value. Maximum torque

ranges should be used only when materials and surfaces being joined are of sufficient thickness, area, and strength to resist breaking, warping, or other damage.

For corrosion-resistant steel nuts, the torque values given for shear-type nuts should be used. The use of any type of drive-end extension on a torque wrench changes the dial reading required to obtain the actual values indicated in the torque range tables. See *Figure 6-43*.

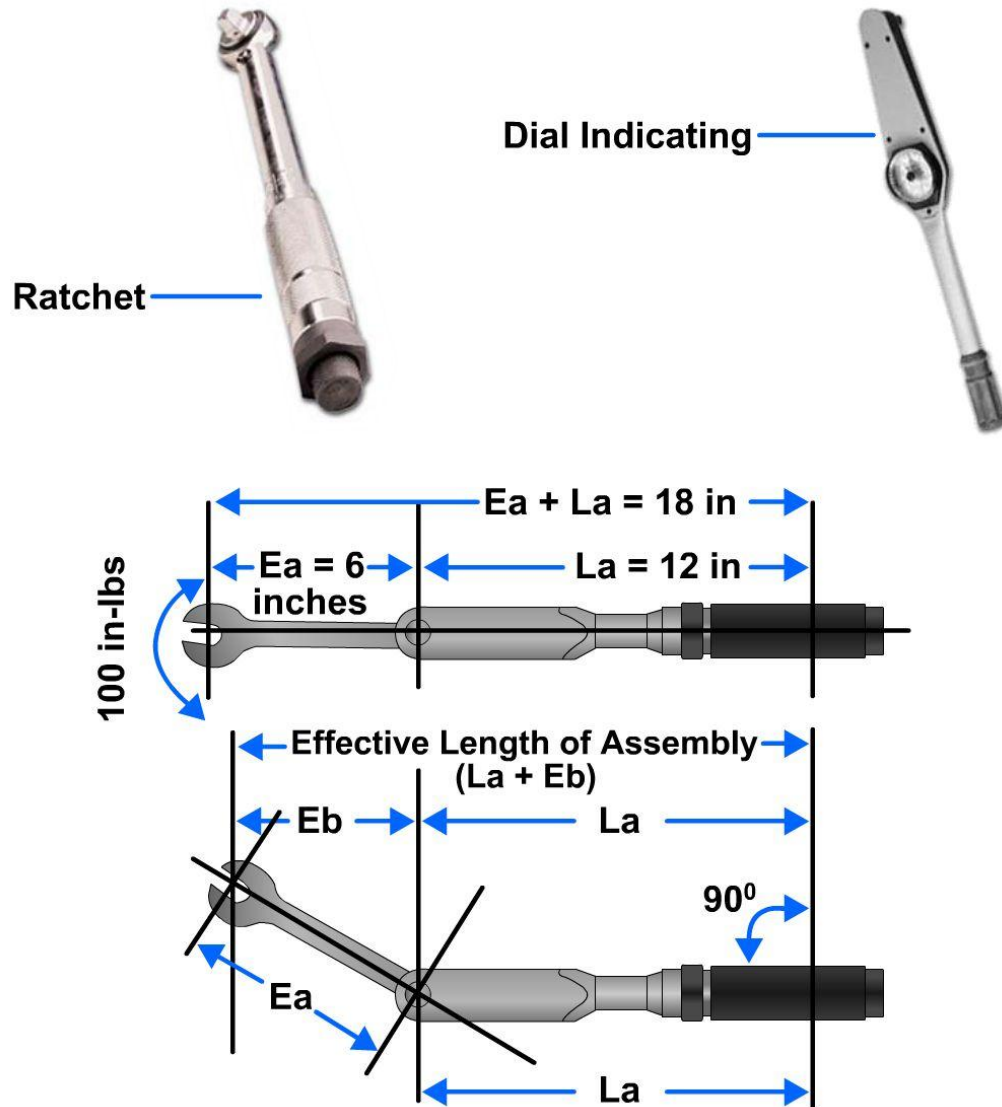


Figure 6-43 — Torque wrenches.

Table 6-2 — Recommended Torque Values (Inch-Pounds)

CAUTION THE FOLLOWING TORQUE VALUES ARE DERIVED FROM OIL-FREE CADMIUM-PLATED THREADS.				
TORQUE LIMITS RECOMMENDED FOR INSTALLATION (BOLTS LOADED PRIMARILY IN SHEAR)		MAXIMUM ALLOWABLE TIGHTENING TORQUE LIMITS		
Tap Size	Tension-type nuts MS20365 and AN310 (40,000 psi in bolts)	Shear-type nuts MS20364 and AN320 (24,000 psi in bolts)	Nuts MS20365 and AN310 (90,000 psi in bolts)	Nuts MS20364 and AN320 (54,000 psi in bolts)
FINE THREAD SERIES				
8-36	12-15	7-9	20	12
10-32	20-25	12-15	40	25
1/4-28	50-70	30-40	100	60
5/16-24	100-140	60-85	225	140
3/8-24	160-190	95-110	390	240
7/16-20	450-500	270-300	840	500
1/2-20	480-690	290-410	1,100	660
9/16-18	800-1000	480-600	1,600	960
5/8-18	1,100-1,300	600-780	2,400	1,400
3/4-16	2,300-2,500	1,300-1,500	5,000	3,000
7/8-14	2,500-3,000	1,500-1,800	7,000	4,200
1-14	3,700-5,500	2,200-3,300*	10,000	6,000
1 1/8-12	5,000-7,000	3,000-4,200*	15,000	9,000
1 1/4-12	9,000-11,000	5,400-6,600*	25,000	15,000
COARSE THREAD SERIES				
8-32	12-15	7-9	20	12
10-24	20-25	12-15	35	21
1/4-20	40-50	25-30	75	45
5/16-18	80-90	48-55	160	100
3/8-16	160-185	95-100	275	170
7/16-14	235-255	140-155	475	280
1/2-13	400-480	240-290	880	520
9/16-12	500-700	300-420	1,100	650
5/8-11	700-900	420-540	1,500	900
3/4-10	1,150-1600	700-950	2,500	1,500
7/8-9	2,200-3000	1,300-1,800	4,600	2,700
The above torque values may be used for all cadmium-plated steel nuts of the fine or coarse thread series, which have approximately equal number of threads and equal face bearing areas. *Estimated corresponding values.				

TORQUING COMPUTATION

When using a drive-end extension, you must compute the torque wrench reading using the formula in *Figure 6-44*:

$$S = \frac{T \times L_a}{L_a + E_a}$$

Figure 6-44 — Drive-end extension formula.

Where:

S = handle setting or reading

T = torque applied at end of adapter

L_a = length of handle in inches

E_a = length of extension in inches

To exert 100 inch-pounds at the end of the wrench and extension, when L_a equals 12 inches and E_a equals 6 inches, it is possible to determine the handle setting by making the calculation shown in *Figure 6-45*.

$$S = \frac{T \times L_a}{L_a + E_a}$$
$$S = \frac{100 \times 12}{12 + 6}$$
$$S = \frac{1200}{18}$$

S = 66.7 inchpounds

Figure 6-45 — Sample calculation.

Whenever possible, attach the extension in line with the torque wrench. When it is necessary to attach the extension at an angle to the torque wrench, the effective length of the assembly will be L_a + E_a, as shown in *Figure 6-43*. In this instance, length E_b must be substituted for length E_a in the formula.

AIRCRAFT SAFETYING METHODS

There are many different types of safetying materials used to stop rotation and other movement of fasteners. They are used to secure other equipment that may come loose due to vibration in the aircraft.

COTTER PINS

Cotter pins are used to secure bolts, screws, nuts, and pins. Some cotter pins are made of low-carbon steel, while others consist of stainless steel and are more resistant to corrosion. Also, stainless steel cotter pins may be used in locations where nonmagnetic material is required. Regardless of shape or material, all cotter pins are used for the same general purpose—safetying. *Figure 6-46* shows three types of cotter pins and how their size is determined.

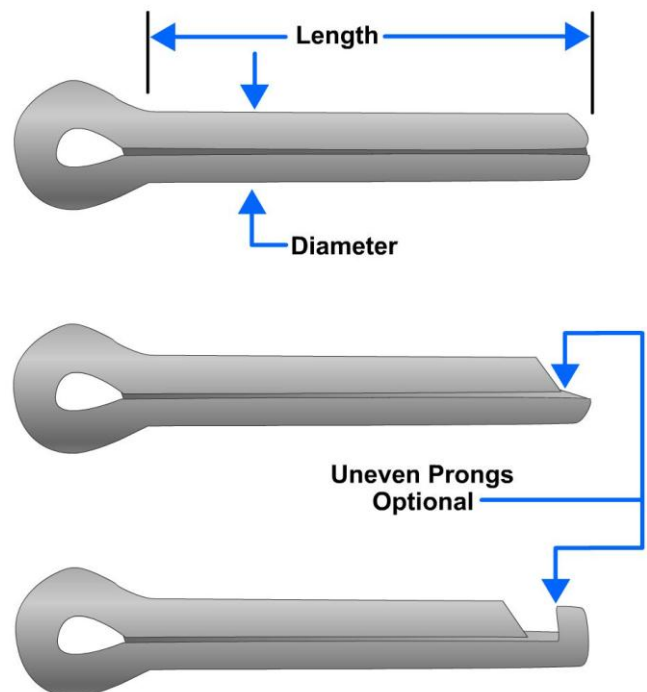


Figure 6-46 — Types of cotter pins.

NOTE

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

SAFETY WIRE

Safety wire comes in many types and sizes. First, the correct type and size of wire for the job must be selected. Annealed corrosion-resistant wire is used in high-temperature, electrical equipment and aircraft instrument applications. All nuts—except the self-locking types—must be safetied; the method used depends upon the particular installation.

Figure 6-47 shows various methods commonly used to safety wire nuts, bolts, and screws. Examples 1, 2, and 5 in Figure 6-47 show the proper method 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. The following general rules apply to safety wiring:

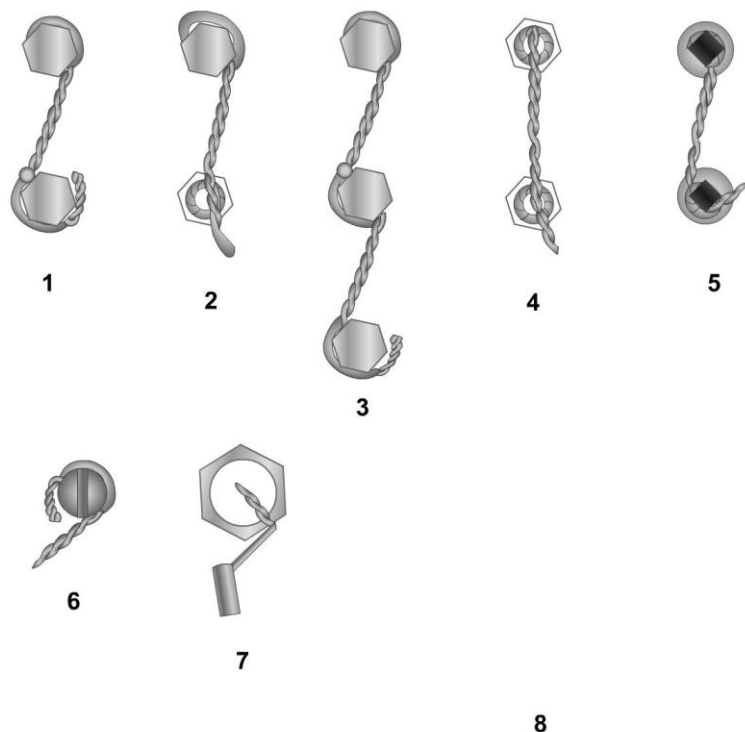


Figure 6-47 — Safety wiring methods.

1. All safety wires must be tight after installation, but not under so much tension that normal handling or vibration will break the wire.
2. The wire must be applied so that all pull exerted by the wire tends to tighten the nut.
3. Twists should be tight and even, and the wire between nuts as taut as possible without over twisting. Wire between nuts should be twisted with the hands. The use of pliers will damage the wire. Pliers may be used only for final end twist before cutting excess wire.

Annealed copper safety wire is used for sealing first aid kits, portable fire extinguishers, oxygen regular emergency valves, and other valves and levers used for emergency operation of aircraft equipment. This wire can be broken by hand in case of an emergency.

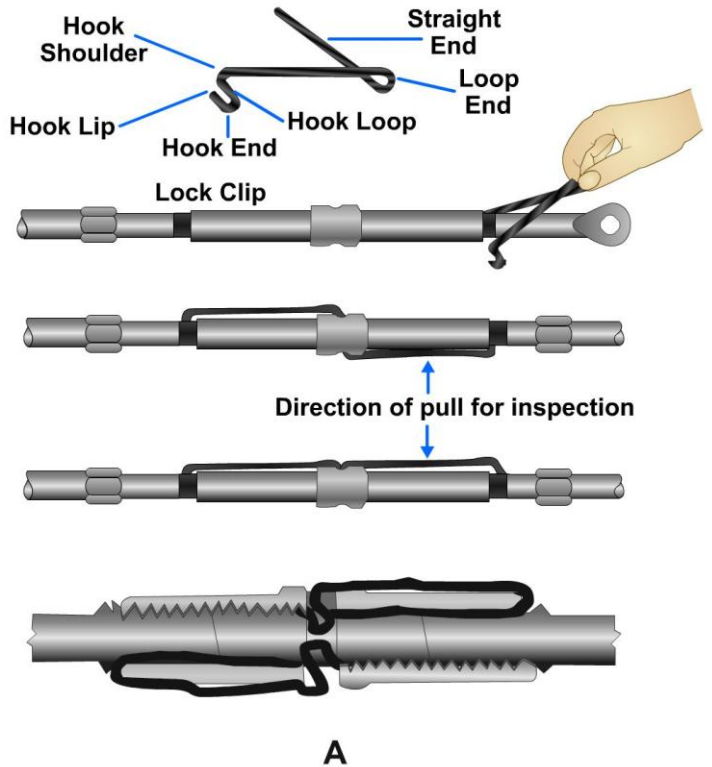
TURNBUCKLE SAFETYING

When adjustments and rigging on the cables are completed, the turnbuckles should be safetied as necessary. Only two methods of safetying turnbuckles have been adopted as standard procedures by the armed services: the clip-locking method (preferred) and the wire-wrapping method (*Figure 6-48*).

Lock clips must be examined after assembly for proper engagement of the hook lip in the turnbuckle barrel hole by the application of slight pressure in the disengaging direction. Lock clips must not be reused, as removal of the clips from the installed position will severely damage them.

Clip-Locking Turnbuckles

The clip-locking method of safetying uses a NAS lock clip. To safety the turnbuckle, the slot in the barrel must be aligned with the slot in the cable terminal by holding the lock clip between the thumb and forefinger at the end loop. The straight end of the clip should be inserted into the aperture formed by the aligned slots by bringing the hook end of the lock clip over the hole in the center of the turnbuckle barrel and seating the hook loop into the hole. Application of pressure to the hook shoulder at the hole will engage the hook lip in the turnbuckle barrel and complete the safety locking of one end. The above steps are then repeated on the opposite end of the turnbuckle barrel. Both locking clips may be inserted in the same turnbuckle barrel hole, or they may be inserted in opposite holes.



Wire-Wrapping Turnbuckles

First, two safety wires are passed through the hole in the center of the turnbuckle barrel. The ends of the wires are bent 90 degrees toward the ends of the turnbuckle, as shown in *Figure 6-48*.

Next, the ends of the wires are passed through the holes in the turnbuckle eye or between the jaws of the turnbuckle fork, as applicable. The wires are then bent toward the center of the turnbuckle, and each one wrapped four times around the shank. This secures the wires in place.

When a swaged turnbuckle terminal is being safetied, one wire must be passed through the hole provided for this purpose in the terminal. It is then looped over the free end of the other wire, and both ends wrapped around the shank.

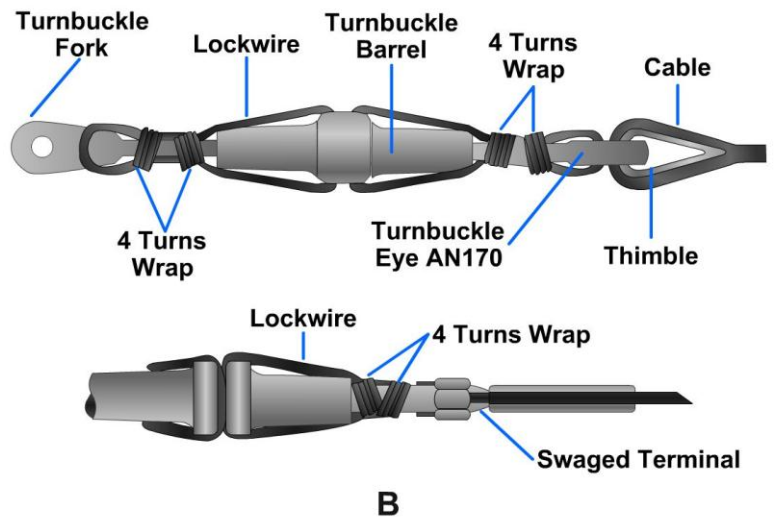


Figure 6-48 — Safetying turnbuckles: (A) Clip-locking method (preferred); (B) wire-wrapping method.

End of Chapter 6

Aircraft Hardware

Review Questions

- 6-1. Solid rivets are classified according to what three factors?
- A. Alloy, length, shape
 - B. Corrosion resistance, strength, alloy
 - C. Material, head style, diameter
 - D. Size, material, and head shape
- 6-2. A rivet with the code number MS20426 has what type of rivet head?
- A. Countersunk
 - B. Flat
 - C. Round
 - D. Universal
- 6-3. What code identifies a rivet with a plain head marking?
- A. 1100-F
 - B. 2017-T4
 - C. 2024-T4
 - D. 5056-H32
- 6-4. What manual should you first consult when replacing an aircraft wire?
- A. General aircraft wire manual
 - B. Maintenance instruction manual (MIM)
 - C. NAVAIR-01-1A-8
 - D. Structural Repair Manual (SRM)
- 6-5. What type of terminal is generally recommended for use on naval aircraft?
- A. Crimped
 - B. Splice
 - C. Soldered
 - D. Solderless crimped
- 6-6. What device is used on naval aircraft to allow the continuous satisfactory operation of onboard electrical equipment?
- A. Bonding wire
 - B. Lightning arrestor
 - C. Static discharger
 - D. Static wick

- 6-7. What are the two most commonly used types of torque wrenches?
- A. Beam and dial
 - B. Deflecting beam and click
 - C. Dial indicating and setting or click
 - D. Electronic and no-hub
- 6-8. Which of the following manuals provides torquing information for a large variety of nuts, bolts, and screws used in aircraft construction?
- A. NAVAIR 01-1A-8
 - B. Maintenance instruction manual (MIM)
 - C. Structural Repair Manual (SRM)
 - D. COMNAVAIRFORINST 4790.2
- 6-9. What is the purpose of a cotter pin?
- A. To secure bolts, nuts, screws, and pins
 - B. Only used on bolts larger than 3/8 in diameter
 - C. To replace the need for safety wire
 - D. To secure safe for flight bolts only
- 6-10. How many different methods are used to secure a turnbuckle?
- A. Two
 - B. Three
 - C. Four
 - D. Six
- 6-11. How many pieces of safety wire are used to secure a turnbuckle using the wire-wrapping method?
- A. One
 - B. Two
 - C. Three
 - D. Four

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